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Role of Embodiment and Presence in Human Perception of Robots' Facial Cues

Ali Mollahosseini^a, Hojjat Abdollahi^a, Timothy D. Sweeny^c, Ron Cole^b, Mohammad H. Mahoor^{a,*}

^aDaniel Felix Ritchie School of Engineering & Computer Science, University of Denver, Denver, CO, 80208

^bBoulder Learning Inc., Boulder, CO 80301

^cDepartment of Psychology, University of Denver, Denver, CO, 80208

Abstract

Both robotic and virtual agents **could one day** be equipped with social abilities necessary for effective and natural interaction with human beings. Although virtual agents are relatively inexpensive and flexible, they lack the physical embodiment present in robotic agents. Surprisingly, the role of embodiment and physical presence for enriching human-robot-interaction is still unclear. This paper explores how these unique features of robotic agents influence three major elements of human-robot face-to-face communication, namely the perception of visual speech, facial expression, and eye-gaze. We used a quantitative approach to disentangle the role of embodiment from the physical presence of a **social** robot, called Ryan, with three different agents (robot, telepresent robot, and virtual agent), as well as with an actual human. We used a robot with a retro-projected face for this study, since the same animation from a virtual agent could be projected to this robotic face, thus allowing comparison of the virtual agent's animation behaviors with both telepresent and the physically present robotic agents. The results of our studies indicate that the eye gaze and certain facial expressions are perceived more accurately when the embodied agent is physically present than when it is displayed on a 2D screen either as a telepresent or a virtual agent. Conversely, **we find no evidence that either the embodiment or the presence of the robot improves the perception of visual speech, regardless of syntactic or semantic cues.** Comparison of our findings with previous studies also indicates that the role of embodiment and presence should not be generalized without considering the limitations of the embodied agents.

Keywords: Social Robot, Embodiment, Physical presence, Retro-Projected Robots

1. Introduction

Social robotics is a rapidly emerging field, which aims to develop robots capable of communicating and interacting with human users in a socio-emotional way (Dautenhahn, 2007; Breazeal, 2005). This is owing to advancements in computer technology, artificial intelligence, and recent innovations in virtual reality and computer graphics. The population of robotic agents including social and humanoid robots made in 2008 was about 8.6 million units (Guizzo, 2010) with a projected annual growth rate of 17% (IDC, 2016). Virtual agents, on the other hand, have received considerable attention in recent years as social agents (e.g. for museum guidance (Kopp et al., 2005), education (Vala et al., 2007), entertainment (Hartholt et al., 2009), and training for job interviews (Hoque et al., 2013)) due to the flexibility of computer rendered faces and the ubiquity of computer screens on mobile devices. Virtual agents are often used when a physical task or interaction such as moving objects is unnecessary. As robotic technologies are focusing more on improving social interaction with users, determining which kinds of robots or virtual agents are best suited for social interaction becomes

increasingly important. One fundamental research question is what would be the difference between virtual agents and robots in terms of human interaction, particularly in perceiving major elements of face-to-face communication (both verbal and non-verbal facial cues and skills).

The most salient difference between a robot and a virtual agent on a computer screen is physical embodiment. **Several investigations have compared various elements of social interaction among robots and virtual agents (Kidd and Breazeal, 2004; Ju and Sirkin, 2010; Fujimura et al., 2010; Delaunay et al., 2010; Al Moubayed et al., 2013; Mollahosseini et al., 2014),** and the majority of these investigations suggested that the physicality of the robot benefits user interaction. However, in the majority of these experiments, a robot with physical embodiment was physically present in front of the subjects. This is potentially problematic since the subject's percepts and evaluations may be affected not only by the robot's embodiment but also by its presence.

Some researchers evaluated the role of presence by comparing a robotic agent with its telepresence or an animated/computer-rendered version of the robot (Kidd and Breazeal, 2004; Lee et al., 2006; Kose-Bagci et al., 2009; Bainbridge et al., 2011). The majority of these investigations suggested that the presence of the robot improves user interaction and social aspects of the robot. However, as shown in Figure 1, few have compared all three conditions in the same experiment/platform. Also, the

*Corresponding author

Email addresses: ali.mollahosseini@du.edu (Ali Mollahosseini), habdolla@du.edu (Hojjat Abdollahi), Timothy.Sweeny@du.edu (Timothy D. Sweeny), rcole@boulderlearning.com (Ron Cole), mmahoor@du.edu (Mohammad H. Mahoor)

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