The telepresence robot contact hypothesis

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Abstract

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1. Introduction

The pervasive role of technology in intensifying the ability of humans to harm one another is well known; the use of technology to promote peace at both the collective and personal levels is considerably more modest. Over the years, there have been calls within the Human-Computer Interaction research community to promote the use of technology to support peace in world conflicts (Hourcade and Bullock-Rest, 2011; Eckert et al., 2019). Often when people think of a technological contribution to conflict resolution, the emphasis is placed on decision support and negotiation for policymakers and national leaders. A different approach that is taken in the current paper is using technology to reconcile the 'common' people in a situation of conflict and build more positive intergroup relations from the bottom up.

One of the most prominent models that act as a guideline for this approach is the contact hypothesis (Allport, 1954), which states that under the right conditions, encounters with members of the opposing group (i.e., the outgroup) can lead to reduced prejudice and more harmonious intergroup relations. We propose using robots as a communication medium for such contact, as they combine both the flexibility and accessibility of online communication and the corporeality of face-to-face encounters in a shared physical space.

We begin by reviewing research on intergroup contact and the need for a new technological medium. We introduce robots as an alternative form of intergroup contact that has, to our knowledge, not been considered previously. We then present a conceptual framework based on previous research, outline considerations for a successful robot-mediated contact, and provide example use cases for deployment in the context of violent intergroup conflicts, taking the Israeli-Palestinian conflict as an example. We conclude with an agenda for future research in this newly emerging field of robotic intergroup contact.

The hypotheses presented in this article are based on observations from an initial test we conducted on intergroup telepresence contact (Peled, 2019). The test system included one remotely controlled telerobot that facilitated conversations between immigrants and local participants. We have analyzed the results qualitatively through post-session interviews.

2. Conceptual framework

2.1 Intergroup contact hypothesis

The contact hypothesis, as formulated by Gordon Allport in his seminal book *The Nature of Prejudice* (1954), specifies four conditions that need to be fulfilled during positive intergroup contact: equal status, having common goals, active cooperation, and institutional support. Fifty years later, a meta-analysis across more than 500 studies in a variety of intergroup contexts (Pettigrew and Tropp, 2006) has revealed that contact is an effective means to reduce prejudice. However, the meta-analysis also showed that the conditions are not strictly essential for a positive outcome, yet they are factors among others that facilitate it. Later research focused on expanding the theory to include more conditions such as forming cross-group friendships (Cook, 1962) and identifying affective drivers, such as empathy and (reduced) anxiety, that play a mediating role in contact interventions (Pettigrew et al., 2011; Brown and Hewstone, 2005). An additional factor that moderates the outcome of contact is *group salience*, the degree in which the participants' group identity is evident. A high level of group salience facilitates the generalization of attitudes from the interpersonal level to the group level (Voci and Hewstone, 2003).

Most previous intergroup contact studies were conducted in face-to-face (FtF) settings. However, face-to-face contact can be challenging to implement, particularly in areas of violent conflict (Hasler and Amichai-Hamburger, 2013). Organizers commonly face practical issues such as gathering diverse groups, finding a neutral, accessible location, and compensating participants for travel expenses. Therefore, recent projects have used technology (especially online communication) to facilitate intergroup encounters.

2.2 Online contact

Communication technologies expand the models of contact and add new modalities of interaction while compromising on the benefits of traditional FtF encounters. Research on online intergroup contact has shown its potential to reduce prejudice and aid in conflict resolution (Amichai-Hamburger et al., 2015; Hasler and Amichai-Hamburger, 2013; Walther et al., 2015). However, online contact is not always constructive. The remote nature of the medium makes participants less accountable for their actions and less engaged in the conversation (White et al., 2015; Schumann et al., 2017). The lack of nonverbal cues (Burgoon and Hoobler, 1994) obstructs the path to a mutual understanding and impairs the turn-taking process, which may evoke negative feelings between the group members, such as anger and frustration (Johnson et al., 2009).

Virtual reality (VR) is studied as a medium that offers an immersive communication experience that increases the user's sense of embodiment during communication (Kilteni et al., 2012). It was positively evaluated for use in intergroup contact, both as a space for dialog (Hasler et al., 2014), and as a tool that allows individuals to immerse themselves in the perspective of the other side (Hasson et al., 2019; Kabiljo, 2019). However, along with its promise, VR also raises a number of ethical and moral concerns. While the experience of *being* in the virtual space intensifies as the technology develops, our corporeal body is left behind as we subsume an abstract representation as our new reality (Penny, 1993). This quintessential mind-body split may alter one's relation to corporeality, leading to psychological deficits, such as *depersonalization* and *derealization* or body neglect (Spiegel, 2018). Additionally, immersive perspective-taking risks in assuming an 'improper distance' (Chouliaraki, 2011; Nash, 2018) between the viewer and the outgroup member, in which one subordinates the other, incorporating their representation, rather than recognizing their irreducible alterity.

Critical theorists have long warned against an abstraction of human nature. Terms such as *reification*, *rationalization*, and *fetishism* describe the underlying condition of prejudice, where virtual, invisible properties get falsely attributed to a material being (Marx, 2015; Lukács, 2017; Silva, 2013; Horkheimer, 2004; Jütten, 2011; Ahmed, 2000). At the same time, the constituting role of the body in forming social cognition is highlighted across a variety of disciplines (Dewey, 1986; Merleau-Ponty, 2013; Gallagher, 2006; Malafouris, 2013). Yet, despite these intuitions and the inherent abstraction of virtual mediums, little attention has been given to robots as a tool for intergroup contact. Remotely controlled robots (telerobots) are a communication medium nonetheless, but they exist and interact with the physical world; we use our body to interact with robots as we would with a living being. Robots provide partial corporeal depth to mediated contact, setting a midpoint between online communication and an FtF meeting.

Robots can also occupy public spaces, transcending both physical borders set by governments and online borders set by IT corporations. They allow spontaneous and organic encounters to occur without authoritative regulation. Users of social media are typically exposed to like-minded people and consume biased news items that contribute to group polarization and an increase of prejudice (Del Vicario et al., 2016). By opening online intergroup contact to public spaces, this phenomenon known as 'echo chambers' can be mitigated. We consider the above advantages sufficient to propose the use of robots for intergroup contact.

For this first milestone, we review the research done so far in Human-Robot Interaction (HRI), hypothesizing on how different design decisions may influence the result of contact.

2.3 Telepresence and telerobots

Originally, the term *telepresence* was used by Marvin Minsky and Patrick Gunkel to describe a vision of a futuristic economy in which people perform manual, physical labor from remote locations (Minsky, 1980). Although the term is nowadays used to describe a human's presence in a virtual environment (Steuer, 1992), telepresence originally refers to the experience of being in a remote environment that is *real* and mediated by a physical sensing agent, that is, a *telerobot*. (Campanella, 2000; Kac, 2005). In phenomenological terms, the experience of operating a telerobot is named *re-embodiment* (Dolezal, 2009). Today's telerobots go beyond industrial use and are deployed in social care (Michaud et al., 2007), education (Tanaka et al., 2014), and interpersonal communication (Ogawa et al., 2011), utilizing the internet as the medium for tele-operation.

When a telerobot serves as a remote representation of a human operator, it is referred to as its *avatar*. The human operator could then be referred to as the *inhabiter* of that avatar. An avatar is an antonym for *agent*, a computer-controlled entity that acts autonomously without any human intervention. A telerobot is usually, however, *semi-autonomous*; its actions are predominantly decided by the human operator, but supported by machine-controlled algorithms. We believe such telerobots are particularly suitable to facilitate intergroup contact, as we outline in the following sections. A semi-autonomous telerobot is sometimes referred to as *surrogate* (Hughes, 2014; Nagendran et al., 2015), a combination of agent and avatar.

While intergroup contact may well take place against a simulated agent of the opposing group (Hasler et al., 2014), a quantitative meta-analysis in virtual environments shows that when the interlocutors are perceived as human-controlled avatars rather than agents, their social influence is increased (Fox et al., 2015). Therefore, in this article, we are limiting our scope to scenarios in which at least one of the group members is represented by a robotic avatar (or surrogate) and the other group member physically interacts with it. That excludes contexts in which the robot acts as a mediator between two physically co-located interaction partners (Hoffman et al., 2015; Shen et al., 2018), or a simulated agent as a proxy for a real human interaction partner, or when the telerobots are interacting with each other and not with humans.

2.4. A conceptual model for telepresence contact

Previous research on intergroup contact provides us with conceptual and computational tools that we can use to model the path from initial contact to the eventual reduction of prejudice toward the outgroup. The model suggested by Pettigrew (1998) outlines a longitudinal process of prejudice reduction: the ingroup member initially *decategorizes* the outgroup member from its group, then reduces prejudice from the general outgroup, and finally dissolves the border between ingroup and outgroup. Researchers have also formulated empirical models that predict and verify the link between common mediators such as anxiety and empathy, or moderators such as group salience to the outcome of the contact (Voci and Hewstone, 2003; Brown and Hewstone, 2005; Pagotto et al., 2010).

Based on these models, we suggest a new conceptual model for telepresence-based contact. Due to the presence of the telerobot, we add another stage on the path to prejudice reduction (see fig. 1). We hypothesize that an ingroup member first develops an attitude toward the robot before projecting it onto the outgroup human operator. The initial attitude toward the robot could be influenced by a previous general bias, or by characteristics of the particular robot. We then expect the perception of the robot as a representation of the operator's agency to be moderated by the degree of perceived *co-presence*. Initially formulated by Goffman as a measure of our awareness of another human being in our physical space (Goffman, 2008), the term is now used in literature to measure the feeling of "togetherness" in mediated communication, virtual (Söeffner and Nam, 2007; Casanueva and Blake, 2001; Bente et al., 2008), and physical (Hwang et al., 2008; Choi and Kwak, 2017). Co-presence differs from the term *social presence* insofar as social presence refers to people's perception of the medium as a social sphere, rather than their recognition of sharing a space with another (Bulu, 2012; Nowak, 2001). Finally, as previous research on intergroup contact suggests (Voci and Hewstone, 2003; Brown and Hewstone, 2005; Kenworthy et al., 2005), a generalized attitude toward the outgroup is moderated by the level of group salience apparent in the conversation.

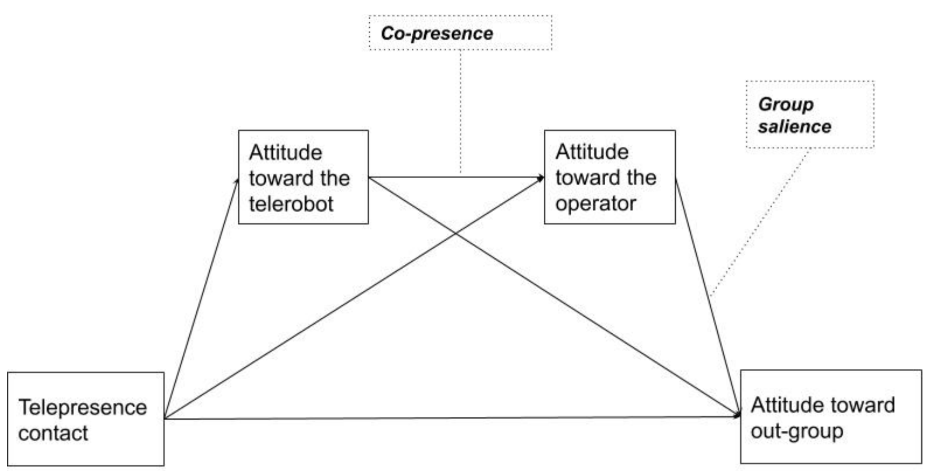

Figure 1: Telepresence Contact: Conceptual path model

2.5 Telepresence systems

A communication event that is mediated by telepresence robots could manifest in different architectures that we define as *telepresence systems*. Utilizing concepts from Paynter's generalized systems theory (Paynter, 1961; Hannaford, 2000), we discuss two types of interactions that occur in telepresence: *signal*, and *physical*. *Physical* refers to real word interactions between elements sharing a physical environment, such as a hand-shake or holding an object. *Signal* interactions occur on an abstract level. They represent a unidirectional logical flow of cause and effect; for example, text that is typed on one end of online communication and appears on the other end. Based on these concepts, we identify three different types of telepresence systems (see fig. 2):

1. *Asymmetric*: The most common type of telepresence communication. Participant A (operator) is represented by a telerobot and is operating it from a remote location using a computer or mobile device. Participant B (interlocutor) is co-located with the robot, interacting with it in a shared physical environment. The interaction experience of the operator is, therefore, qualitatively different from that of the interlocutor. Implementations of asymmetric systems include industrial robots, military robots, surgical robots, office work telepresence, and social service robots.

2. *Symmetric bidirectional*: Both participants are simultaneously interacting with a co-located robot and operating their remote telerobot. The operators do not see a dedicated control interface as they would in a computer-based interface. Instead, they interact with the robot of their partner, allowing it to capture their movements and transmit them to the telerobot representing them on the opposing end. This type of system is more challenging to implement, and only a few implementations exist as prototypes and proofs-of-concept (Nagendran et al., 2015).

3. *Symmetric unidirectional*: Both participants are operating a telerobot via a control interface, without any physical human-robot interaction taking place. The two robots are co-located with each other, while the participants are in separate spaces. Implementations of this system include cooperative multi-robot tasks (Sirouspour and Setoodeh, 2005) and *Robot combat* competitions (Clarkson and Foreword By-Dwyer, 2002). This system may facilitate contact in cooperative or confrontational events in front of an audience, such as a joint theatrical performance of two remote operators.

Although the *symmetric unidirectional* system has its own merits, we focus our discussion on the first two systems. We require that at least one participant physically interacts with a robot, exhibiting the corporeal depth of physical interactions is missing from online communication. In the following section, we provide an example scenario that illustrates the mechanics of the two relevant systems.

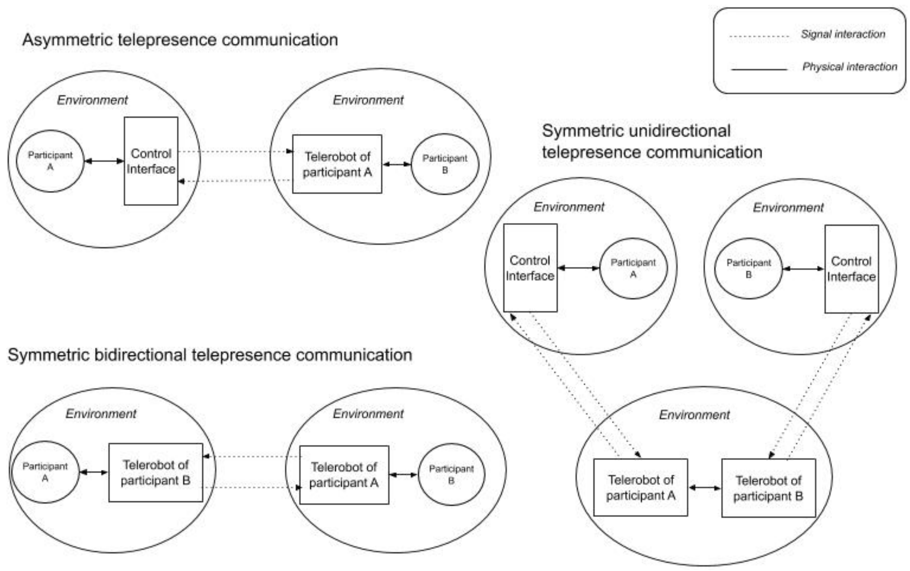

Figure 2: Systems of telepresence communication

2.6 The handshake paradigm

Handshakes are an important and common social gesture in most parts of the world (Schiffrin, 1974). It is a reciprocal action, beginning with one person reaching out in an open request and then reciprocated by the partner. It is a haptic gesture in which subtle variations in touch can have social significance (Hillewaert, 2016). To illustrate the difference between symmetric and asymmetric systems, we will use the handshake process as a benchmark.

Usually, in an asymmetric system, the telerobot is equipped with a camera that streams the robot's vision back to the operator. When the interaction partner reaches for a handshake, the operator will see this via the interface. The operator uses the control interface to reciprocate and have the robot reach out its hand. Movement is initiated with the push of a button in the most basic interface, or by moving a motion-tracking device or haptic glove in a more advanced one. Once the interaction partner touches the robot, the handshake is picked up via a pressure sensor on the robot's palm and is transmitted back to the control interface. The interlocutor is experiencing a real handshake, but for the operator, the touch could manifest in different modalities, for example: as a screen flicker, a sound effect, or as a vibration in a haptic glove.

In symmetric systems, both of the participants interact only with the telerobot in front of them. The handshake is initiated when one participant reaches their hand toward a robot. The gesture is picked up by a body tracker and causes the opposing robot to mirror the behavior of its operator and reach out its hand to the interaction partner on the other side. The partner reciprocates; at this moment, both robots have their hands reached out. When touch sensors on the robots detect that both participants are shaking their robot's hand, a squeezing actuation commences in both robots to generate the feeling of the handshake for both partners.

The following sections outline design considerations for telepresence robot design and architecture concerning their estimated influence on intergroup contact. They are summarized in Appendix A: Summary table. # 3. Equality in system architectures One of Allport's conditions for positive intergroup contact is having an equal status between group members, for example, colleagues in a workplace context (Allport, 1954). That condition, however, cannot be fulfilled when there are persistent power differences between groups; that is usually the case in long-lasting and deep-rooted conflicts (Maoz, 2011). To circumvent this issue, we can resort to equality only in the *situation* of an intergroup encounter. It was shown that having symmetry and equality in communication is beneficial for contact in groups that are in asymmetric conflicts, such as the Israeli-Palestinian conflict (Maoz, 2005).

Symmetric telepresence systems provide the hardware foundation for equality in contact situations as both participants face the same conditions. Asymmetric systems, however, produce an experience that is different in nature for both sides. The side that is operating the telerobot from a remote control interface is more aware of the interaction medium and may feel concealed behind it. Consequently, they may exhibit behaviors that characterize anonymous computer-mediated-communication (CMC). Research models have shown a varying effect of CMC on the outcome of intergroup contact and the reduction of prejudice (Walther et al., 2015). The *deindividuation* model warns that anonymity may release a person from social regulation and norms, leading to a negative effect on the conversation. SIDE theory (Spears et al., 2002) provides a contrasting view in which a depersonalized encounter increases group salience, as it motivates individuals to act under a group context while pronouncing enhanced norms and tropes. Models such as SIP (social information theory) and *hyperpersonal* communication (Walther, 1996) advocate that more intimate interpersonal relations may form in online contact because of the need for the participants to make up for the lack of non-verbal cues.

The side that is interacting with the robot, however, is less aware of mediation that is taking place and may experience strong senses of *agency* (I am the initiator of an act) and *ownership* (my body is that is moving) in the interaction with the robot (Gallagher, 2000; Cole et al., 2000). Therefore, behaviors may resemble more that of a direct encounter than online contact. CMC-related effects may still occur, corresponding with the level of co-presence. When the robot is perceived more like a medium rather than an avatar, the interlocutors would be more conscientious of their ability to manipulate their identity and presence.

This asymmetry in the participants' perception of the medium could be beneficial.

In one use-case between advantaged and disadvantaged groups, a disadvantaged-group member may operate a telerobot remotely from their home, while the advantaged-group member is interacting with it in a public space. This scenario is likely to reduce anxiety as the operator remains in their comfort zone and may get empowered by the ability to see through the robot's camera while not being seen by the interaction partner. That may not only lower the participation threshold in an intergroup contact project but may also encourage bringing up more difficult topics related to conflict during the conversation. However, such a reversed power asymmetry in robotic intergroup encounters could also disrupt the experience. In an initial test case conducted in an intercultural setting between minority and majority groups in Finland, participants felt uncomfortable with the asymmetry. One member of a minority group noted that they felt as if they were a government official investigating their exposed partners (Peled, 2019, p.132).

To summarize, asymmetric telepresence systems may have some benefits associated with CMC, but may also induce a sense of inequality in communication. Symmetric systems provide the foundation for equal grounds, leaving it up to further design choices to maintain this balance. In the following section, we turn to design factors that are likely to influence the process and outcome of robotic telepresence contact in an intergroup context.

4. Telerobot design considerations for intergroup contact

4.1 The use of a 2D display and the dual-ecologies problem

The telepresence robot market is rapidly growing, and is predicted to accelerate even more in the upcoming years due to increased demand for advanced technological solutions to support remote working and social services [1]. Telerobot forms are continuously branching into new directions, but the dominant form remains that of a tablet device attached to a motor vehicle (Kristoffersson et al., 2013) (See fig. 3). The tablet typically displays the operator's head, as in a video call. Examples from market leaders include *Double Robotics* [2], *Mantaro* [3] and Revolve Robotics [4]. Such telepresence robots are geared toward remote offices and public service environments, such as hospitals or schools.

There is a fundamental issue with the use of a 2D display on a telepresence robot. It was described as the *dual ecologies problem* by Choi and Kwak (Choi and Kwak, 2016). In their study, the perceived presence of a user in a tablet-based

[1] https://www.marketwatch.com/press-release/telepresence-robots-market-size-2020-to-showing-impressive-growth-by-2024-industry-trends-share-size-top-key-players-analysis-and-forecast-research-2020-04-20
[2] https://www.doublerobotics.com/
[3] http://www.mantarobot.com/products/teleme-2/index.htm
[4] https://telepresencerobots.com/robots/kubi

Figure 3: The *Double Robotics* Double 3 telerobot

video call was higher when it was disembodied (tablet only) than when it was attached to a wheeled robotic body. The authors explain this by referring to the different ecologies present in the same robot; One is a 2D projection of the remote location, and another is the physical presence of the robotic body in a shared space. They suggest that the receiver of communication experiences confusion, having to interact simultaneously with the immediate environment, and with the depiction of the remote environment.

Our initial test showed similar results: the use of a display on the body of the telerobot was disruptive to the participants' perceived sense of co-presence. Participants reported reverting to the experience of using a phone-like device while they were interacting with the display, despite having to touch the robot to initiate actions in the virtual interface (Peled, 2019, p.127).

Back projection solutions such as those of *Furhat Robotics* [5] attempt to solve this incongruence by projecting 3d-mapped virtual information directly onto the robot's surface. While this may moderate the negative effects of the display, it does not entirely address the dual ecologies problem of having two different spatial sources combined into one. We, therefore, recommend the use of a display to be planned carefully for intergroup contact. Preferably, the appearance of the robot could be designed without an external display, maintaining uniformity and consistency.

4.2 Visual appearance and dehumanization

The effect of a robot's appearance on a human's attitude toward it has been studied extensively in the literature, predominantly in studies of Human-Robot Interaction (HRI) and social robotics (Hancock et al., 2011). A pivotal discussion revolves around the question of *anthropomorphism*: the degree in which a robot's appearance and behavior resemble that of a human. Current literature paints

[5] https://furhatrobotics.com/

a picture that is manifold (Fink, 2012); While anthropomorphic features may increase a human's empathy toward and acceptance of the robot, the effect is context and culturally-dependent. In some cases, people prefer a zoomorphic (animal-shaped) appearance or a caricature style over a human form, particularly in the realms of child therapy and elderly care (Aucouturier et al., 2008; Lorenz et al., 2016). Human-like robots may also raise negative emotions when they appear eerily human but are yet noticeably non-human, widely referred to as the theory of the *Uncanny valley* (Mori et al., 2012). Telepresence robots from Ishiguro's laboratory are known for their bold exploration of the uncanny valley see 4, (Becker-Asano et al., 2010; Ogawa et al., 2011).

Additionally, research by Groom et al. (2009) suggests that robot operators have a greater sense of *self-extension* (Belk, 1988) to their avatar when it is non-human. They explain the findings by the fact that a humanoid robot assumes its own identity, making it harder for the operators to project themselves onto the robot. Operators that treat their avatar as an extension of themselves are likely to portray a personality that is closer to their own and to be more emotionally involved in the conversation (Kiesler and Kiesler, 2005).

Despite the apparent advantages of a non-anthropomorphic appearance, telepresence-based contact adds another dimension to the equation since the attitude formed toward the telerobot is projecting onto its human operator. Non-anthropomorphism now introduces the risk of dehumanization. The act of seeing an outgroup member as non-human or less than human is both a marker and a driver for intergroup-conflict (Haslam, 2006; Kteily et al., 2016). Specifically, individuals involved in intergroup conflict tend to view the outgroup as either animal-like or mechanistic automata, both common forms for robots. Current research does not yet deal with the effects of avatar anthropomorphism on intergroup conflict. Nevertheless, a study on video games points out that people find it easier to make immoral decisions toward non-human avatars (Lin, 2011). Additionally, the distance formed by CMC increased dehumanization in decision making (Lee et al., 2015b).

When using a zoomorphic, mechanistic, or caricaturistic appearance, one should take measures to mitigate dehumanization. Encouraging the display of secondary human emotions such as affection and admiration may help group participants to humanize one another (Leyens et al., 2000). Such could rise as a result of self-disclosure in the conversation (Kashian et al., 2017), or by discussing an unrelated case of group suffering (Gubler et al., 2015). Additionally, the use of visual, auditory, and intellectual cues that remind the interlocutors of the human operator could mitigate the effect of a non-anthropomorphic avatar.

As noted earlier, forming a positive or negative attitude toward a robotic avatar does not necessarily imply that it would transfer on to the human operator. When a telerobot is perceived more as a medium and less as an avatar (i.e., a low level of co-presence), the attitude will likely form toward the medium and not toward the group member. Findings indicate that the level of co-presence is itself moderated by the level of anthropomorphism. Research by Kuwamura et al. (Kuwamura et al., 2012) found that the interlocutors experienced distortion of their partner's personality when it conveyed through a non-human entity. For instance, compared to a humanoid telerobot, participants interacting with a stuffed-bear felt confused and had difficulty imagining that they were talking to a human.

tbl. 1 provides a summary of the above factors that correlate with anthropomorphism. We hypothesize that negative effects may be balanced or mitigated by adding external cues and explanations. For example, we could place visual cues that remind the interlocutor of the human inhabiting the avatar. We expand more on this in the section regarding group salience. Appearance choice should always be context-dependent and culturally sensitive to the situation at hand. As a general rule, a softer (discussed in the section on materiality), non-threatening, and equal appearance (for example, equal height, as noted by Lee et al.(2015a)) is favorable for intergroup contact.

Table 1: Anthropomorphism: summary table.

Level of anthropomorphism	Risk of the uncanny valley	Risk of dehumanization	Operator's sense of self-extension	Interlocutor's sense of co-presence
Low	Low	High	High	Low
High	High	Low	Low	High

Figure 4: From left to right: Telenoid, Elfoid, Hugvie by Ishiguro labs. Retrieved from http://www.geminoid.jp/en/robots.html

Figure 5: Geminoid and Professor Hisroshi Ishiguro. Retreived from http://www.geminoid.jp/projects/kibans/resources.html

4.3 Voice

In a telepresence robot-based contact, an operator may choose to use their voice or a synthetic voice that does not disclose their personality, gender, and culture. They may also use a synthetically cloned voice that is highly similar to their natural voice (Jia et al., 2019). A synthetic voice adds modalities for speech augmentation and language translation, as we discuss in the section regarding interaction modalities.

Research about the effect of an avatar's voice on user attitude shows that as with visual appearance, one must strike a balance between relatedness and consistency. Lee and Nass studied the sense of social presence of e-commerce agents with machine-generated voices (Lee and Nass, 2005) concerning their personality (introvert or extrovert). When the voice personality of an agent is closer to that of the interlocutor, the perceived sense of social presence increased. However, the consistency of the voice with its personality is essential. Social presence drops if a voice's style is incongruent with its textual character. Another study by Mitchel et al. (Mitchell et al., 2011) found that a mismatch between the voice and face of a talking head generated an uncanny sensation. A human with a synthetic voice felt as uncanny as a robot with a human voice. Therefore, an optimal voice would be one that takes the telepresent human into account, without diverging abruptly the physical form of the avatar.

4.4 Materiality

The choice of materials has considerable implications for robot design. In industrial robots, materials are chosen *functionally*, following the task at hand. In robots designated for human interaction, rather than materials, we examine *materiality*. Conceptualized by Hayle, materiality is "physical qualities that present themselves to us" (Hayles, 2014, p.72). Materiality is exhibited through two main aspects of a robot's constitution: 1) The outer skin: the part of the robot that touches and is touched, and 2) Actuation: the material that actuates, generating the robot's movements. With the former, we place materials on a scale of firmness and rigidness; how soft they feel to the touch. With the latter, we define materials on a scale of flexibility and linearity that describes the nature of the material's movement.

Previous research in social robotics supports the use of soft materials for the outer skin of robots, especially in interaction with children (Kozima and Nakagawa, 2006) and in elderly care (Broekens et al., 2009; Kidd et al., 2006). Soft materials contribute to a sense of *affective touch* between the robot and humans (Kerruish, 2017; Stiehl et al., 2005). The human body and other natural forms are inherently soft, favoring co-existence with other soft materials (Danese, 2003). However, carrying an object closer to the realm of the living risks invoking an uncanny feeling as with an anthropomorphic appearance. For example, touching a smooth, soft, material that is also cold evokes the uncanny (Willemse et al., 2017; Nie et al., 2012).

A soft touch on the surface doesn't necessarily imply a softness as a whole. For example, a gripping robotic hand made from powerful servo motors wrapped in a soft skin could still easily, and inadvertently, crush soft tissue. *Soft Robotics* is a rapidly developing research field for robots that operate on soft materials down the level of actuation (Bao et al., 2018). Commonly used materials are fabrics and silicone rubbers, while the most typical form of actuation is pneumatic: applying air pressure or vacuum. Presently, the largest consumers of soft robotics are the medical industry, utilizing the soft materials for invasive and surgical procedures. The use of soft robots for human interaction is nonetheless actively researched and has so far exhibited positive results (Bewley and Boer, 2018; Jørgensen, 2018; Walker, 2019). In our test of soft robotic telepresence, we have reached similarly promising conclusions (Peled, 2019).

Designers using soft robotics for interaction should take special note to some idiosyncratic features of soft actuators. Due to the highly organic style of soft-robotic actuation, the risk of falling into the uncanny valley is increasing as the robot moves like a living creature. Additionally, pneumatic soft robots are often tethered (connected by a cable), which restricts their ability to move around the space (Rich et al., 2018). Nevertheless, a soft approach deems viable for telepresence contact. Soft movement and touch may increase empathy and intimacy between the participants, resulting in a more positive evaluation of the group they represent. Softness also instills a notion of safety; an inability to cause harm. That is a desirable climate in situations of intergroup conflict.

4.5 Designing with group salience in mind

The process of forming a generalized opinion toward the outgroup does not end at the interpersonal level. The most widely agreed-upon moderator for generalizing a positive attitude to the intergroup level is *group salience* (Kenworthy et al., 2005). Accordingly, when participants are aware of their interaction partner's group membership and if the interaction partner is regarded as a (typical) representative of his or her group, positive effects of the interpersonal encounter are more likely to generalize to the outgroup as a whole. One approach, suggested by Pettigrew (1998), is to expose group identities gradually, starting with a low salience, allowing initial contact to form, and increasing it over time as the interaction partners establish an interpersonal relationship.

Group identity can be transmitted through a variety of channels in robotic telepresence, beginning with the design of the avatar; its appearance, voice, and its surroundings, and proceeding into the content of the interaction. A robotic avatar may have a non-humanoid appearance, but still maintain group identity through group symbols, cues, and language. It may speak in a group-specific language or accent, wear typical accessories or flaunt national colors. The freedom to use material objects brings up new design possibilities that are not available in an online encounter. Group cues may be positioned in subtle ways to be gradually revealed by the interlocutor. If the initial appearance and behavior of the robot are engaging enough, an interpersonal bond may form despite the presence of group-related cues.

4.6 Avatar co-design

The ability to customize an avatar is widespread in video games, virtual reality, and social media applications. It improves engagement with the platform (Ng and Lindgren, 2013) and has consequences on the social behavior of the user. According to studies of *self-extension* in the digital world (Belk, 2013; Messinger et al., 2019) and of the phenomenon known as the *proteus effect* (Yee et al., 2009), users tend to have increased self-confidence and behave more extroverted when they perceive their avatar as more attractive. The impact of self-extension to avatars may be so strong that the changes in behavior remain after even usage.

In robotics, customizing an avatar is a more complex task than in a virtual environment. Design options are constrained by the hardware platform of the robot, requiring co-design between the robot engineers and the user. Assembling the robot takes physical effort and requires basic knowledge in mechatronics. Nevertheless, involving users in the design and assembly process of their robotic avatar may have benefits. Groom et al. showed that operators had a greater sense of self-extension to a robot that was assembled by them, rather than by another (Groom et al., 2009). Robots were also successfully co-designed with children as the target users. The YOLO robot focused on creativity and storytelling, allowing children to design behaviors and movements (Alves-Oliveira et al., 2017), while the PAL involved children in designs for diabetes self-management (Henkemans et al., 2016). Co-design methods also improved the general attitude of students toward robots in educational settings (Reich-Stiebert et al., 2019).

In the context of intergroup contact, and especially in situations of conflict, co-designing avatars may have even greater virtues. Participants could control their representation and its behavior, considering how they wish to be seen by the other side; thus, supporting 'controlled' means for escalation and de-escalation that has been found beneficial in other media-based intergroup contact projects (Zancanaro et al., 2012). The assembly work in itself may be therapeutic, both as tactile experience (Sholt and Gavron, 2006) and as a self-expressive art form (Muri, 2007). Finally, a participatory approach for robot-building has the potential to empower oppressed groups and minorities by providing meaningful education in modern communication technologies. # 5. Interaction modalities In this section we explore possible affordances (Gibson, 1966, p.285) in telerobot design, and theorize over different modalities (Kress, 2009), modes for interaction, that may assist in intergroup contact, and consider implementation detail.

5.1 Movement in space

The ability to move a body in space distinguishes robots from other interactive technologies. However, not all robots have the same degrees of freedom and granularity when it comes to movement. In the field of social robots,*mobile robots* typically travel around using wheeled motion. Examples include service robots, such as Pepper[6] and Samsung bots[7], and telepresence robots such as Double Robotics[8] and Beam[9]. Other robots only move their body while remaining stationary in place; for example, care robots such as PARO [10], and telepresence robots from Ishiguru laboratories [11]. Due to the complexity of maintaining both modalities in interaction, mobile robots often keep a physical distance from the user, interacting using voice and visuals they travel around the space. Stationary robots, on the other hand, tend to rely more on haptic interaction, allowing the user to hold and touch them. Only a few robots attempt to combine both modalities, such as Teo (Bonarini et al., 2016).

Touch-based human-robot interactions have an affective value (Andreasson et al., 2018; Kerruish, 2017) that may benefit intergroup contact and should hold a high priority in the design process. Furthermore, in the case of symmetric telepresence, moving around is in itself limited since the operator does not have a dedicated control interface for traveling, and movement relies only on body tracking. In asymmetric systems, camera navigation is possible but may still divert the attention of the operator from the primary task at hand, which is maintaining intimate interpersonal interactions.

Movement in space may nonetheless prove beneficial in intergroup conflict scenarios when groups are not allowed to travel to the opposing group's location. In such cases, there is a political value in the ability to move around a forbidden area. Moreover, in asymmetric conflicts where the oppressed group suffers from tight movement restrictions in their day-to-day life, as is the situation in Palestine (Brown, 2004), an operator may feel empowered by having the ability to travel with their avatar. That, in turn, may contribute to a greater sense of equality and confidence within the conversation.

5.2 Nonverbal communication and emotional expression

Nonverbal communication (NVC) signals such as facial expressions, eye gaze, and bodily gestures play a substantial role in our day-to-day interactions. In telepresence-based contact, those signals need to be accurately picked up from the operator and portrayed using the telerobot's body without losing or changing their meaning.

In a pioneering work by Argyle (Argyle, 2013), nonverbal signals were enumerated and categorized according to their level of awareness. The majority of them, as defined by Argyle, are *mostly unaware* on the part of the sender and *mostly aware* on the receiver side (Argyle, 2013, p. 5). For example, we are seldom

[6] https://www.softbankrobotics.com/emea/en/pepper
[7] https://research.samsung.com/robot
[8] https://www.doublerobotics.com/
[9] https://suitabletech.com/
[10] http://www.parorobots.com/
[11] http://www.geminoid.jp/en/robots.html

aware that we are smiling during a conversation, but the sentiment is registered much more attentively with our conversation partner.

Since NVCs communicate emotion, we should handle them with great care in telepresence contact. Unaware emotional signals from the operator can be detected using facial recognition, prosodics, and body tracking, but modern deep learning systems are still subjected to noise and errors, and can only recognize generic emotions (Zhang et al., 2016; Hossain and Muhammad, 2019). A mistake in communicating an emotional state could lead to confusion and frustration in the conversation. Therefore, it may be safer to rely strictly on explicit gestures made by the operator with full awareness. Expression of emotions in an asymmetric system could be invoked by the operator using emojis (Kaye et al., 2017) or other dedicated buttons that activate an emotional gesture in the robot. In body-tracking systems, explicit body gestures could be used (such as a thumbs-up, or a sign-language symbol), or touch-based interactions, such as a pat or a stroke on the robot's body, a high-five, or a hug.

Even if body signals are accurately detected, their meaning is not guaranteed to preserve across cultures. Gestures require active translation (Hasler et al., 2017), and facial expressions are no longer regarded as universal [jackFacialExpressionsEmotion2012]. The problem further exacerbates when opting for a non-anthropomorphic avatar that does not have eyebrows and is not capable of granular gaze motion as in the humanoid SEER robot (Todo, 2018).

A possible solution could be to use the *flow* and *rhythm* of body movements to express emotions instead of explicitly formed gestures (Hoffman and Ju, 2014). Dance is suggested to be cross-culturally universal (Sievers et al., 2013), and much of our emotional states are expressed through the body rather than facial expressions (Aviezer et al., 2012). Successful attempts that use movement as a mechanism for expression in robots have made use of existing frameworks and tools, including Laban's movement analysis (LMA) [Laban and Ullmann (1971);shafirEmotionRegulationMovement2016] in [Nakata et al. (1998);Masuda and Kato (2010) and the PAD emotional state model (Mehrabian and Russell, 1974) in (Ardila et al., 2019; Noguchi and Tanaka, 2020).

Some signals, such as shifts in gaze and body orientation, are completely unaware-of during the conversation, yet they have an impact on turn-taking and attention signaling (Kendon, 1990; Richardson et al., 2009). A smooth turn-taking flow can promote the sense of equality in contact, and it was demonstrated to benefit human-robot interaction (Vázquez et al., 2017; Lala et al., 2019). Turn-taking signals cannot be explicitly pronounced by the operator, without impairing the flow of the conversation. Instead, they should be a part of the robot's semi-autonomous functionality. In symmetric systems, end-of-turn could be predicted using several tracking modalities (de Kok and Heylen, 2009), while an asymmetric interface can infer the end-of-turn using typing and clicking indicators.

5.3 Verbal communication

Language, as defined by critical theorist Jürgen Habermas, is the medium through which we acquire a fundamental mutual-understanding between individuals (1984). While its use may cause both de-escalation and escalation of the conflict, it is often the only tool available to convey layered and abstract information. In the CMC world, we may also use language in creative ways to make up for the lack of embodied interaction and nonverbal modalities (Keating, 2017).

The outstanding benefit of mediated verbal interaction for intergroup contact is the capacity to translate between different languages and dialects in real-time (Amichai-Hamburger, 2012). Often groups in conflict do not speak a common language and are required to speak in a third language in the language of the advantaged/majority group. This situation forms an obstacle to achieving equality in contact. Language translation may reinforce equality in communication, as all participants can express themselves in their native language. Machine translation, however, may also be destructive to cultural and political nuances (Lehman-Wilzig, 2000; Cronin, 2012), and contemporary deep-learning translators exhibit stylistic and gender bias based on their training datasets (Hovy et al., 2020; Stanovsky et al., 2019). The loss of cultural context during translation can be especially harmful in conflict resolution (Cohen, 2001), and new deep learning models are required for this task. On example is Timo Honkella's "peace machine" (Honkela, 2017; Koulu and Kontiainen, 2019), which focuses on preserving cultural-dependent meanings within a translation.

While no data exist on current implications of machine translation during intergroup contact, human translators and interpreters often suffer from a lack of trust by the participants who fear of bias and misinterpretation (Monzó-Nebot, 2019); a machine translator may enfold similar risks. In our initial test for automatic language translation in contact between minority and majority groups in Finland, participants enjoyed their newly acquired ability to speak to one another in their language, but have raised concerns about being misrepresented by the machine (Peled, 2019).

Some mitigating steps could be taken to improve the experience of the participants. First, when using speech recognition, feedback of the result in the operator's native tongue should be provided, perhaps at the cost of delaying the flow of conversation. Second, when possible, the interface should display the confidence level of the translation before it gets sent to the other side. Finally, in case a mistake was realized by the operator only after submitting, there can be a quick "oops'' button that has the robot express an apologizing gesture. If used according to those principles of design and interaction, real-time language translation could be an important facilitator for telepresence intergroup contact.

5.4 Synchrony, reciprocity and feedback

Synchrony and reciprocity facilitate interpersonal sympathy and empathy across all communication modalities (Bernieri and Rosenthal, 1991; Burgoon et al., 1993;

Sevdalis and Keller, 2011). The process is also referred to as "social entrainment" (Phillips-Silver et al., 2010; Stupacher et al., 2017). It includes interactions such as rhythmic movements (e.g., clapping, jumping), a smooth conversation beat, synchronized dance, give-and-receive interactions, gaze synchrony, affective matching, and mimicry. Positive effects are also observed in human-robot interaction scenarios, particularly in cases of care and therapy robots for children and the elderly (Aucouturier et al., 2008; Lorenz et al., 2016).

Achieving interpersonal synchrony over mediated communication stumbles upon the problem of *latency* (Campbell, 2015). The unavoidable time delay due to physical distance between the participants can instill confusion and frustration when performing rhythmic and simultaneous tasks. Research in the field of online music performance is at the forefront of tackling such issues (Oda, 2017) and can be used as an inspiration. Semi-autonomous methods in the likes of action prediction, lag compensation, and global metronomes enable musicians to collaborate in jam sessions from different locations around the globe. The same methods can assist in synchronizing robot-mediated activities. In symmetric systems, the participants would be coordinating the same action, for example, clapping. In asymmetric systems, one participant would use a control interface, for example, by tapping or shaking a mobile phone, while another would act in front of the telerobot.

Some reciprocal actions do not require real-time synchrony between the participants and could be implemented easily. For example, the above mentioned hand-shake example and other similar gestures such as a "high five" could be performed in a turn-based flow, where one participant reaches out first, and then the other reciprocates. Such actions may not have the same valence as real-time synchronization, but could still benefit the conversation due to their reciprocal nature. Additionally, people tend to be forgiving toward the sluggishness of robots, which may lower the sense of awkwardness that might occur during the use of reciprocal actions in an FtF encounter.

In asymmetric systems where the robot's operator is using a control interface, having instant feedback to the control actions provides a sense of reciprocity with the control medium and can increase perceived agency and ownership within the operator (Dolezal, 2009). At the high-end of the spectrum, advanced control systems, such as the ones for 'Robonauts' at the Johnson Space Center (Cole et al., 2000), mix Virtual Reality and haptic feedback. As a bare minimum, an operator should have visual feedback on how the robot acts in response to control commands.

In our initial experiment, participants expressed concern over their inability to see the facial expressions they were invoking with the robot, or their avatar's arm when it was being touched (Peled, 2019). When designing an asymmetric control interface, it is necessary to provide maximum visibility of the telerobot's body to the operator. If one camera is not enough, multiple camera angles could be utilized. Additionally, placing mirrors on-site could allow the operators to examine their re-embodied appearance. Finally, practicing the use of the telerobot ahead of the encounter could help operators to get comfortable with the new interface without the pressure of the ensuing intergroup contact.

6. Peacebuilding scenarios

6.1 Public space interventions

Robotic avatars are an excellent communication tool for organized intergroup encounters where participants are unable to meet face-to-face. However, the physical presence of telerobots makes them exceptionally suitable for public space interventions. Robots can transcend national borders and roam public spaces, having the potential to reach crowds that wouldn't normally engage in intergroup contact. In symmetric systems, robots could be placed in public urban areas on both sides and wait for passersby to initiate contact. In asymmetric systems, only one robot would be placed out in the open, while operators would inhabit the avatar from their home or a dedicated control spot.

One might consider whether the group identity of the telerobot's operator should be widely exposed to passersby, allowing them to make a voluntary decision to make contact, or whether they would first approach the robot and only realize its group identity during the conversation. A meta-analysis by Pettigrew et al. (Pettigrew et al., 2011) concluded that in contacts that had a negative outcome, it was worse when initiated involuntarily. However, when the group identity is known, members may avoid interaction (Wessel, 2009), which results in a self-selection bias in organized interventions between groups (Maoz, 2011). A balanced approach may work well here: Some cues could be exposed, providing only hints about the telerobot's identity, allowing passersby to approach an intergroup encounter voluntarily.

A robot that emerges in the middle of public space might be intriguing enough for some people to approach, particularly for those who generally have positive attitudes towards robots. One method to get even more public interest would be to equip the telerobot with some actions designed to draw a crowd. For example, play a sound, a musical theme, or perform an inviting gesture. In an asymmetric system, an operator has more control over the robot's interaction with the environment. They may look around by moving a camera, or even drive around using wheeled motion. When planning a public space intervention, the designated site and its demographics should be considered along with the design of the robot and interaction content. Tailoring the contact experience to its local context may increase the likelihood of public engagement and improve the outcome of the encounter.

6.2 Interaction content

The formed conversation between the participants can flow spontaneously, or it can be guided using the robot's semi-autonomous functions. Modern types of interaction may include cooperative games and simulations that engage the participant toward a common goal, in-line with the principles set by Allport. Games have shown potential for peacebuilding in face-to-face meetings (Brynen and Milante, 2013) and online contact (Hasler and Amichai-Hamburger, 2013). When interacting with a robot, its body parts may be appropriated as game-controllers, for example, by squeezing the arms of the robot; Thus, indirectly forming touch interactions between the participants. When integrating interactive visuals, it is necessary to embed a 2D display within the telerobot or place one beside it. In such cases, the interface design should carefully manage the attention of the user to avoid the dual ecologies problem.

Traditional forms of conflict resolution can also benefit from robotic interaction. If used as a mediator, a transformative approach to conflict mediation emphasizes recognition and empowerment rather than problem-solving (Bush and Folger, 2004). The robot may encourage the participants to express themselves freely and make sure that everyone has a right to be heard. Active mediation, however, may also bear a cost, as the robot may be perceived more like a middle-agent rather than an avatar, reducing the sense of co-presence within the participants. Mediating functions should then be implemented as transparently and seamlessly as possible.

While we advocate for equality in communication, this does not mean that existing power relations should be ignored during contact. A confrontational contact model that “emphasizes the conflict and power relations between the sides” (Maoz, 2011, p.119), although riskier, produces higher perceived equality within the contact (Maoz, 2011). Furthermore, equality emerges when the interaction focuses on fulfilling the different needs of the group members. While an advantaged group member needs to feel morally accepted, a disadvantaged group strives for a sense of empowerment (Shnabel and Nadler, 2008).

At the forefront of technological conflict mediation, machine learning is being sought as a tool for peacebuilding that can understand complex sentiments and situations (Honkela, 2017), predict conflict escalation before it occurs (Perry, 2013), and offer help to resolve issues (Sycara, 1993). As noted earlier, machine learning tools should always be used with caution and awareness of their training environment.

6. Discussion

This article sets a theoretical scaffold for the use of robots in intergroup contact on which empirical studies could be based upon, and more focused theories could be articulated. The range of possibilities for interaction is broad, and only meticulous field testing would narrow it down. Toward any organized attempt for intergroup contact, one should always consider the broader context, the long-term effects, and the ethics of research. That is especially true in the context of violent, asymmetric conflicts, where one group is a dominant majority, and another is an oppressed minority; even more so, when technology is involved, along with its inherent biases and connotations of power. A common concern is that the act of leveling the play-field, treating both groups as equals, will dissolve the real-world injustices and reduce the motivation for social change (Saguy et al., 2009; Hewstone, 2009). That is reflected in the Israeli-Palestinian setting by the “Anti-Normalization” movement (Salem, 2005). The movement rejects attempts for normalizing relations between Israel and Palestine that are not predated by an overall restoration of justice in the area.

We have suggested some ways to tackle this concern by recognizing power relations and injustices from within the system architecture, the design of the telerobot, and the content of interactions. Additionally, the practice of co-design can increase the involvement of minority groups in the process, disseminate technological knowledge, and reduce the notion of a higher power from above that restores peace without perceiving the situation and its nuances. Finally, complete transparency should accompany any attempt to insert technology into a conflicted scenario. That includes disclosing any source of funding for resources, the identity of the platform designers, and the location and maintainers of the internet servers in-use. Teleoperation software and hardware must be open-sourced to their entirety, and training sets for any machine learning models used should be disclosed, opting for open-source datasets instead of data owned by commercial companies.

The guidelines presented here, while being tailored for use in intergroup conflict scenarios, may also apply to other contexts of robot-mediated communication. Our design considerations focus on empathy, equality, understanding, and mutual respect, essential values in any human-to-human interaction. In an era where communication is becoming increasingly remote, robots present an opportunity to bring back material and tangible aspects to our communications. We are excited to further evaluate the use of telepresence robots as a means of conflict resolution and as a positive social tool in our daily lives.

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