

Through the Humanoid Looking Glass: Limits and Shifts of Resemblance in Social Robotics

Joffrey Becker, Mathilda Gaulard*

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Abstract: Social robots constitute a significant component of therapeutic mediation tools used with children diagnosed with autism spectrum disorder (ASD). Predominantly anthropomorphic, these robots are designed to facilitate interaction by relying on the simplicity of their expressive modalities, achieved through simplified and predictable behaviors. Their interactional simplicity makes them particularly valuable tools for healthcare professionals. Numerous studies highlight their potential benefits in supporting joint attention, imitation, and emotion recognition. Are anthropomorphic robots, however, truly an adequate means of addressing children's difficulties? In this article, we show that although the anthropomorphic approach currently dominates the field, it presents several limitations that must be addressed. These limitations concern the cost and accessibility of such devices, their acceptability among children and professionals, their limited adaptability to the situated practices of care, as well as the additional technological workload they impose on caregivers. Drawing on an examination of social robotics applied to autism and its limitations, this article proposes to broaden the scope of inquiry by considering a conception of the social that is not restricted to face-to-face interaction but instead encompasses its multiple dimensions. As with any technical object, the design of mediation robots is shaped by networks of human, institutional, and symbolic relations that determine their uses and their effects. Based on a review of the main existing devices and on fieldwork conducted with healthcare professionals, we identify two principal models of mediation. We argue that these models do not always align with care practices and with the situated forms of knowledge on which such practices rely. We propose to explore a complementary pathway in mediation robotics. This approach is being developed within the framework of the Médiations Robotiques en Soins de Santé (MR2S) project. It is grounded in the design of non-anthropomorphic, softer, simpler, and cheaper technical devices that build upon the experience of healthcare professionals. Our approach pays particular attention to an aspect that remains relatively unexplored in social robotics applied to autism: sensoriality. The purpose of the project is to design robotic objects capable of enriching the therapeutic relationship while being sustainably integrated into existing care practices.

* Joffrey Becker, ETIS, CY Cergy Paris University, France, E-mail: joffrey.becker@ensea.fr

Mathilda Gaulard, ETIS, CY Cergy Paris University, France, E-mail: mathilda.gaulard@ensea.fr

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1. Introduction

The figure of the humanoid occupies a rather singular place in the history of robotics. Even before the emergence of contemporary social robots, the reproduction of the human body and human behaviors was not merely a technical challenge, but a reflective enterprise aimed at making humans visible to themselves (Becker 2015). The humanoid, and the automaton that precedes it, functions as a kind of mirror, a fictional double onto which situated conceptions of intelligence, autonomy, and social relations are projected. This projection is fundamentally incomplete. It is inscribed in the materiality of artifacts designed by scientific and industrial communities, and it is shaped by a constant tension between imitation and invention.

The reflexivity associated with the humanoid finds a new mode of existence in today social robotics. In seeking to insert social robots into human environments, roboticists engage us in a kind of pact with their machines. Their ambition comes with recurrent, and not always fulfilled, promises. It is also accompanied by a climate of concern. Fears related to loss of control, replacement, insecurity associated with teleoperation or autonomy add ethical and social questions to the existing technical challenges. Interaction with robots, however sophisticated they may be, is difficult to compare with interaction with humans or even animals. It is poorer, more constrained, and relies on the scripting of behaviors. If robotics makes humans visible to themselves, it paradoxically makes relationships and the social invisible.

This invites us to question what the term “social” truly means within social robotics. In a vast majority of studies, the social is understood through the lens of face-to-face interaction between a human and a machine. This interactional framework is generally examined using tools from experimental psychology. Such an approach overlooks several essential dimensions, including institutional contexts, professional collectives, situated practices, and the processes through which relevance and meaning are established.

These multiple dimensions of the social invite us to shift our perspective and to pay close attention to the ways in which technical devices are embedded within existing practices in order to understand their concrete effects. It is from this standpoint that the *Médiations Robotiques en Soins de Santé* (MR2S) project is situated. The project focuses on robotic mediation with children diagnosed with autism spectrum disorder (ASD), drawing upon fieldwork and concrete situations of use. Its objective is to design a mediation robot by taking into account the experience of the professionals involved as well as that of the children. While the interactional simplicity of robots constitutes an asset in the context of mediation with children with ASD, we hypothesize that current solutions only partially meet the expectations of practitioners. Our approach does not seek to break with existing models, but rather to open new pathways and, in doing so, to restore depth to the notion of the social.

In the first part, we present the relationship between social robotics and autism through examples of robots, highlighting the central role played by humanoid designs. We then examine

the limitations of the devices most frequently used in this context. We show how the predominant models of mediation struggle to be integrated into professional practice. Finally, we present our approach as a possible third pathway.

2. Social robotics and autism

Social robotics has long sought fields of application, and it has found in autism a particularly promising domain. Over many years, various models of social robots have been developed with the aim of using them as mediation tools. One of the main arguments put forward is that it is easier to interpret the behaviors and intentions of a robot than those of a human. These machines are less complex, rely on simplified social signals, and are more predictable. They are therefore particularly well suited to initiating interactions with individuals on the autism spectrum (Diehl et al. 2012). Robots have shown very good results in improving communication skills and in supporting the transfer of learning to everyday life (Diehl et al. 2012; Kouroupa et al. 2022; Dubois-Sage et al. 2024).

They are used to work on specific skills. Robots, for example, are employed to support joint attention, a capacity to share a point of view that represents a significant challenge for children with ASD. They can capture the child's attention through movements or sounds, and then direct that attention toward an object or a specific task, thereby encouraging the child to follow the robot's gaze or gestures (Robins et al. 2018). Robots also serve as mediation tools for turn-taking in interaction. They can structure activities involving exchanges or games in which children must wait for their turn, which is essential for social communication. The robot can provide cues indicating when it is the child's turn, thus facilitating the learning of sharing and turn-taking (Scassellati et al. 2012). Robots can also initiate imitation behaviors. These machines can perform simple gestures or mimic facial expressions, inviting children to reproduce their actions (Billard et al. 2007). Additionally, they function as pedagogical tools, for instance by being programmed to teach concepts or skills through interactive and playful methods. Their predictable and non-judgmental interactions can make them less stressful for children with ASD (Boucenna et al. 2014; Rasouli et al. 2022). Finally, certain social robots can express emotions in simplified ways through facial expressions or changes in posture, which helps children with ASD better understand emotions and social responses (Nadel et al. 2006).

The majority of robots used in studies are anthropomorphic. The NAO robot is the most widely used with children, whether or not they present neurodevelopmental disorders. It has been the focus of numerous studies and has shown good results, particularly in improving social skills through sustained gaze and joint attention (Robaczewski et al. 2021; Shamsuddin et al. 2012). The Kaspar robot was developed specifically for children on the autism spectrum; it helps improve social interaction by facilitating communication and promoting eye contact, notably through imitation (Wood et al. 2021). Buddy is not specifically designed for children with neurodevelopmental disorders, yet it is used in educational and therapeutic contexts to encourage the development of social interactions (Gouzien-Desbiens 2018). Pepper is another example of a humanoid robot employed in healthcare and educational settings, even though it is not specifically focused on neurodevelopmental disorders. It has nonetheless demonstrated positive effects, particularly in interaction, communication, and social skills (Pigureddu et al.

2023). The CommU robot is characterized by clear and articulated eye movements. Despite its simplicity, it can display a variety of expressions, which makes it particularly well suited for assessing emotion recognition (Takata et al. 2023). Zeno resembles a young boy; its face is highly realistic and covered with artificial skin. This machine is often used to improve emotion recognition based on facial expressions (Puglisi et al. 2022). QT is a small robot which face is a screen capable of displaying different facial expressions; it is used to work on communication, emotional expression, and social skills (Puglisi et al. 2022). Leka is less known but increasingly present in care centers. Following a more pedagogical approach, the robot provides sensory stimulations adapted to the individual needs of children, such as vibrations, color changes, and sounds. It has shown particularly good results among autistic children aged 2 to 4, notably in terms of spontaneous interaction time and engagement (Gouzien-Desbiens 2018; Khalid & Ali 2024). This robot primarily plays a reinforcing role within the activities performed by the children.

Zoomorphic robots are also used in centers for children with ASD (Burns et al. 2021), although they occupy a more marginal position in this context. They are more commonly employed in facilities caring for older adults with neurodegenerative disorders. This is notably the case for the Paro robot (Lafont 2021).

3. The limitations of current robotic mediation

Robots offer highly promising possibilities in terms of social interaction and educational content. Yet they also present some limitations. The first concerns their accessibility. These robots are still very rarely used in centers that support children with autism. They are generally absent from most care facilities. Their cost represents a major barrier, with prices ranging from 6,000 to €12,000 for robots such as NAO, to which must be added hundreds of hours required for programming and adapting their functions to the specific needs of mediation (Gouzien-Desbiens 2018). The financial cost and the level of investment required to use these tools create obstacles not only for the care centers, but also for the professionals who must operate them. They are, moreover, out of reach for families, which poses a significant issue. Professionals seek to align practices across different stakeholders and families, and this alignment plays an important role in reinforcing the skills developed in daily life. Consequently, the creation of tools that are not accessible to all hinders the possibility of harmonizing practices.

Humanoid robots also raise questions of acceptance. While anthropomorphism can facilitate interaction, it can likewise provoke fear or rejection. This feeling of uncanny strangeness (well known to readers of E. T. A. Hoffmann) found its formulation in robotics when Masahiro Mori (1970) proposed a theory explaining the discomfort experienced in front of machines that resemble humans without behaving like them. This theory applies to robots that are too close to human appearance, whose mechanical movements generate a sense of unease. The phenomenon can be explained by the gap between the robot's anthropomorphic appearance and the mechanical, awkward nature of its behaviors (Becker 2015; Levillain & Zibetti 2017). The human-like appearance creates behavioral expectations that are never fully met. The appearance of robots can also frighten children on the autism spectrum. This is, for

example, the case with CommU, which was used with children under 4 years old who were too frightened by the robot to participate in the study (Kumazaki et al. 2018).

The development of humanoid robots also heightens certain concerns among healthcare professionals. A sense of mistrust has emerged toward some robotic applications (Pino et al. 2015), particularly among caregivers and participants with mild cognitive impairment. These concerns relate to several aspects: the effectiveness of the robot, fears that robots might replace caregivers, as well as worries regarding data confidentiality and the safety of using such systems.

Moreover, many caregivers emphasize that they already lack sufficient time to attend to individuals, and therefore have none to spare for managing the operational issues of robots. Although many express genuine interest in this new type of mediation tool, they are quickly discouraged by the technological workload associated with these devices. This issue permeates the entire field of therapeutic social robotics (Michiels 2021). Furthermore, when some companies offer “turnkey” solutions, these are unfortunately not always adapted to the needs of children (Duris & Labossière 2021). The skepticism elicited by social robots, (much like that associated with more functional robotic devices, such as mobility-assistance robots) characterizes numerous therapeutic contexts, regardless of the populations targeted or the cultural setting (see Wright 2018).

Regardless of their function, all robots deployed in care settings have a significant social impact. They reconfigure relational dynamics, professional practices, and the traditional roles of caregivers. The introduction of robots into facilities that support children with autism spectrum disorder also raises issues of acceptability and appropriation among healthcare professionals. It is therefore essential to better understand the reservations expressed by practitioners in order to design robots that are not only beneficial for autistic children, but also usable and accepted by those who accompany them on a daily basis.

The autonomy of the machines constitutes another limitation. Even if robots offer interactions that are more or less autonomous, human assistance is always required for their operation, without necessarily making the caregiver’s role particularly central, valued, or engaging. In addition, for safety reasons, most robots cannot be used in a fully autonomous manner (Puglisi et al. 2022). Since robots are not independent, most of their behavioral responses during interaction must be prepared in advance by caregivers (Lafont 2021). The case of Kaspar illustrates this limitation well. Its behavioral responses are restricted because they must be preprogrammed before use (Dautenhahn et al. 2009). This lack of autonomy is partly related to insufficient sensing capabilities. The QT robot, for example, is equipped with few sensors and can only be used effectively together with a touch screen (Puglisi et al. 2022).

A final limitation relates to the difficulty of generalizing the results obtained from experiments involving children and robots. Studies assessing the effectiveness of anthropomorphic robots remain limited and often involve small participant groups (Erol Barkana et al. 2024) or highly specific contexts over short periods of time. This is the case, for example, with the QT and Zeno robots (Puglisi et al. 2022), for which further studies are necessary to confirm, or refute, the beneficial impact of these devices for children with ASD. Some studies argue that human-like form is essential to foster empathy (Takata et al. 2023), emotion recognition, and the development of expressive abilities. However, facial expressions are not the only means of revealing internal states or eliciting empathy. It is necessary to take

into account other forms of bodily expressivity rooted in sensoriality, as well as simple movements of the body, posture, and gesture.

4. Two models of robotic mediation

From the limitations of these machines, two initial categories of mediation emerge. Both are centered on the robot, yet they involve different types of relationships with adults. This distinction was confirmed by the healthcare professionals we met.

The first category places the child in an exclusive relationship with the machine. The robot is positioned facing the child, at a safe distance, and the preferred mode of interaction is a face-to-face exchange, leaving little room for external intervention. This situation can be a source of concern for some educators, who fear that they may eventually be replaced by machines. Others, by contrast, view it as an opportunity to free up time for other tasks. This tension also reveals the challenges inherent in their caregiving work and the limited time they sometimes have to invest in the relationship in the way they would like.

In these face-to-face situations with machines, whom are the children actually engaging with? What relationship is the robot mediating? From the child's perspective, it is easy to assume that the partner is the robot as an agent. This, however, remains to be verified. From the machine's perspective, we know this is not the case. The robot offers activities that have been pre-programmed. Its sensitivity, and everything that appears to constitute its capacity to interact, depends entirely on the prior work required to make these capabilities operational. Children are therefore not interacting solely with the robot. They are also interacting with the team of roboticists who made this interaction possible and, consequently, with the ways in which that team designed and anticipated the robot's interaction with a human.

In this regard, it is important to note that the designers of behaviors and activities rely on their own representations (Becker 2015). These are informed not only by technical and scientific knowledge, but also by the ways in which they imagine human users (Vidal 2012; Becker 2015). Such representations are more or less well documented and draw on expertise that varies considerably from one design team to another. This is partly why activities such as interactive storytelling, dancing, or simple gymnastics movements are so popular both in nursing homes and in institutions for children. These are generic activities that do not always hold therapeutic relevance, requiring caregivers to adapt them, or even to create new activities.

This brings us to a second category of mediation. The behaviors produced by robots such as Nao or Pepper are, ultimately, quite limited. They do not allow these robots to be integrated into practice over extended periods of time. One observation is particularly striking when visiting care institutions equipped with such machines or when speaking with caregivers: there are no machines in operation (a finding also noted by Michiels 2021). The robots often end up forgotten in storage rooms. This appears to be directly linked to the lack of versatility and adaptability of the machines. Once again, professionals regret that these devices are not truly designed to fit the specific characteristics of interactions between children and therapists. To make them more suitable, and to integrate them more directly into therapeutic practices, it is necessary to design a repertoire of relevant activities, whether purely educational or aimed at working on specific aspects such as turn-taking in interaction, joint attention, and so on.

This issue raises a significant problem. For a time, a robot such as Nao appeared to be the most adaptable option for mediation with autistic children, particularly thanks to the work of the company Zorabots. In reality, however, this is still not the case. Caregivers themselves must take charge of this aspect, attempting to navigate both the technical limitations of the machine (and thus the constraints imposed by the roboticists mentioned earlier) and the specific needs of care (bearing in mind that these needs vary greatly from one child to another).

This situation implies that the mediation provided by the robot is indeed oriented toward the child–caregiver dyad, but that it also depends on the technical support and possibilities offered by the engineers who designed the machine. It is, certainly, a more direct form of mediation, offering greater flexibility while stimulating the creativity of therapists. However, it remains difficult to implement. It requires caregivers not only to devote time to the robot (time they already lack) but also to reflect on the relationship between the cost of these machines and their therapeutic and educational benefits. Ultimately, they often prefer other tools that are technically simpler than robots, or devices that allow them to retain full control over their practice. As psychologist Olivier Duris notes, “it is essential that the therapist always offers a ‘human’ transference relationship to their patient, expressing their emotions and feelings while giving meaning to what they observe, so as to support the subject toward a possibility of subjective interaction” (Duris & Labossière 2021).

5. Towards a third pathway

These difficulties lead us to explore a third pathway, one that aims for a form of mediation involving practitioners even more directly. As many professionals observe, autistic children tend to have a natural affinity with robots. Robotic mediation indeed offers many advantages. However, some professionals struggle to fully integrate it into their practices. They request to be involved in the design phases of these machines and express the need for technical devices that are simpler, more accessible, and more affordable; devices that, for example, could help maintain continuity between the care center and the home. Moreover, these machines must contribute to enriching the relationship between therapist and child, rather than impoverishing it by separating them (as can occur in the first category of mediation) or by becoming too complex for either party. It is therefore necessary to explore alternative pathways.

This final category of mediation is more prospective and experimental in nature. We began to explore this path within the framework of the *Médiations Robotiques en Soins de Santé* (MR2S) project, supported by the French National Research Agency. This work started in September 2024, in collaboration with the mutual insurance organization La Mayotte. The overall approach can be summarized in a concise formula: softer, simpler, cheaper.

The MR2S project aims to deepen our understanding of the social and cognitive dynamics involved in robotic mediation, drawing primarily on collaborative design practices and experimental approaches. Its goal is to design, test, and assess the integration of a non-anthropomorphic robot prototype into therapeutic mediation processes for children diagnosed with autism spectrum disorder.

The form itself plays a relatively minor role in interaction design. The work conducted by Fritz Heider and Marianne Simmel in the 1940s demonstrated that animating very simple

geometric figures is sufficient to elicit intentional interpretations (Heider & Simmel, 1944). Other studies confirm this broad and general tendency toward anthropomorphic introjection (Airenti, 2012). These latter works involve highly diverse objects, designed with an emphasis on their behavior rather than on their formal qualities alone (Bianchini & Quinz, 2016; Becker, André & Dutech, 2019). Such objects deserve closer examination.

Our aim is not to challenge the results already obtained with humanoid robots, but rather to enrich research on robotic mediation by exploring alternative forms and other types of relationships grounded in analogical communication¹ (Bateson, 1980). We consider that this approach offers a dual advantage. It reduces the technical issues associated with the constraints of imitating the human form, and it creates more open frameworks for supporting communication between humans. Moreover, by minimizing manufacturing costs, we seek to develop objects that can foster continuity in the therapeutic mediation practices implemented by caregivers and support staff. The objective of the project is therefore to design an object that is simple and easily adaptable to interactive situations involving children.

This approach is grounded in fieldwork that takes into account the realities of these interactive situations. We therefore spend time engaging with healthcare professionals and observing their practices. This has notably allowed us to identify the importance of sensory-focused work and to note the lack of technical responses in this area. Indeed, robotic mediation tends to concentrate primarily on developmental difficulties and social skills. It is far less common to find robots specifically designed to address sensory-related issues, particularly those associated with sensory overload.

In this regard, many children with ASD seek sensory stimulations to reduce their stress. They often experience difficulties in processing, integrating, and coordinating this type of information. To manage these challenges, children may, for example, isolate certain sensory channels. This is manifested through the emergence of repetitive behaviors or stereotypies (Meltzer, 1975). The work of harmonizing sensations and supporting bodily reappropriation is part of the caregivers' and support staff's daily objectives. This work is already the subject of research involving a wide variety of objects that explore the potential of the haptic dimension within child-machine interaction, drawing on a user-centered design approach. This field of investigation (which is highly promising yet still emerging) opens up compelling perspectives for sensory regulation. However, it still struggles to yield intervention tools validated through experimental research (Pérusseau-Lambert et al., 2018).

¹ These non-verbal modalities of communication are notably explored in the context of Animal-Assisted Therapies (AAT) (see O'Haire, 2013).

6. Conclusion

Contemporary social robotics primarily focuses on the study of face-to-face interactions between humans and robotic agents. This is also the case in the context of therapeutic mediation with children on the autism spectrum. Our article has sought to move beyond this narrow conception of the social. We argue that it overlooks broader sociological scales and contributes to rendering invisible the human arrangements embedded in and surrounding machines. The centrality assigned to the human–robot dyad is not neutral. It tends to sideline professional practices, institutional frameworks, collective dynamics, and the materiality of care situations themselves.

Mediation robots, like other technical objects, are “haunted” by networks of relations. A robot is not merely an entity, but rather the point at which materials, human labor, skills, institutions, values, cultural representations, power relations, and inequalities converge (Casilli, 2019). It is social by nature. In this sense, it carries the choices made by its designers. These designers appear as genuine “ghosts in the machine,” making each robot an assemblage that mediates a diversity of human presences and voices. Yet the conceptual decisions that contribute to the existence of such machines have very concrete effects. They convey particular representations of the autistic child as well as specific ways of providing care, without necessarily considering the therapeutic setting as a situated phenomenon co-constructed by children, caregivers, healthcare professionals, technical devices, and institutional environments.

The MR2S project also provides an opportunity to move beyond the “Promethean shame,” by seeking to uncover the human responsibilities concealed by technical objects (Anders, 1957). It aims to restore the complexity surrounding the design of robots used in therapeutic mediation. This aspect is fundamental, particularly when technical devices interact directly with vulnerable populations. Unfolding the socio-material and symbolic networks embedded in robots, and integrating them into the design process, is a necessary condition not only for better understanding the epistemological frameworks and the various knowledge networks in which they are situated, but also for better anticipating their effects on the social worlds they seek to enter. By restoring depth to the “social,” this approach invites us to reconsider the place of the robot not as an ambiguous double of the human, but as a partner in inquiry; one that helps us better understand what it means to interact, to support, and to care.

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