The Telerobot Contact Hypothesis*

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1 Introduction

In evaluating the current state of human rights and ecological sustainability, the bright future promised by globalization and technological advancement has, so far, underperformed. On the one hand, an exponentially growing realization of the earth's finite resources [83] meets the human race's seemingly inept ability to navigate the market to morally favorable prospects [150]. On the other hand, the prospect of a globally connected society has done little to alleviate hate, prejudice, and conflict between conflicting groups and nations. In some cases, the internet has even become a petri dish for disseminating prejudice and violence [41, 67, 130, 144]. At the same time, we are dealing with the global COVID-19 pandemic, which provided a blatant reminder of both the perils and importance of physical closeness, and our reliance on technology to bridge over physical gaps.

This research investigates how communication technology could provide a more grounded and physical experience when face-to-face encounters are not possible. Particularly, we look for technology as a means for reconciliation and peacebuilding between groups in conflict that are plagued by a history of prejudice and racialized narratives. Building on the proven principles of the *intergroup contact hypothesis*, outlined by Gordon Allport in the 1954 seminal work *The Nature of Prejudice* [**(year?)**], we explore *telerobotics* (remotely operated robots) as a new medium that has the potential to facilitate positive intergroup contact. We hypothesize that if designed equally, openly, and with cultural sensitivity, the physical presence of robots as a communication tool could address the *intercorporeal lack* that is in virtual mediums[117]. Telerobots could maintain the openness and accessibility of virtual spaces such as VR and Social Networking Services, but alleviate dissociations and confusions enacted by the dismissal of the body [30, 121, 145]. A more grounded interaction could also counteract tendencies for abstraction and reification of the other [1, 46, 127] and to engage with the corporeality of identity [61]. Finally, by bringing online communication *Down to Earth* [84] we make sure to not forget the importance of the environment that supports it.

We have previously established the potentialities of telerobot-based contact and suggested basic guidelines and possible pitfalls [105]. In this article, we expound on this notion with a more comprehensive literature review and expand or conceptual model for full *telerobot contact hypothesis*.

2 Taxonomy: telepresence, telerobots, and avatars

Telerobots are often referred to as *telepresence robots*. 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 [91]. While *teleoperation* describes the broad action of remotely operating a robot, telepresence refers to the immersive experience of being in a remote environment, mediated by a physical sensing agent, that is, a *telerobot*[32, 70, 124]. In phenomenology the term *re-embodiment* is also used to describe the experience of telepresence [42]. Today's telerobots go beyond industrial use and are deployed in social care [90], education [134], and interpersonal communication [101], utilizing the internet as the medium for teleoperation.

When describing a telerobot serves as a remote representation of a human operator, it is often 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. A semi-autonomous telerobot is sometimes referred to as *surrogate* [63, 94], a combination of agent and avatar. While intergroup contact may as well take place against, or supported by, a fully simulated agent [53, 59, 69, 116, 123], here we focus our attention on scenarios in which at least one of the group members is represented by a robotic avatar, which was shown to increase social influence [43].

3 Conceptual model

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 [108] 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 [26, 102, 140].

Based on these examples, we suggest a path model for telerobot-based contact (see fig. 1) which includes the stages of projecting the telerobot interaction to the interpersonal and then projecting the interpersonal to the intergroup. The path depends on the type of experience - interaction with a telerobot or operation of a telerobot. In the case of interaction, we hypothesize the attitude toward the outgroup member will 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 [48], the term is now used in similar fashion for virtual [17, 35, 128], and physical [37, 64] environments. Co-presence was found to mediate positive attitude and intimacy in social networks [2].

When operating a telerobot we are looking for a close and long-lasting social link between the operator and its robotic avatar. Several models are used in the literature to describe these phenomenon, including: Belk's *extended self* [16], the *proteus effect* [147], *parasociality* [66], and *self-presence* [14]. Self-presence entails engagement and a lasting social effect and was shown to mediate intergroup friendship, we therefore chose it as a moderator. However, it was not found to be a sufficient moderator for improving the broad attitude toward the outgroup [6, 15].

Indeed, the final stage of outgroup generalization and reduction of prejudice proves to be the most elusive. Many factors have shown mixed results in online and VR contact studies, but significant evidence suggests that outgroup group salience (the presence of cues suggesting the outgroup member's group affiliation) is important [27**?** , **(author?)** [34]]. Another model suggested by Gaertner and Dovido is the *common ingroup identity model*[44]. According to this model, priming the participants with the fact that they belong under a common superordinate group helps reduce intergroup bias. However, recent attempts to achieve this effect in VR have either failed to create the common ingroup [5, 6] or have shown that it has no significant effect[106], indicating that the model may need to be revised in computer-mediated contact.

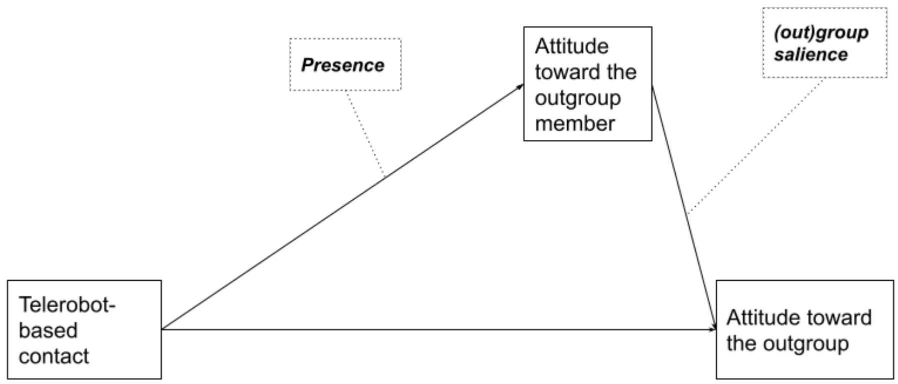

Figure 1: Telepresence Contact: Conceptual model

The following sections present our hypotheses for telerobot and interaction design . We look into questions of robot appearance, functionality, interaction modalities and peacebuilding scenarios.

4 Design hypotheses

4.1 System architecture

A communication event that is mediated by telerobots could manifest in one of three different architectures that we identified as *telerobot systems*: asymmetric, symmetric bidirectional, and symmetric unidirectional [105]. Fig. 2 illustrates the three types Utilizing concepts from Paynter's generalized systems theory [51, 103], we describe two types of interactions: *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.

Although the *symmetric unidirectional* system has its own merits, in our hypothesis we assume that that at least one participant is physically interacting with a robot, therefore we focus on the first two systems.

Due to their nature, symmetric telerobot systems provide the hardware foundation for equality - one of Allport's conditions for positive intergroup contact. Equality in communication was also shown to promote peacebuilding in the

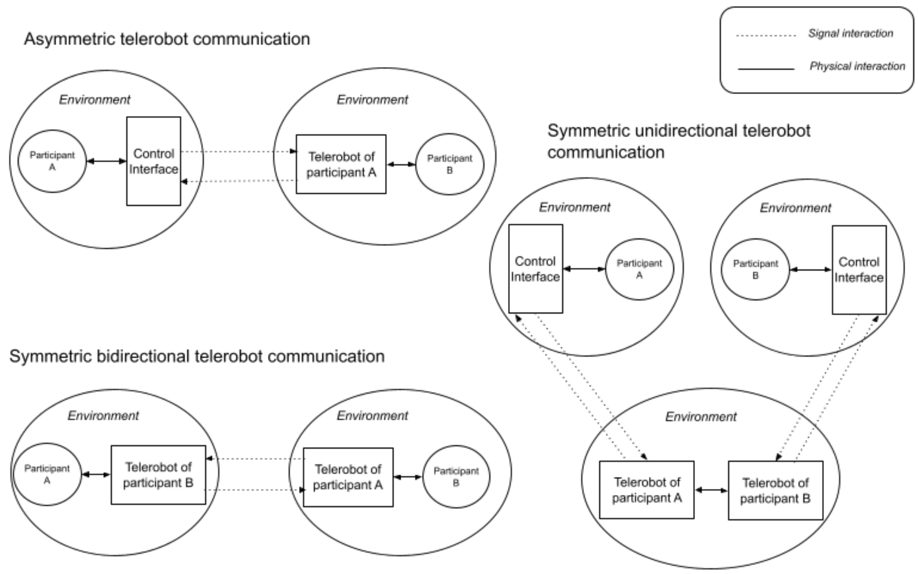

Figure 2: Systems of telepresence communication

Israeli-Palestinian conflict[87]. A symmetric system also assures that telerobot operation incorporates maximum self-presence and engagement, since it is a seamless experience for the operator. In symmetric systems the telerobot mirrors the actions of the operator without any need of intentional operation.

Asymmetric systems, however, produce an experience that is different in nature on both ends. The participant 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 [143]. 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 [129] provides a contrasting view in which a depersonalized encounter in the presence of a group identity further 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 [142] 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 participant that is interacting with the robot in an asymmetric system will have stronger senses of agency, ownership and identifiability when interacting directly with the robot [38, 45]. They are, therefore expected to exhibit less of the CMC-related effects. However, insofar as the robot is perceived as a medium rather than an avatar (meaning a low level of co-presence), the interlocutors may still be conscientious of the mediation taking place and experience effects of deindividuation.

In our previous experiment with asymmetric telerobotic contact between minority and majority groups in Finland we have reported on possible benefits in empowering disadvantaged groups, but also on an incurred discomfort and resentment to due unequal setting [104, p.132, **(author?)** [105]].

To summarize, asymmetric telepresence systems may have some benefits associated with CMC and deindividuation, but may also induce a sense of inequality in communication. Symmetric systems provide the foundation for equal grounds and provide a high level of self-presence in operation.

4.2 Visual appearance

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 [50]. In relevance to intergroup to contact, we identify two main aspects to address: anthropomorphism, avatar customization. However, we also identity two guiding principles: Firstly, as suggested in a studies by Bremner et al. on personality perception of robot avatars tele-operators [22, 23], while a robotic avatar's appearance may shift the perception of the teleoperator's personality, it is highly dependent on context, on the behavior of the operator, and on additional cues such as speech and nonverbal communication. A person conducting a serious interview via an avatar of a stuffed bear as in Kuwamara's experiment[80] may invoke a confusion and a low sense of co-presence, but a teleoperated animal puppet theater as in Kawahara et al [71] is likely to prompt different perceptions. The difference between robot-mediated communication and standard CMC is that now we have the ability to insert physical cues into the system. Those can include group cues such as cultural or religious symbols, or individual cues that specifically identify the context and the telerobot's operator.

Secodnly, in accordance with Allport's condition of equality, a telerobot's appearance should consider its target audience and context so to not seem overly powerful or week in comparion to its interlocutors. A study by Rae et al. found that the height of the robot has an effect on the introloctur's perception of the operator [112]. We anticipate similar consequences when inequality is accentuated in other characteristics of the robot such as power, speed, and volume.

4.2.1 Anthropomorphism We have previously established the intricate relationship between human-likeness and the experience of the interlocutors in a telerobotic interaction [105]. While anthropomorphism could increase co-presence and lower the risk of dehumanizing attitudes, it also decreases the sense of self-presence and increases the risk of negative attitudes due to the uncanny valley effect. A recent study measured perceived trust toward the most modern models of anthropomorphic robots and found that the uncanny valley is still present [98]. tbl. 1 provides a summary of the factors that correlate with anthropomorphism.

Seeing that the above analysis calls for an intermediate approach, it is worthwhile to look at the solution of *theomorphic robots* provided by Trovato [137]. Such robots attempt to portray a divine, nonanthropomorphic appearance, without dehumanizing the avatar. As mentioned earlier, the effect of anthropomorphism is highly dependent on context and on other cues. For example, if using a nonhuman appearance, cues that remind of the operator's human origin could be placed in the scene.

Table 1: Anthropomorphism: summary table.

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

4.2.2 Customization The ability to customize an avatar is widespread in video games, virtual reality, and social media applications. It improves engagement with the platform [96] and primes the user's mindset to achieving certain goals [119].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 [49]. 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 [4], while the PAL involved children in designs for diabetes self-management [56]. Co-design methods also improved the general attitude of students toward robots in educational settings [113].

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 [148]. The assembly work in itself may be therapeutic, both as tactile experience [125] and as a self-expressive art form [93]. Finally, a participatory approach for robot-building has the potential to empower oppressed groups and minorities by providing meaningful education in modern communication technologies.

Highly anthropomropohic robotic avatars could also be modeled to resemble their operator. The most notable example is *Geminoid* from Ishiguru laboratories.[3] In a small-sacle survey among visitors in Ars Electronica, their impression of Geminoid was a combination of amusement and fear due to the uncanney valley effect [13]. Additionally, as noted in a VR study by Peña et al., self-resembling avatars could have mixed results on the result of intergroup contact [106]. On the one hand, the priming effect mentioned earlier my strengthened one's beliefs and idealogies which in turn amplified the social distance to the outgroup. On the other hand, customizing an avatar to resemble one's self increased the sense of identifiability which reduced the negative effects of deindividuation (mostly relevant to asymmetric systems).

Figure 3: Geminoid and Professor Hisroshi Ishiguro. Retreived from http://www.geminoid.jp/projects/kibans/resources.html

4.3 Use of an embedded display

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.[4] Telerobot forms are continuously branching into new directions, but the dominant form remains that of a tablet device attached to a motor vehicle [79] (See fig. 4). The tablet typically displays the operator's head, as in a video call. Examples

[3] http://www.geminoid.jp/projects/kibans/resources.html

[4] 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

from market leaders include *Double Robotics*,[5] *Mantaro*[6] and Revolve Robotics.[7] Such telepresence robots are geared toward remote offices and public service environments, such as hospitals or schools.

Figure 4: The *Double Robotics* Double 3 telerobot

The question of using a simulated face display on a robot, vis-à-vis an embodied, mechatronic face, has been troubling the HRI community since the early days of personal service robots [135]. Recently, the sense of inconsistency felt when interacting with a 2D display on a telepresence robot was verbalized by Choi and Kwak as the *dual ecologies problem* [36]. In their study, the perceived presence of a user in a tablet-based video call was higher when it was disembodied (tablet only) than when the tablet 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 [104, p.127].

Back projection solutions such as those of *Furhat Robotics*[8] attempt to solve this incongruence by projecting 3d-mapped virtual information directly onto

[5] https://www.doublerobotics.com/
[6] http://www.mantarobot.com/products/teleme-2/index.htm
[7] https://telepresencerobots.com/robots/kubi
[8] https://furhatrobotics.com/

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.

4.4 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 [65]. 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 [85] 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. [92] 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.

4.5 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" [55, 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 [77] and in elderly care [24, 76]. Soft materials contribute to a sense of *affective touch* between the robot and humans [75, 131]. The human body and other natural forms are inherently soft, favoring co-existence with other soft materials [39]. 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 [97, 146].

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 [12]. 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 [19, 68, 141]. In our test of soft robotic telepresence, we have reached similarly promising conclusions [104].

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 [114]. 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.

5 Interaction modalities

In this section we explore possible affordances [47, p.285] in telerobot design, and theorize over different modalities [78], 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[9] and Samsung bots[10], and telepresence robots such as Double Robotics[11] and Beam[12]. Other robots only move their body while remaining

[9] https://www.softbankrobotics.com/emea/en/pepper
[10] https://research.samsung.com/robot
[11] https://www.doublerobotics.com/
[12] https://suitabletech.com/

stationary in place; for example, care robots such as PARO,[13] and telepresence robots from Ishiguru laboratories.[14] 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 [21].

Touch-based human-robot interactions have an affective value [7, 75] 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 [25], 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 [9], 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 [9, p. 5]. For example, we are seldom 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 [62, 149]. A mistake in communicating an emotional state could

[13] http://www.parorobots.com/
[14] http://www.geminoid.jp/en/robots.html

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 [72] 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 [54], 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 [136].

A possible solution could be to use the *flow* and *rhythm* of body movements to express emotions instead of explicitly formed gestures [58]. Dance is suggested to be cross-culturally universal [126], and much of our emotional states are expressed through the body rather than facial expressions [11]. 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) [**(author?)** [81];shafirEmotionRegulationMovement2016] in [**(author?)** [95];**(author?)** [88] and the PAD emotional state model [89] in [8, 99].

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 [74, 115]. A smooth turn-taking flow can promote the sense of equality in contact, and it was demonstrated to benefit human-robot interaction [82, 138]. 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 [40], while an asymmetric interface can infer the end-of-turn using typing and clicking indicators.

5.3 Verbal communication

Langauge is often the only tool available to convey layered and abstract information, as may be required during peacebuilding efforts. In the CMC world, we may also use language in creative ways to make up for the lack of embodied interaction and nonverbal modalities [73]. We have previously outlined the risks and benefits of using machine translation for verbal communication [105]. Despite the obvious benefit of enabling dialogue between speakers that do not speak the same language, caution is needed when using automatic interfaces. Minute mistakes in translation could impair participants' confidence and trust in the process.

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 telerbot-based contact.

5.4 Synchrony, reciprocity and feedback

Synchrony and reciprocity facilitate interpersonal sympathy and empathy across all communication modalities [18, 29, 122]. The process is also referred to as "social entrainment" [110, 132]. 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 [10, 86].

Achieving interpersonal synchrony over mediated communication stumbles upon the problem of *latency* [33]. 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 [100] 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 [42]. At the high-end of the spectrum, advanced control systems, such as the ones for 'Robonauts' at the Johnson Space Center [@ 38], 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 [104]. 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.

5.5 Semi-autonmous functions

The formed conversation between the participants 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 [28] and online contact [52]. 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 [31]. 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.

At the forefront of technological conflict mediation, machine learning is being sought as a tool for peacebuilding that can understand complex sentiments and situations [60], predict conflict escalation before it occurs [107], and offer help to resolve issues [133]. As noted earlier, machine learning tools should always be used with caution and awareness of their training environment.

6 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 facilitate bi-directional 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. Another advantage of public space interventions is that any form of intergroup contact that is watched by an audience manifests as *Viacrious Contact*[117]: an indirect contact with the outgroup member supported by the imagination of the audience. Vicarious contact was shown to have potential to improve attitude between groups [139], even if it was being watched on television [**(author?)** [111]. We elaborate on two types of public space interventions: dyadic and performative.

6.1 Dyadic intervention

In a dyadic intervention a telerobotic avatar appears in a public space, ready to engage in a one-on-one conversation with passersby. The group identity of the telerobot's operator could be widely exposed to passersby via physical cues, allowing them to make a voluntary decision to make contact, or they could first approach the robot and only then realize its group identity during the conversation. According to a meta-analysis by Pettigrew et al. [109] contact that begins voluntarily is less likely to exacerbate intergroup attitudes.

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 Performative intervention

A performative type of intervention is oriented toward an audience, and typically consists of remotely controlled characters rather then avatars. For example, a theaterical show performed by a member of an oppressed group as a form of political activism (see Boal's *theatre of the oppressed*[20]]). The advantage of this type of intervention is it does not portray the telerobots as avatars of the operator, but rather as *puppets*, which avoids the risk of dehumanization and confusion at the cost of a lower co-presence. To remind the audience that an outgroup member is performing the show, physical cues should be used. The performance could be an asymmetric single-performer show against an audience, or a symmetric collaboration with a performer at another location.

7 Conclusion

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 [57, 118]. That is reflected in the Israeli-Palestinian setting by the "Anti-Normalization" movement [120]. 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.

8 Appendix A: Summary table

Aspect	Hypothesis
System architecture	• An asymmetric system would invoke CMC related theories such as SIDE and hyperpersonal communication that are positive for contact, but only in one side of the conversation. • An asymmetric system may provide a power advantage for oppressed groups and highlight existing inequalities, but may also cause inconvenience to the participants. • A symmetric system would provide a more equal foundation for the conversation and a stronger sense of agency and ownership for the operators since the interface is transparen
Visual appearance	When choosing the level of anthropomorphism, the following should be considered: • A hig
Voice	A synthetic voice that maintains a human tone but is consistent with the non-anthropomor
Materiality	Use of soft materials and soft actuators: • Supports intimacy and empathy due to the relat
Co-design	A co-design approach to robotic avatars: • Increases operator self-extension toward the avat
Movement in space	Stationary robots: • Allow the operator to focus on the interaction rather than on mobility.
Nonverbal communication	• Turn-taking and attention signals such a gaze aversion promote the sense of equality. • I
Verbal communication	• Automatic language translation could assist in communication, but is prone to error. • D
Synchrony, reciprocity and feedback	• Rhythmic synchronized activities such as dance and mimicry, as well as reciprocal action
Public space interventions	• External hints on group identity and a full exposure upon contact balance the potential
Interaction content	• Games support peacebuilding and may use the robot's body as a game controller. • Sem
Ethical considerations	• Recognizing existing power relations within the system and telerobot design may tackle

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