Cue the Future:

Bridging Computer-Mediated Communication and Human-Computer Interaction

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Abstract

Since the advent of computing machines, scholars have theorized about the relationship between humans and computers. Computer-mediated communication (CMC) and human-computer interaction (HCI) are two fields that have made important contributions to understanding the role of computers in communication. With the rise of new multimedia, multisensory, and interactive computing systems, these two fields can benefit from the integration and inform research on the new media environment. In this paper, we first provide an overview of how CMC and HCI research have evolved in the past decades. Then we review the similarities and differences between CMC and HCI in conceptualizing cues and social presence. By proposing a typology of cues (cues as social signals, cues as message elements, cues as social categories, and cues as affordances), we attempt to delineate the status quo of research on human-computer relationships. We further suggest that new media forms such as chatbots, telepresence robots, voice agents, and virtual/augmented reality technologies blur the boundaries between CMC and HCI areas of research. Future research on these topics should envision the potentiality of integrating the fields of CMC and HCI.

Introduction

Amongst the pioneers of computing, the earliest machines were seen as transformational and ones that could dramatically alter our understanding of what it meant to be human as well as human's relationship with these machines. Whether they were attempts to simulate human intelligence (Turing, 1950; Weizenbaum, 1966) or to think critically about the role of humans working with machines (Engelbart, 1962; Licklider, 1960; Wiener, 1950), these questions were at the forefront of discussions about the possibilities and consequences of computing. As the computer transformed from taking up entire rooms to desktops and personal computers, some of these pioneers created solutions for human-computer interaction that we still utilize today (e.g. Engelbart and the Mouse) and tested the limits for computers to emulate and respond to human language (Weizenbaum, 1976).

As the industry pushed toward exponential growth in processing power and lower economic costs, scholars began envisioning a world where computing was ubiquitous, networked, and passively embedded into everyday objects (Weiser, 1991). Some of these predictions have not only proven remarkably prescient but also given rise to a new set of scholarship concerning human use and interaction with computing systems (Bell & Dourish, 2007). Recent studies have showed that users are becoming less cognizant of their interactions with disembodied, social robotics in technologies like mobile phones (Fortunati, 2013), demonstrating one of the key indicators of ubiquitous computing as it recedes into the background.

Alongside this line of research on interaction with computing systems, there has been another thread that examines how people interact with one another through these computing

machines (Zhao, 2006). Known as computer-mediated communication (CMC), researchers are interested in how computing tools afford and influence social interactions and how CMC differs from face-to-face (FtF) interactions (Kiesler, Siegel, & McGuire, 1984; Short, Williams, & Christie, 1976; Walther, 1996; Sundar, Jia, Waddell, & Huang, 2015). CMC theories have offered important insights for our understanding of how certain features of computing tools deliver messages, how people form strong bonds with one another in mediated environments, and how unique networks are created through these computing systems (e.g., email, SMS, social networking sites, etc.).

With the emergence of new media technologies such as dating apps, humanoid robots, virtual and augmented reality devices, the core questions that communication scholars raise about the role of computers are still being debated and explored. While some CMC research seeks to understand why and how interpersonal communication may be different in mediated environments, research in the HCI field examines the psychological similarities between interaction with humans and with media (Sundar et al., 2015). While early CMC research focused more on the limitations of media that fail to replicate face-to-face (FtF) interaction (e.g., Kiesler et al., 1984), HCI research on communication has centered more on the imperfection of human mind that equates machines to humans (Sundar et al., 2015).

Despite the different emphases that CMC and HCI scholars place on the human-computer relationship, the increasingly complex computing environments and the ways that people use new media technologies are blurring the boundaries between them. For instance, the growing use of chatbots require researchers to synthesize CMC and HCI theories to understand users' perception of them as both mediated communicators and non-mediated

communication terminals. The application of computer agents will lead researchers to explore users' perception of them as pre-scripted programs versus real social actors. Additionally, as telepresence robots enable users to respond to the physical bodies and the distant communication partners at the same time, the integration of CMC and HCI will help explain users' social responses to such robots. As virtual and augmented reality technologies have offered new modalities of interaction (e.g., touch, smell), both CMC and HCI fields would benefit from theorizing about these new media practices.

Given these increasingly complex computing environments and the ways that people interact with and through these new media technologies, this paper seeks to bridge CMC and HCI through reviewing and synthesizing key concepts from both fields and then explore how the convergence could direct research on new media technologies. Specifically, the two important concepts that we focus on and link to both CMC and HCI are cues and social presence. Like with other theoretical constructs such as the distributed self (Banks, 2015) and affordances where scholars have recently recognized a need to clarify terminology and research implications (Evans, Pearce, Vitak, & Treem, 2017), it is in response to new developments of technologies that we theorize the importance of cues and social presence, highlight the similarities and differences of their existing conceptualizations, and explain how a synthesis of CMC and HCI is necessary for researchers to make sense of the changing media environment. Lastly we also suggest how scholars can productively move forward with the integration of CMC and HCI.

Brief Overview of CMC Research

CMC can be traced to Licklider and Taylor's (1968) work on computers as a communication device, where they envisioned computers externalizing communicators' mental modeling process and displaying communicators' messages on computer screens. Short and colleagues' (1976) analyses of non-verbal cues including voice and tones delivered through audio and video channels were a precursor to what we now understand as CMC, and the concept was formally introduced by Hiltz and Turoff (1978) when they defined computerized conferencing as "any system that uses the computer to mediate communication among human beings" (p. 30).

According to Walther (2010), early CMC research developed along two traditions. One tradition reflected network analytic perspectives and examined how CMC supported the shaping of a virtual community and enhanced connections through shared interests. The other tradition focused on teleconferencing research, where scholars investigated how CMC systems were designed to support group communication and how the blockade of socio-emotional cues would affect decision making.

CMC research grew significantly in the 1990s as scholars tried to understand the impact of the Internet (Walther & Parks, 2002). Many researchers were interested in how people would ground meaning given the different features of the technologies (Clark & Brennan, 1991). With the rise of online bulletin boards for sharing common interests and hobbies, some scholars were focusing on the motivations and posting patterns in online forums (Baym, 2000) as well as instant online messaging services (e.g. Internet Chat Relay, AOL Instant Messenger) (Herring, 2004). It was in this environment that many of the core theories surrounding text-based CMC were developed, with scholars debating about the cues-

filter-outed perspective (Culnan & Markus, 1987; Sproull & Kiesler, 1986), including media richness (Daft & Lengel, 1986), social presence theory (Short et al., 1976) as well as non-deterministic approaches to CMC including the social information processing theory (Walther, 1996), the hyper-personal model of CMC (Walther, 1996), and other perspectives.

With the growing use of various forms of computer technologies such as mobile phones, tablets, and robots, computers are no longer the only focus of CMC research. The term "computer" in CMC has been used as a generic concept that includes any digital devices that connect people from different places (Zhao, 2006). The topics of CMC research have also evolved from whether technology affords various human communicative dynamics to processes of social interactions within different computer-mediated contexts (Herring, 2004). For example, CMC researchers have investigated relational maintenance, social identities, online deception, information sharing, group discussion, social support, persuasion, impression management, and others (Baym, 2000; Bazarova, 2012; Ellison, Heino, & Gibbs, 2006; Herring, 2004; Toma & Hancock, 2012; Wright, 2002). However, as these social phenomena occur across different media platforms such as dating apps, social network services, and online forums, there is recognition in academia that one of the key challenges in thinking about current day research of CMC is "how and whether new technologies affect the utility of theories that were developed in the context of somewhat older technological contexts. […] We will need new theoretical concepts with which to describe the functional attributes of groups of technologies" (Walther, 2011, p. 470-473).

Brief Overview of HCI Research in Communication

HCI is broadly defined as "a discipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" (Hewett et al., 1996, p. 5). While the unifying goal for scholars from computer science, information science, psychology, and visual design in this field has been to understand the interaction between humans and computers, there have been different threads. One facet of HCI research seeks to understand the relationship between human psychology and mental models for understanding technological artifacts (Gibson, 1979; Norman, 1988). By measuring the different levels of attentional, attitudinal, and behavioral responses to computing platforms (Fogg, 2002), researchers attempt to design technologies that would limit mistakes and frustration surrounding the use of these technologies. This field, commonly known as user experience research, is an important HCI tradition that optimizes people's interactions with computing applications and focuses on the implications for the interaction design of technologies (Dourish, 2006; Grudin, 2012; Rogers, 2012).

A second line of HCI research focuses on the programmed intelligence of the computer, and how it helps inform us on people's thought processes of distinguishing the computer from human agents (Turing, 1950; Searle, 1980). Scholars have not only focused on the technical capability of computing systems but also honed in on the philosophical question of whether computers could truly master the scope, context, nuance, and interpretation of human linguistics to the point where they could offer feedback and work through human interactions (Winograd & Flores, 1986). While some of this work on questions of artificial intelligence were criticized for their conceptualization of intelligence as

passing a series of predetermined language tests or responding to questions with pre-programmed scripts (Agre, 1997; Weizenbaum, 1976), HCI researchers continued to program tools that can react to written and spoken language (Hurtienne, 2009). One important perspective that HCI researchers brought to understanding language and computers was that people do not necessarily interact with machines in ways that map onto a pre-designed plan, rather they continually construct meanings around linguistic instructions and take situated actions depending on the circumstances (Suchman, 1987).

In the field of communication, scholars have specifically focused on how users perceive and respond to computer technologies as social actors (i.e., computer as source) and how users obtain information from websites (i.e., computer as an interactive medium) (Lee & Sundar, 2010; Sundar & Limperos, 2013). The former direction has been referred to as the Computers are Social Actors (CASA) paradigm (Nass, Steuer, & Tauber, 1994). The CASA paradigm relies on the results of a series of experimental studies to demonstrate that human brains have not evolved enough to distinguish computers from humans (Reeves & Nass, 1996). Computer users tend to humanize computers and apply the social scripts of interpersonal communication to interaction with computers. The findings were later described as "media equation" (Reeves & Nass, 2002) and have been replicated in television studies (Nass, Reeves, & Leshner, 1996) and social robot studies (Lee, Peng, Jin, & Yan, 2006). The latter direction has centered on the motivations and gratifications of Internet use, the credibility of the online sources, and the cognitive effects of the webpages (Lee & Sundar, 2010). More recently some communication scholars have sought to explicate how human-machine communication has engaged and influenced our daily practices (C. Edwards & A.

Edwards, 2017; Gehl & Bakardjieva, 2017). Gunkel (2012) argued that a research paradigm is shifting from computers as intermediaries to computers as interlocutors. Guzman's forthcoming book on Human-machine communication also reflects scholars' efforts to evaluate the philosophical and methodological approaches to understanding various digital interlocutors.

Some have argued that there are distinct waves and paradigms that characterize the expansion of HCI research (Harrison, Sengers, & Tatar, 2011; Rogers, 2012). The first wave focused on a singular interaction that a person has with a particular application, bot, or device - interaction design being the dominant paradigm (Grudin, 2012; Löwgren and Stolterman, 2004). While these helped understand cognitive models for engagement, it tended to be highly experimental and overlooked actual communicative and social practices that people engaged in with technology. The second wave broadened HCI research to include group collaboration and introduced theories and methods such as ethnomethodology that linked design to concepts like situated action and participatory design (Bödker, 2006; Suchman, 2007). Some HCI scholars are advocating a third wave of research, which recognizes a need to place HCI research into the larger media system in which various emerging technologies are innovated (Bödker, 2006; Harrison et al., 2011, Rogers, 2012). This is increasingly prevalent with new computing systems that frequently co-exist alongside human actors operating on the same media platform (e.g. chatbots on Twitter) or are used to mediate and facilitate other human interactions (e.g. intelligent agents and avatars used in group settings). It is here where researchers have recognized a need to merge traditional HCI theories and concepts with other fields and perspectives. As Rogers (2012) argued, "adapting alternative

theories from other areas to address new concerns in HCI continues to be a staple of HCI research. [...] The ones likely to be successful are those that can address a range of interdependencies between design, technology and behavior" (p. 14).

Cues and Social Presence

Given the need to merge HCI with other fields and to revamp theoretical frameworks to explain CMC, we seek to theorize how the changing media environments necessitate an integration of HCI and CMC to guide emerging research. As both fields are related to human-computer relationships, there has been overlap in some of the concepts they use but also differences in their conceptualizations and interpretations. In this paper, we attempt to bridge CMC and HCI research through the conceptualization of cues and social presence. Despite extant literature on the effects of cues, the term "cues" was often directly adopted without concept explication. Its meanings have ranged from transmission signals and social context information to physical and biological attributes (Fiore et al., 2013, Kiesler et al., 1984; Short et al., 1976; Sproull & Kiesler, 1986). Therefore, a more rigorous analysis of cues is needed in the current scholarship.

The other concept that has been discussed across HCI and CMC is social presence. While there is an overarching definition of social presence from the International Society for Presence Research (2000) - "when part or all of a person's perception fails to accurately acknowledge the role of technology that makes it appear that s/he is communicating with one or more other people or entities" (Presence defined), social presence has been explicated from a variety of perspectives including the bandwidth of media technologies (Short et al., 1976), the perceptual illusion (Lombard & Ditton, 1997), the psychological state (Lee, 2004),

and the phenomenological state (Biocca, Harms, & Burgoon, 2003). Unlike cues that have been under theorized, social presence is well defined but can be approached and used in many different contexts (Lombard & Jones, 2015). Therefore, another goal of the study is to pull apart the pivots of these definitions and more clearly map out how different social presence experiences can be evoked by corresponding cues.

By referring to Dubin's (1978) categorical law of interaction and Slater and Gleason's (2012) approach of theory building, we categorize cues into different types. Then based on the similarities and differences of CMC and HCI scholars' interpretation of cues and social presence, we further discuss how CMC and HCI have evolved in response to the changing media landscape and how these two fields may guide future communication research.

Cues in Computer-Mediated Communication

In this section, we introduce the role of cues and social presence through the lens of CMC. We break down cues into several analytical categories across various contexts: cues as mediated social signals, cues as social categories, and cues as message elements.

Cues as Mediated Social Signals

Scholars in the 1970s began to notice the differences between media technology forms such as videos, monaural speakers, and telephones. Short and colleagues (1976) were among the first scholars to systematically compare the warmth and intimacy delivered in mediated communication contexts. They proposed social presence theory and hypothesized that social presence was positively related to the bandwidth of a communication system. In their research, social presence was conceptualized as "the degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships" (p.

65). When measuring social presence, they operationalized it as "the subjective quality of medium" (p. 66). Short and colleagues (1976) also mentioned that the cues referred to non-verbal communication "signals" that include tone of voice, touch, proximity, and eye contact (p. 74). When cues were reduced due to the bandwidth of the media technologies, the efficiency of interaction would be undermined (Short et al., 1976).

As more technologies such as short message services, emails, and videoconferencing developed in the 1980s, scholars proposed media richness theory (Daft & Lengel, 1986; Rice, 1992) where the match between the equivocality of the communication task and the richness of the medium (i.e., multiplicity of cues, availability of feedback, message personalization, and language variety) determines communication effectiveness. Similar to how cues are conceptualized in social presence theory, cues in media richness theory are also regarded as social signals such as facial expressions, gaze, physical distance, and tones (Rice, 1992). However, one of the differences between social presence theory and media richness theory is that in social presence theory, the transmission of these cues is constrained by the media bandwidth, whereas the transmission of cues in media richness theory is limited by the extent to which media reduce uncertainty and proffer time interval for communicators to receive and understand information (Daft & Lengel, 1986). Short and colleagues (1976) and Rice (1992) were among the pioneers in exploring key differences in communication channels in a technologically mediated environment. For them, cues are social signals that are influenced by various media features, which later became an important assumption in the development of CMC as a field.

Cues as Social Categories

In the 1990s, online chat rooms, online discussion groups, and teleconferencing technologies became more common for everyday interaction. Research on the Social Identity Model of Deindividuation Effects (SIDE) (Reicher, Spears, & Postmes, 1995; Postmes, Spears, & Lea, 1998) has provided explanatory power in users' sense of group identity. The SIDE model posits that anonymity, which could be understood as a lack of cues as social signals, can interact with group norms in facilitating the social influence in a mediated environment (Spears & Postmes, 2015). SIDE scholars theorized that anonymity would lead individuals to switch attention to cues as social categories. Rogers and Lea (2005) used the term "the membership of social categories" to refer to such cues (p. 153). Specifically, when cues as mediated social signals are blocked in a communication context, users will look for group information that insinuates group norms and social identities (Reicher et al., 1995). For example, SIDE scholars have found that lack of individuated information would lead to group conformity and the reinforcement of perceived group norms through group identification (Kim & Park, 2011; Lee, 2006; Lea, Spears, & de Groot, 2001). Thus, cues as social categories can contribute to the salience of group norms. Examples of these cues are group avatars, color labels, aliases, interests, genders, and even IP addresses. They could also simply be the knowledge about the group and the settings of the mediated environment such as a YouTube webpage (Walther, De Andrea, Kim, & Anthony, 2010).

Rogers and Lea (2005) further discussed the relationship between cues and social presence. They argued that lack of cues might finally result in higher social presence instead of lower social presence in that these cues can generate a feeling of group affiliation when users switch attention to cues of group membership. Individuals thus will feel immersed in

the group environment, “enabling the medium to become a social entity and thus conveying social presence” (p. 153). As Rogers and Lea (2005) discussed the capacity of the medium to evoke immersion experience, their conceptualization of social presence still emphasized the subjective quality of the medium.

Cues as Message Elements

During the same time period, the widespread text-based live chat systems triggered the development of social information processing (SIP) theory. Compared with social presence theory and media richness theory that focus on the bandwidth of communication systems, Walther and Burgoon (1992) focused on the asynchronous nature of CMC. They suggest that over time individuals will achieve the same level of information exchange and impression formation in FtF and CMC settings, as users in mediated environments will rely on the cues presented to them. Walther and Parks (2002) mentioned that in the message exchange process, individuals will observe the content of the messages, style of writing, and even timing of the message exchange. Walther, Loh, and Granka (2005) further provided a list of kinetic cues (e.g., body language, eye gaze), vocal cues (e.g., loudness, fluency), and verbal cues (e.g., insult, sarcasm) to code users’ expression of affinity in CMC.

As an extension the SIP theory, Walther (1996) argued that in CMC contexts, users could exaggerate the impression of others. Interpersonal relations could be inflated both positively and negatively. This hyper-personal perspective, known as the hyper-personal model, was developed as online users were given the ability to customize their profiles and selectively present the desired images on social media (e.g., LinkedIn, Tinder), online games (e.g., Second Life), and other platforms. The hyper-personal model suggests that senders of

information can take advantage of the asynchronous nature of CMC to edit, remove, and rewrite messages for selective self-presentation (Walther, 2007; Walther et al., 2015). It also suggests that when receivers get the messages, they will form stereotyped impression of the message senders, which is known as over-attribution processes.

The interpersonal perspective of CMC and the hyper-personal perspective have conceptualized cues consistently. Prior research has referred to cues as language styles, use of emoticons and emojis, pauses, editing status, and delay in response (Walther 2007; Walther et al., 2005, 2015). Also, message senders could manipulate the cues of their avatars, their nicknames, and their basic profile information such as gender and ethnicity. We list these cues as message elements because even the minimal availability of information (e.g., indications that responder is "typing") could be perceived as part of the messages from the information senders.

Both the interpersonal and the hyper-personal perspective of CMC discuss the process of developing interpersonal relationships through computer technologies rather than the media features per se (Toma, Hancock, & Ellison, 2008). Therefore, scholars' interpretation of social presence in these two perspectives is different from that in social presence theory, media richness theory, and SIDE. In CMC contexts, users may experience presence as social actor within medium, which refers to the idea that users respond to the cues presented by the mediated communicators and overlook the role of media technologies (Lombard & Ditton, 1997). Lee's (2004) definition of social presence may also fit into these two perspectives of CMC as users can be in a mental state where they experience para-authentic characters as real

people. Additionally, Zhao's (2003) conceptualization of co-presence as "sense of being with others" (p. 450) may also reflect the impression formation process in CMC.

Cues in Human-Computer Interaction

In this section we review the cues that may evoke social presence in prior literature of HCI and break them down into the analytical categories of cues as non-mediated social signals, cues as social categories, cues as message elements, and cues as affordances.

Cues as Non-Mediated Social Signals

Cues as social signals in CMC include voice, touch, eye contact, and so on. In HCI studies, these cues are not delivered from other communicators through media channels. Rather they are designed into the media themselves and are often manifested in technologies like humanoid robots. Fiore and colleagues (2013) defined social cues in human-robot interaction as "biologically and physically determined features salient to observers because of their potential as channels of useful information" (p. 2). They suggested that cues from robots could be interpreted as "social signals" based on environmental and cultural differences (p. 2).

In the 1990s, Nass and colleagues (1994) proposed the CASA paradigm, which examined cues like voices of computers. For example, researchers found that participants rated male-voiced computers as more credible than female-voiced computers (Morishima, Nass, Bennett, & Lee, 2001; Nass, Moon, & Green, 1997). Voice can also indicate personality. Nass and Lee (2001) suggested that compared to extroverted participants, introverted participants would be attracted to the introverted computers that had lower speech rate, lower volume level, lower fundamental frequency, and lower pitch range.

Researchers have also found that participants, even 12-month old babies, could easily follow robots' eye gaze directions (Okumura, Kanakogi, Kanda, Ishiguro, & Itakura, 2013; Xu, Zhang, & Yu, 2013). Andrist, Mutlu, and Tapus (2015) suggested that when robots were designed with eye gaze, their communication with humans was much more smooth.

As part of the non-verbal cues, movement and gestures are another two important cues in HCI. Lee and colleagues (2006) suggested that by controlling robot AIBO's moving angles, moving speed, and moving styles, individuals perceived the robot AIBO to have different personalities. Robots' demonstration of gestures increased their likeability and attractiveness as well (Salem, Eyssel, Rohlfing, Kopp, & Joublin, 2013). Bevan and Fraser (2015) suggested that designers could let robots shake hands with humans to increase their communication effectiveness.

These cues as non-mediated social signals would easily evoke individuals' feelings of social presence. Lombard and Ditton (1997) described this type of social presence as presence as medium as social actor, referring to individuals' reactions to the cues presented by machines or computers themselves. Similarly, Lee (2004) suggested that when artificial social actors are perceived as real social actors, individuals would experience social presence. In human-robot interaction, social presence can be defined as the degree to which participants feel as if they were communicating with an intelligent being (Lee et al., 2006). Zhao (2003) further argued that this sense of being with other artificial social actors may occur when users suspend their disbelief in interaction with computer agents.

Cues as Social Categories

Scholars in HCI have also studied the cues as social categories. Individuals can form group identities with computers, robots, or other technologies (Nass, Fogg, & Moon, 1996; Reeves & Nass, 2002). For example, Reeves and Nass (2002) had one group of participants wear a colored wristband and provided the simple cue of a label on the computer that matched the color of the wristband. They found that those who had the matching color of wristband perceived themselves to be part of a team with the computer.

In the context of human-robot interaction, Eyssel and Kuchenbrandt (2012) provided participants with two robots' names. One robot was assigned a Turkish name and the other was assigned a German name. They found that the participants who had the same nationality with the robot rated it as more positive. Kuchenbrandt and colleagues (2013) further found that even though researchers only told the participants whether they were on the same team with the robot NAO, participants still favored the robot on the same team more than the robot on a different team. The findings suggest that individuals only need minimal cues or information about social identities to respond socially to media technologies.

Cues as social categories are likely to evoke the same type of social presence as cues as non-mediated social signals. Individuals can perceive the computers as real people and feel medium-as-social-actor presence (Lombard & Ditton, 1997) or co-presence with computers (Zhao, 2003) when they are exposed to cues as social categories.

Cues as Message Elements

Cues as message elements include language style, use of emoticons, pauses, and so on. These cues exist in HCI as well. For instance, the voice assistant Siri needs response time to react to users' questions. Some robots (e.g., Robot Jiaojiao and LeChange) are designed

with a screen to show emoticons and emojis (Cole, 2015). Moon (2000) found that when computers used texts to demonstrate interpersonal language patterns such as slowly moving from one topic to another, or when they exhibited high reciprocity in text-based conversation with humans, participants were more likely to disclose their private information to the computers. Bracken and Lombard (2004) conducted a study on computers' praise and found that children's learning efficiency was enhanced if they received positive text-based feedback from computers. These studies suggest that individuals perceive computers to possess human communication skills and language styles.

As the studies above were based on the CASA paradigm, the type of social presence that cues as message elements could evoke is also medium-as-social-actor presence. That is, individuals treat computers as social actors because they have the misperception that computers can understand, respond, and provide feedback to humans.

Cues as Affordances

Sundar and his colleagues (2015) argued in the Theory of Interactive Media Effects that technology affordances on user interfaces could be understood as cues that affect users' assessment of the interfaces. Here cues are understood as reflections of the technology affordances. Gaver (1991) conceptualized affordances as "attributes of both the object and the actor" (p. 79). Technology affordance is the interaction between users' perception and the properties of the technologies (Gaver, 1991).

According to Sundar and his colleagues (2015), a user interface includes four types of affordances: modality affordance, agency affordance, interactivity affordance, and navigability affordance. Specifically, modality affordances (e.g., the visual and audio

functions) can affect users' perception of the quality and credibility of the content on the user interface (Sundar et al., 2015). For instance, Oh, Robinson, and Lee (2013) found that the affordance of page flipping would predict higher usability, higher engagement, and more positive evaluation of a website than the affordance of double clicking. Agency affordances such as authority cues and peer cues also can help users evaluate the credibility of information sources. Peer cues are powerful in affecting users' online shopping intentions and their attitudes toward online products (Sundar, Xu, & Oeldorf-Hirsch, 2009). Interactivity affordances are understood as the extent to which users' inputs determine the outputs of the interfaces (Sundar et al., 2015). Navigability affordances refer to "the interior design of the interface" (Kim & Sundar, 2012, p. 243). If user interfaces are designed with user-friendly navigation buttons, the credibility of the user interface can be enhanced.

All these affordance cues could trigger users' social presence experience (Kim & Sundar, 2012). Here social presence can be thought of as individuals' sense of being with others (Kim & Sundar, 2012), sense of co-presence (Zhao, 2003), and transportation (Lombard & Ditton, 1997). A synopsis of the category of cues in CMC and HCI and its relations to technologies, social presence, and theoretical frameworks is attached in Table 1. The categories of cues are not mutually exclusive to each other.

Overlap and Divergence Between CMC and HCI

From our typology above, we start to see how CMC and HCI overlap and diverge from each other in their approaches to understanding cues and social presence. In this section, we explicitly compare these perspectives and then explain how the typology can be useful for future research.

Both CMC and HCI scholars have noticed the role of interpersonal communication cues in the human-computer relationship such as facial expressions, voice, gestures, and proxemics (Nass et al., 1994; Postmes et al., 1998; Short et al., 1976). They have also studied how cues can highlight team membership in the digital contexts (Reeves & Nass, 2002; Spears & Postmes, 2015). In addition, CMC and HCI scholars have noticed the role of conversational styles in developing relationships with either human communication partners or computer technologies (Moon, 2000; Walther, 1996). Though developing interpersonal relationships through and with computer technologies involve different types of social presence, scholars in both CMC and HCI have tended to view social presence as users' experience of partially or fully overlooking the role of technologies and perceiving para-authentic or synthetic social actors as real people (ISPR, 2000; Lee, 2004).

We also lay out instances where their approaches to theorizing the human-computer relationships are different. When referring to cues as social signals, Short et al. (1976) and Rice (1992) focused on how media bandwidth limits the transmission of social signals, while media equation theorists focused more on how social signals like voice may mimic real interpersonal communication and evoke users to respond to technologies as social actors (Nass & Moon, 2000).

In the context of group discussion, CMC scholars have emphasized how users form group relations with others when they switch their attention to group identity (Spears & Postmes, 2015). For example, CMC scholars have examined the effects of anonymity in the group discussion contexts (Hollenbaugh & Everett, 2013; Kang, Brown, & Kiesler, 2013;

Lee, 2006; Rains, 2007). However, there is much less research that explores users' identification with computers or robots in the HCI context.

Cues as message elements have been another focus in prior CMC research, where scholars have looked at how these cues enable communicators to avoid the limitation of media bandwidth, form impression of others, rely on stereotyped knowledge to predict others' mental and physical states, and promote communication effectiveness. Within HCI, there has been less research on the message elements in conjunction with technology as a factor for understanding users' interaction with computer devices.

Despite less research on social categories and message elements, HCI scholars have made more contribution to understanding the affordances of technology. For instance, Kim and Sundar's (2013) work on interactivity affordances suggested that using a steering wheel for a car racing game or a light gun for an action video game could elicit higher feelings of presence than joysticks.

In addition to different contributions to knowledge of cues, CMC and HCI scholars have different interpretations of social presence. In CMC research, scholars have conceptualized social presence as the perceived quality of a medium (Short et al., 1976), the sense of being with others (Zhao, 2003), and the perceptual illusion that users respond to mediated social actors without fully acknowledging the role of technologies (Lombard & Ditton, 1997). In HCI research, social presence has been mostly referred to as the illusion that the media technologies become social entities (Lombard & Ditton, 1997), or as the mental state where synthetic social actors are experienced as real social actors (Lee, 2004). Overall, CMC scholars emphasize how the mediating role of technologies has been overlooked in

users' presence experiences while HCI research accentuate how technologies themselves are perceived not as machines but as social beings.

The typology of cues and their association with social presence have manifested how CMC and HCI have conceptualized human-computer relationships, revealed the key differences in their focuses, and evolved with the innovation of media technologies. Previous CMC literature has focused on how users interact *through* computer technologies and how they rely on the cues available to them to develop, maintain, and end interpersonal relationships with others, while HCI literature in the field of communication has centered on how users interact *with* computer technologies, respond to them as social actors, and use cues to retrieve and evaluate online information (Lee & Sundar, 2010). Today, the diffusion of new media technologies such as chatbots and telepresence robots is challenging the demarcation between CMC and HCI. These technologies enable users to interact both *with* a digital social actor and *through* a computer system. For example, Guzman's (2017) research on users' perception of voice assistants has substantiated that users perceived the voices to be both in the machines and of the machines. Given that both disciplines have recognized a need to broaden their research by updating their theories, exploring new media contexts, and introducing alternative viewpoints, it is here where a merger of CMC and HCI becomes necessary and a typology of cues becomes useful in informing future research.

Applying CMC and HCI to New Media Contexts

In the sections above, we examined the similarities and differences between CMC and HCI through categorizing and reorganizing cues and social presence. In this section, we specifically examine how communication research on new media technologies such as

chatbots, voice agents, telepresence robots, and virtual/augmented reality can benefit from our theoretical framework.

The growing ubiquity and sophistication of chatbots that can simulate conversations may be most representative examples for the integration of CMC and HCI. Defined as computer programs that interact with users using natural languages (Miner et al., 2016), chatbots can be physically embodied or disembodied, co-present with users or telepresent in its status, and communicate with people in text or through voice (Li, 2015; Shawar & Atwell, 2007). For example, Microsoft Little Ice, a computer program that was designed to mimic a teenage girl has over 90 million users interacting with it via text, voices, images, and animated GIFs (Graphics Interchange Format) (Bingblog, 2016). Microsoft also launched the Twitter bot Tay that was not only a simulated conversation bot but also one that was supposed to respond to other users' Twitter posts. The project ended after Tay made insulting comments toward other users (Hunt, 2016).

Drawing on the typology of cues rooted in CMC and HCI, one future research direction could be to test the effects of cues as message elements in users' interaction with these computer programs. Chatbots like Tay and Little Ice are designed to have their own language styles, editing status, and response delays. To learn about how users develop interpersonal relationship with these chatbots and how these cues as message elements can evoke users' social presence, researchers can refer to the categorization in Table 1 and combine theoretical frameworks from both CMC and HCI to explain users' interaction with them. For example, researchers can manipulate chatbots' response delay or language styles and apply the hyper-personal perspective of communication and media equation to see how

users form exaggerated impression of these chatbots and respond to them as expected by designers. Researchers can also use theories like the SIP theory to test whether users can achieve the same level of interpersonal relationship with chatbots as with physically embodied robots over time.

Cues as social categories may also be applied to research on users' communication with bots. As some online bot accounts can show avatars, IDs, assigned gender, and hobbies just like human accounts, users may fail to differentiate between chatbots and real humans in an anonymous online environment (Edwards, Edwards, Spence, & Shelton, 2014). As these cues may lead to group identification with chatbots, it would be meaningful to examine how users approach chatbots in a group discussion context (Author, 2017). Researchers can examine the effects of cues as social categories through the lens of SIDE and CASA to further understand how users form group identities with chatbots and how these chatbots impose group pressure on users' attitude change.

Another research area where the intersection of CMC and HCI is necessary is on computer agents. Compared to chatbots whose major function is for social interaction with humans, computer agents were defined as intelligent programs that can be regarded as personal assistants instead of tools (Serenko, 2006; Schiaffino & Amandi, 2003; Shinozawa, Naya, Yamato, & Kogure, 2004). Computer agents should demonstrate human intelligence including inference, learning, independence, creativeness, and adaptability (Lieberman, 1997). Examples of these computer agents include voice agents such as Siri that respond to users' commands, web guides that generate personalized feedback (Selker, 1994), interface agents that simulate users' online searching behavior (Lieberman, 1997), robot journalists

that produce credible news (Clerwall, 2014), and artificial intelligent programs such as AlphaGo that employs value network and tree search (Silver et al., 2016).

Taking Apple Siri as an example, HCI researchers may argue that it is the smart assistant program that individuals are interacting with. Individuals would likely experience medium-as-social-actor presence because they would respond to Siri, the voice agent, as a social entity. But voice agents also exhibit characteristics of CMC because it is possible that individuals perceive presence as social actor within medium when users interact with the program through computers. Here, the computers have become mediators between the agents and users. This perspective was supported in the Katagiri, Takahashi, and Takeuchi (2001) study where participants attributed different identities to computer agents instead of computers as social actors. Serenko (2007) corroborated that users tended to attribute more responsibilities to interface agents when these agents owned a high level of autonomy. As these interactive agents are often embedded into media devices (Jung, Martelaro, Hoster, & Nass, 2014), understanding users' perception of these non-human agents as human, computer interlocutors, or some combination therein will require using and testing the cues and social presence from both CMC and HCI.

Another emerging media technology that requires the synthesis of CMC and HCI is telepresence robot. A telepresence robot (e.g., Beam and Double robots) is a wheeled device that incorporates video conferencing functions and remote control (Kristofferson, Coradeschi, & Loutfi, 2013). Telepresence robots have been applied in the educational settings for connecting homebound students to real classrooms (Double Robotics, 2017) and the health settings for efficient patient-provider communication (Ackerman, 2016).

When interacting with telepresence robots, users may not only respond to their communication partners through the video screen. They may simultaneously respond to the gestures and motions of the robots. Thus, telepresence robots can present both cues as non-mediated social signals in HCI and cues as mediated social signals in CMC. For example, Sirkin and Ju (2012) examined the effects of a telepresence robot's in-space gestures (i.e., how the body of the robot moves) and on-screen gestures (i.e., how the remote communicator moves). They found that the consistencies between both types of cues as social signals increased user's confidence and evoked stronger social responses. The findings suggest that users may experience both medium-as-social-actor presence and social-actor-within-medium presence at the same time. Putting these findings in the context of our typology, more research that aims to understand the relationships between same types of cues from CMC and HCI and simultaneous experience of different types of social presence is necessary in understanding communication with telepresence robots. For example, researchers can rely on the typology to study how the perceived distance between the user and the mediated communicator interact with the one between the user and the physical robot in evoking users' social responses to telepresence robots. Researchers can also test whether the experience of medium-as-social-actor presence will outweigh the experience of social-actor-within medium presence during users' interaction with telepresence robots.

Some telepresence robots (e.g., Jibo Robot) use their screen to present emoji (i.e., cues as message elements) and can navigate their moving paths (i.e., cues as social signals). Researchers can thus examine how different types of cues compete against or interact with

each other in evoking social presence. They can further explore whether there is a hierarchy of cues on telepresence robots that evokes different types and strength of social presence.

Last, it is not only artificially intelligent bots that are complicating the contemporary media environment, but also virtual and augmented reality technologies that can change our visual representation of the world. As technologies that either supplants reality with a complete virtual environment (VR) or ones that merge virtual content with physical reality (AR) (Milgram & Kishino, 1994), these visual technologies raise questions that could benefit both CMC and HCI. While CMC research in this area has focused on the effects of VR avatars and attitudes (Yee & Bailenson, 2007) or VR experiences and behavioral responses (Ahn, Bailenson, & Park, 2014; Won, Haans, Ijsselsteijn, & Bailenson, 2014), new possibilities in collaborative VR environments and haptic interactive tools could bring in HCI concepts. For example, the addition of force and touch feedback can increase VR users' presence experiences (Popescu, Burdea, & Bouzit, 1999). Bailenson, Yee, Brave, Merget, and Koslow (2007) tested the effects of virtual interpersonal touch and found that users can recognize others' emotions through haptic devices. Bailenson (2018) further argued that mimicking real touch in VR environments would improve users' communication effectiveness with others and open up a more productive public discussion space. In this context, users' interaction with both cues as affordances (e.g., haptic devices) and cues as mediated social signals (e.g., the gestures of the avatars in VR) may influence their social presence experiences. Researchers can thus combine the TIME model and the social presence theory to study users' cognition and behavior in using VR. Future research on the roles that avatar cues, virtual environment cues, technology cues, and other kinds of interactive

feedback play in human communication should draw on existing research on CMC as well as HCI to understand users' attitude and behavioral change.

AR differs from VR in that it merges digital content and physical reality, which means that users have to react to both real world cues and virtual cues. Some early research that demonstrates the complexity of this for human communication was a study where users were asked to interact with one person wearing a Google Glass that would display the social media posts the other person sent (Bowman, Banks, & Westerman, 2016). In this scenario, we have the text-based message cues that are classic CMC constructs being brought into FtF social interaction, further complicating the relationship between mediated cues and non-mediated cues. While traditional CMC theories assumed the absence of certain audio and visual cues, AR makes it possible to display additional mediated social signals and message elements juxtaposed with physical interaction. As AR technologies continue to progress toward wearable devices and glasses (Author, 2016), these kinds of interactions will become increasingly common and require researchers to unpack multiple layers of cues, social presence experiences, and interactions with content and technology.

Conclusion

CMC and HCI have been two major areas that explain human-computer relationships. While CMC research has focused on the differences between interpersonal communication and mediated communication, HCI research has developed along interaction design, behavioral change, and artificial intelligence. Based on prior literature, we briefly reviewed the evolution of HCI research and CMC research and analyzed how cues can be categorized into different types and evoke different types of social presence. We linked the category of

cues to the areas that require the integration of CMC and HCI to fully understand users' communication with these new media technologies. The typology of cues and its effects on social presence presented a prospect for new media research.

On the other side, the relationship between CMC and HCI in this paper may only be our best understanding of the current scholarship of the human-computer relationship. The growth of artificial intelligence and virtual and augmented reality technologies has continued to blur the relations between CMC and HCI and will undoubtedly give rise to new theories. More challenges of understanding the user experience and psychological processing of these emerging technologies will come to light. The ideas of Cyborg coupling (i.e., our physical body paired with technologies) (Biocca, 1997) may substantially change our definitions and conceptualization of CMC and HCI. Facing these ongoing technological developments, this piece is an attempt to facilitate theoretical and methodological development by organizing concepts and helping researchers from multiple disciplines speak a common language about different phenomena, as well as motivate new scholars to consider new research questions utilizing this framework.

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Table 1:
A category of cues in CMC and HCI and its relation to social presence

Cues	Examples	Theoretical Frameworks		Understanding of social presence	
		CMC	HCI	CMC	HCI
Cues as social signals	Voice, touch, facial expressions, gestures, physical distance, eye contact, etc.	Social presence theory (Short et al., 1976); Media richness theory (Rice, 1992); SIDE (Postmes et al., 1998; Spears & Postmes, 2015)	The CASA paradigm (Nass et al., 1994); The MASA paradigm (Xu & Lombard, 2016)	Subjective quality of the medium (Short et al., 1976); Features of the media (Rice, 1992)	Medium-as-social-actor presence (Lombard & Ditton, 1997); Perceiving artificial social actors as real people (Lee, 2004); Intelligent being (Lee et al., 2006)
Cues as message elements	Language style, pauses, editing status, response delay, emoticons, punctuations, etc.	Social information processing theory (Walther et al., 2015); Hyper-personal perspective (Walther, 1996, 2007)	The CASA paradigm (Moon, 2000)	Presence as social actor within medium (Lombard & Ditton, 1997); Sense of being with others (Zhao, 2003); Para-authentic characters (Lee, 2004)	Medium-as-social-actor presence (Lombard & Ditton, 1997); Perceiving artificial social actors as real people (Lee, 2004);
Cues as social categories	Group names, avatars, color labels, ID gender, IP address, knowledge, social context	SIDE (Postmes et al., 1998; Spears & Postmes, 2015)	The CASA paradigm (Nass et al., 1996); Media equation (Reeves & Nass, 2002)	The capacity and the quality of medium (Rogers & Lea, 2005)	Medium-as-social-actor presence (Lombard & Ditton, 1997); Copresence with computers (Zhao, 2003); Perceiving artificial social actors as real people (Lee, 2004)
Cues as affordances	Modality, agency, interactivity, navigability	-	TIME (Sundar et al., 2015); MAIN (Sundar & Limperos, 2013)	-	Copresence (Zhao, 2003), "we are together" (Lombard & Ditton, 1997); Sense of being with another (Kim & Sundar, 2012)

Note: The categories of cues are not mutually exclusive.