Exploring Gender Differences in Perceptions of 3D Telepresence Collaboration Technology: An Example from Emergency Medical Care

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ABSTRACT
Previous research on gender differences and collaboration technology illustrate the need to investigate gender issues as early as possible in the development cycle in order to avoid any negative consequences the technology may impose. Therefore we are investigating the potential of 3D telepresence technology now when only a proof-of-concept demonstration of the technology exists. We conducted a controlled lab study using a post-test design in which male and female paramedics diagnosed and treated a trauma victim (a computerized mannequin) in collaboration with a physician via 2D video or a 3D proxy. The results show several gender differences that imply male paramedics may inherently receive more benefits from use of the 3D telepresence technology than female paramedics.

Author Keywords
3D telepresence, emergency medicine, collaboration, experiment, gender.

ACM Classification Keywords
K.4.3 [Computers and Society]: Organizational Impacts – Automation, Computer-supported collaborative work.

INTRODUCTION
Previous research has shown that there are gender differences with respect to how technology is perceived and used [e.g., 8, 9, 16]. In fact Liff and Shepherd [14] talk of an evolving gender digital divide. Often gender differences are discovered after a technology is designed and deployed, when individuals may have already experienced negative consequences and it is most expensive to modify the technology. Thus it is important to investigate inherent gender biases in technology as early as possible in its research and development (R&D) cycle. This paper reports on one such investigation.

The overall goal of the investigation is to evaluate the potential of emerging 3D telepresence technology in facilitating collaboration between geographically separated medical personnel in emergency medical situations. 3D telepresence technology has the potential to provide richer visual information than current 2D video conferencing techniques and may increase the physician's sense of presence with the remote patient [18]. Using the 3D technology in medical situations could provide people, e.g., living in rural or catastrophic areas, with better medical care although physicians or other experts are not physically present.

To evaluate the potential of the 3D technology, we conducted a controlled experiment using a post-test design to compare outcomes when a paramedic in a simulated emergency medical situation collaborates with an emergency medicine physician either using state-of-the-art 2D video or a 3D telepresence proxy. The 3D proxy was required because today only a proof-of-concept demonstration version of the technology exists. The experiment results will help guide the design and implementation process of the 3D technology.

The results of the lab study show there are statistically significant differences with respect to how male and female paramedics perceive the 3D telepresence technology in the context of their work and organization. These differences emerge in how paramedics judge: their self-efficacy (perceived ability to perform the same tasks in the future); social influence (what others in authority would think about their use of the technology in their workplace); and, their interaction with the physician. These differences suggest that male paramedics may inherently receive more benefits than female paramedics from 3D telepresence technology if

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the current vision of the technology is not modified to take these gender differences into account.

RESEARCH METHODS

Hypothesis

Previous research that investigates interaction between gender and information and communications technology (ICT), and in particular collaboration technology, illustrates that gender affects behavior, use and perception of both technology and collaborative activities. As described by Turkle [16] men and women perceive, handle and relate to new technologies differently. This has also been reported in relation to internet use and online learning tools [8]. Liff and Shepherd [14] point at the implications of an evolving gender digital divide with respect to technical and social aspects of internet access. Gallivan [9] reports gender related differences when investigating how ICT professionals adapt to technological change, pointing to the idea that women are affected by and handle the changes differently than men. Large et al [12] demonstrates differences between six-grade girls and boys in relation to collaborative Web searching behavior. Thus our hypothesis was:

Gender differences in paramedics' perceptions of collaboration via 3D technology in emergency medical situations will emerge.

Experiment design

We conducted a controlled lab study using a post-test design. This approach to evaluation has been successfully used in previous research e.g., [15]. The emergency medical task used in the study was the diagnosis and management of a difficult airway. Paramedics receive training in this task, yet it is extremely challenging. Even the most experienced physicians in this task often have a sense of urgency and anxiety associated with control of the difficult airway, because patients will die within minutes if they do not receive appropriate treatment [10]. The inability to successfully manage a difficult airway is the most common cause of preventable death in pre-hospital care of injured patients [1]. A computerized mannequin, the METI human patient simulator, was used to simulate the patient. This state-of-the-art mannequin can be programmed to act and respond in a life-like manner.

The task was completed by 40 paramedics who collaborated with a physician under one of two conditions: 2D video technology or a 3D proxy. In the 2D video condition, four views of the mannequin, paramedic and patient monitor were provided to the remote consulting physician using digital cameras directly connected to three 21-inch high resolution monitors. One camera was a remote-controlled pan-tilt-zoom camera that the consulting physician could control. All cameras were placed in optimal positions for this particular emergency medical situation. That is, the expert physicians determined the best locations for the three cameras for the given task.

In the 3D proxy the paramedic and the physician were co-located. The physician was allowed to move around freely and point using a laser pointer but could not touch anything. This replicates the current proposed design of the 3D technology [18]. In the proposed design, multiple cameras will capture a 3D time-varying computer model of the emergency medical scene and events. This model will be recreated at a remote location, e.g., at a major hospital center with an on duty emergency medical physician. 3D head position and orientation tracking of the physician will be used to allow the physician to dynamically and continually explore and see different aspects of the emergency medical situation.

Due to the scarcity of emergency medical physicians available to participate in the experiment, the same two physicians consulted in all sessions. Both physicians were specialists in emergency medicine and male. In 2006 80% of U.S. emergency physicians were male [6]. Thus female paramedics are very likely to only interact with male physicians. Each participating physician followed as closely as possible an interaction script we developed collaboratively with them. In the results reported in this paper there were no statistically significant differences based on the consulting physician.

Social facilitation suggests that an individual's performance is enhanced when an audience is physically present [7]. An observer was physically present in the same room as the paramedic during all sessions, and an expert mannequin operator located in an adjacent room was continuously available through an open microphone. In addition, all paramedics knew they were being video-recorded and their performance would be evaluated. Thus, we suggest that the physical presence of the consulting physician in the 3D proxy condition had a minimal or no impact because all paramedics had an audience which was both physically and virtually present.

Study participants

Study participants were all paramedics with an average of over 7 years of experience as a certified trained paramedic. 10 participants were female and 30 male. This distribution approximates gender distribution in the U.S. paramedic profession [4]. Participants were randomly assigned to each condition, with equal distribution of gender and years of experience across both conditions.

Measures and Data collection

Participants completed a post-questionnaire and participated in an open-ended interview after each task session. The post-questionnaires contained 70 questions probing participants' perceptions regarding self-efficacy (the belief in one's ability to perform a task [2], technology acceptance (compatibility, relative advantage, complexity, social influence), and perceptions of the collaborative process (interaction with the physician, usefulness of information, levels of trust). Self-efficacy is considered a

powerful determinant of how well a task will be performed in the future [2]. Technology acceptance is a composite measure of psychological, social and organizational aspects of perceived usefulness that predicts the use and adoption of innovations [17]. Perceptions of the collaborative process measure the quality of the interaction and degree of trust among collaborators and are critical components of successful collaboration.

When developing the questionnaire we employed validated instruments used in previous studies to measure the constructs related to technology acceptance [15, 17], interaction [5]; usefulness of information [13], trust [3]. The wording of items was in some cases modified to suit our context. Because self-efficacy is task-specific, and we did not find a self-efficacy questionnaire for difficult airway management, we developed questions based on Bandura's recommendations [2] and in consultation with emergency medical physicians.

RESULTS

We performed a PLUM ordinal regression test to explore the gender effect. The results from the tests show that gender has a statistically significant effect at the $p < 0.05$ level on self-efficacy, the social influence aspect of technology acceptance, and interaction. No significant differences were found with respect to other components of technology acceptance, usefulness of information, trust or satisfaction. Due to page limitations, these statistically insignificant results are not included in this short paper.

Self-efficacy

The PLUM procedure showed that overall the male paramedics felt more confident than the female paramedics to perform certain key tasks in airway management after using the 3D proxy condition (ρ=.014.)

Question	Mean Male	Mean Female	ρ
I can quickly observe problems with manual mask ventilation	6.60	5.60	.004
I can quickly decide on alternative strategy when manual mask ventilation is unsuccessful	6.36	5.40	.009
I can decide when to perform a surgical cricothyrotomy	6.20	5.20	.026

Table 1. Self-efficacy mean responses: 3D proxy condition

In addition, differences with respect to specific types of tasks also emerged (Table 1), in particular, the ability to make fast decisions. These tasks are crucial in airway management because the patient will die if decisions are not made quickly enough. These results suggest that the advice provided by the consulting physician is perceived to be better by males than females in the 3D proxy group. No differences related to gender were found in the group that collaborated via 2D video.

Social influence

The data analysis shows that female paramedics rated social influence significantly higher than male paramedics in the 2D condition, whereas male paramedics rated social influence higher in the 3D proxy condition. These results are based on responses to the statement: people who influence my behavior would probably think that when appropriate paramedics should consult with a remote physician using the newest technology.

Condition	Mean Response Male	Female	ρ
2D	4.93	6.50	.016
3D proxy	5.64	4.20	.041

Table 2. Social influence results

Interaction

The results show that there is a difference in the 3D proxy condition where males perceive the interaction with the physician to be freer and less constrained than the females. On a scale from 7 (Free) to 1 (Constrained) the mean response for the male paramedics were 6.80 vs. 6.00 for the females (ρ=.048). No statistically significant differences related to gender were found in the group that collaborated via 2D video.

Performance

We are in the preliminary stages of analyzing the performance data but initial analysis shows gender differences in the time it takes from when the mannequin's breathing stops until the decision to perform a cricothyrotomy is made. In both conditions, females take longer to make the decision and they take the most time in the 3D proxy condition (Table 3.) An ANOVA shows that this difference is statistically significant (df=1, F=4.998, ρ=.031.) This is an important difference because the time taken to make this decision could impact the patient survival rate and time to recovery.

Condition	Time to cricothyrotomy decision (h:mm:ss) Male	Female
2D	0:04:31	0:05:26
3D proxy	0:04:25	0:06:55

Table 3. Decision making means: 2D and 3D proxy

Limitations

Limitations of this study include the percentage of female participants, and the use of male physicians and a 3D proxy.

DISCUSSION

This paper explores whether gender differences in perceptions of a collaboration technology emerge at the proof-of-concept stage, i.e., before the technology is designed and deployed. These types of studies can alert computer scientists early in a technology's R&D cycle regarding the technology's potential for unintended

consequences, and thus ideally increase the probability of a better design being created.

The hypothesis that gender differences would emerge was partially supported. Statistically significant gender differences were found in perceptions of self-efficacy, social influence, interaction with the collaborating physician, and time between breathing stops and decision to perform a cricothyrotomy. Previous research shows a high correlation between efficacy judgments and subsequent performance [2]. That is, higher levels of self-efficacy translate to higher levels of job performance. If a technology affords higher level of self-efficacy for males than for females (as suggested by our results), males may have a subsequent advantage with respect to future job performance. This is an important issue requiring further investigation to understand its cause and possible solutions.

Hartzel [11] also found gender-related differences in self-efficacy were associated with software adoption and use. Social influence also impacts technology adoption and use. Furthermore, male paramedics rated their interaction with the physician in the 3D proxy condition higher than female paramedics did. In comparison female paramedics rated social influence higher than males in the 2D condition. These results suggest females may be more likely to adopt and use the 2D technology and males the 3D telepresence technology.

Yet, there were no statistically significant differences for other factors, i.e., compatibility, relative advantage, complexity, usefulness of information provided by the physician, trust of the physician and other aspects of task performance. Clearly the technology provides some benefits with no gender bias.

This study is the first that we know of which investigates gender bias of a technology before the technology or system has been developed. We encourage others to perform similar investigations because both men and women are often required to use technology at work and can benefit from using it in their everyday lives. Due to space limitations we leave the discussion regarding possible ways to design and introduce new technology to eliminate gender related differences and enhance benefits for everyone for a subsequent paper.

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