

Examining The Role Of Socially-Assistive Robots In The Development Of Theory Of Mind In Children With Autism

The prevailing understanding of children with autism is that they are incapable of developing advanced social skills. However, this claim may be challenged by the increased interest in robotic therapy, especially in the last two decades. Would robots, equipped with new programs and intelligence, be able to help children with autism develop more advanced social skills?

Autism in Children

Children with autism spectrum disorders often exhibit a lack of basic social skills such as joint attention and play, overly-focussed areas of interest and problematic repetitive behaviours (Feil-Seifer and Mataric 2005, p.3). One key deficiency in these children is in the range of social skills related to Theory of Mind, which refers to the “cognitive capacity to attribute mental states to self and others” (Goldman 2012, p.2). Essentially, most people act based on what they think other people are thinking about. However, children with autism struggle to discern what other people are thinking about.

A leading researcher at the crossroads of autism and robotics, Maja Mataric demonstrates this empathetic deficiency of autistic children in the short film “When Dinosaurs Ruled the Earth” (Smith 2017). When the autistic C.J. saw a girl fall, he laughed at her because he innocently found the situation humorous. Here, C.J.’s under-developed Theory of Mind thinking led him to overlook the possibility that the girl could be sad while he was feeling happy.

Socially Assistive Robots (SARs)

Using a novel angle to bridge the gap between children with autism and their neurotypical peers, Maja Mataric investigates how robots may help autistic children develop social skills. We will focus on children with autism who are at a similar level of cognitive functioning as C.J., who has above-average mental capabilities and attends school with his neurotypical peers. Designed based on Mataric’s research, “Kiwi” is a fictional robot targeted at children with autism and will be used extensively in this discussion.

Mataric’s Socially-Assistive Robots (SARs) are created using the conceptual synergy of assistive robots and social robots engaged in Human-Robot Interaction. Assistive robots are like robotic wheelchairs and arms, which have advanced motor movements to aid people. On the other hand, social robots are programs like Apple’s Siri, which can communicate with people. Mataric integrates these two functions into her SARs, creating social robots which have a physical presence. Nevertheless, SARs continue to provide aid to the user through “social rather than physical interaction” (Feil-Seifer and Mataric 2005, p.1).

SARs used in autism therapy are intended to “encourage children to develop and employ social skills”. (Scassellati, Admoni and Mataric 2012, p.282). They are not there to teach specific skills, but to serve as catalysts for social interaction (Feil-Seifer, Mataric 2008, p.50). Mataric’s Kiwi robot demonstrates this catalytic effect when it blows bubbles to encourage the autistic child, C.J., to engage in play. Then, other children may join in the play and begin interacting with C.J. Instead of teaching C.J. how to blow bubbles to attract the attention and favour of his peers, Kiwi acts as a social facilitator for C.J. What roles can SARs play in helping children with autism cope with their deficiencies in social skills? Are SARs able to help these children develop Theory of Mind thinking?

The Neurotypical Development of Theory of Mind (ToM)

To extract the key ideas on Theory of Mind (ToM) development in autistic children, we can first draw insights from ToM development in neurotypical children. A prominent child development psychologist, Michael Tomasello (1999) gives us ideas on how the neurotypical development of ToM takes place.

“Human beings are designed to work in a certain kind of social environment, and without it developing youngsters would not develop normally either socially or cognitively.” (p. 78)

Tomasello sees the importance of the cultural environment in shaping children’s development.

“I will distinguish two ways in which the human cultural environment sets the context for the cognitive development of children: as cognitive “habitus” and as a source of active instruction from adults. Then I will consider how children learn in, from, and through this environment.” (p. 79)

In this cultural environment, he highlights adults as key driving agents who encourage active social participation from children. More specifically, he refers to adults who have emotional attachments to the child when he mentions that “human adults universally take a more active, interventionist role in *their* children’s development than do other primates and animals.” Hence, in the cognitive development of children, it is pertinent to have a trusted adult – most often the parents – to guide and teach the children.

However, having a trusted adult is not enough – Tomasello claims that neurotypical children need to participate in their cultural environment to start learning about themselves as social agents.

“... at nine months the infant begins to reproduce the adult’s intentional actions on outside objects. This of course opens up the possibility of acquiring the conventional use of tools and artifacts of various types, and thus represents the first truly cultural learning ...” (p. 81)

Interacting with the physical environment and other social agents, which is a form of cultural participation, helps the child learn to imitate adults. Eventually, this process of imitative learning allows the child to engage in joint attention with the adult (p. 89), allows the child to begin a process of social referencing.

“As infants begin to follow into and direct the attention of others to outside entities at nine to twelve months of age, it happens on occasion that the other person whose attention an infant is monitoring focuses on the infant herself... After coming to this understanding, the infant can monitor the adult’s intentional relation to the world including herself. By something like this same process infants at this age also become able to monitor adults’ emotional attitudes toward them as well – a kind of social referencing of others’ attitudes to the self.” (p. 89)

Social referencing of the emotional attitudes, as outlined by Tomasello, may allow the child to start representing the mental states of others in their minds. By being able to see that different individuals may have different mental states, the children can also identify that difference people can hold different thoughts. Eventually at an older age, this social referencing results in a more developed ToM thinking.

Based on Tomasello’s ideas, the presence of a trusted adult and actual participation in social interactions are necessary preconditions for (neurotypical) children to gradually develop ToM thinking. Extending Tomasello’s ideas to children with autism, we may conclude that they too would need a trusted person to guide them in their participation in social discourses. Yet, a

common problem is that neurotypical children may be unwilling to interact with autistic children because of their behavioural differences. Mataric demonstrates this social isolation of autistic children in her short film, by portraying C.J. as a child who prefers to “spend every lunch and recess alone, playing with dinosaur games or puzzles” (Smith 2017). Without initiated social participation from both autistic children and their peers, it would be difficult to encourage the development of ToM thinking.

Behavioural therapy is often used to train children with autism to develop their social skills, helping them fit in their social environment. However, the prevailing consensus is that “theory of mind abilities are seriously deficient in autistic individuals, improve little with development, may never reach normal functioning levels, and appear to eventually hit a developmental ceiling” (Ozonoff and McEvoy 1994, p.1). Nevertheless, the inefficacy of traditional behavioural therapy could be because the pre-conditions of a trusted adult and social participation were absent. Now, we will look at how robotic therapy may overcome these weaknesses in behavioural therapy to help children with autism.

SARs and ToM thinking in autistic children

Earlier, we established social participation as an important caveat in encouraging autistic children to continually participate in social discourses and gradually develop ToM thinking. When Kiwi suggested that C.J. become the leader in a game of dinosaur tag, it was paving the way for C.J. to interact with his peers. This first step helps autistic children like C.J. to join in social discourses and learn from their cultural environment as their neurotypical counterparts do.

Yet, SARs can go beyond that role. They are promising because children with autism have a stronger affinity for robots, instead of humans (Scassellati, Admoni and Mataric).

“... robots occupy a special niche between inanimate toys (which do not elicit novel social behaviors) and animate social beings (which can be a source of confusion and distress to children with autism).” (p. 276)

This preference for robots to humans may stem from the SARs’ reduced variety in facial expressions and increased behavioural predictability. In contrast, humans may engage in more unanticipated, sudden actions, which are often uncomfortable for autistic children who prefer repetitive motion. As such, autistic children tend to be better able to form bonds and connect with robots.

Unfortunately, Mataric’s SARs are currently programmed to respond to environmental stimuli, most notably what they detect from their owner. For instance, when C.J. is feeling sad, the SAR will respond accordingly by offering kind words. This form of communication can be described as monadic, where the SAR receives an input, processes the output, and responds accordingly. The SAR behaves in response to its owner, hardly introducing unpredictable behaviour. An autistic child would see their SAR as a personal companion *for* him, just as Mataric intended, without considering the perspective that the SAR could be another social agent with its own thoughts and desires. On the other hand, most children dynamically create shifts in social situations, presenting unexpected situations for the autistic child to handle.

Correspondingly, an important skill in social situations is for children to be able to dynamically interpret and respond to social stimuli. Other social agents are not just responding to the child, but also actively prompting them for responses. This dynamic interpretation promotes ToM development, since there is a need to continually re-interpret what others think and feel, and then develop socially-appropriate responses. The SARs’ lack of active thinking seems to impair them from being social agents just like other children. In this respect, the SARs merely

help their owners cope with social interactions by indicating what is acceptable or not. Then, SARs may not be able to promote ToM development in autistic children.

Yet, it is this very lack of unpredictability in SARs which allow them to be popular among children with autism – they seek the comfort of predictable behaviour. For SARs to be successful in encouraging ToM development in autistic children, it would then be important to capitalise on their popularity and favour amongst children with autism.

SARs as “Parents” – A Trusted Figure

Earlier, I posited the importance of a trusted adult that the autistic child feels connected to in ToM development. Mataric’s SARs like Kiwi have the potential to close this gap. The formation of close bonds between autistic children and their SARs is parallel to neurotypical children feeling connected to their parents. In fact, Mataric’s vision of having personalised SARs aligns well with this importance of a trusted mentor who can provide an emotionally safe environment.

Using this notion of a trusted adult, I argue that SARs who have formed close connections with their owners are in a better position to encourage ToM development in their owners. SARs are largely emulating the role of the parents in the development of ToM in neurotypical children. Yet, it is important to recognise that Mataric does not intend SARs to be replacing parents. Instead, the SARs are supposed to “fill in large gaps where attentive and individualised human care is diminishing or entirely unavailable” (Mataric 2006, p. 82). Mataric hopes that SARs will serve as personalised caregivers for children with autism, essentially being “trusted adults” in the children’s lives.

The potential of SARs to be agents of instruction can also be seen in Mataric’s robots. One of Mataric’s SAR systems, Nao, was shown to be able to encourage imitative learning amongst autistic children using graded cueing (Hazle 2014). The Nao robots’ use of varied feedback and prompting, or graded cueing, had a positive effect in autistic children’s ability to imitate poses from the robot. With the help of SARs, autistic children do seem to demonstrate better social responses. Additionally, a close analysis of Mataric’s Kiwi robot shows that it is capable of joint attention with its owner C.J. Kiwi was first talking to C.J., before it asked him to identify the happy faces among the children playing outside. Here, Kiwi and C.J. jointly share their attention on the faces of the children outside.

As Tomasello claims, having a parent, imitative learning and joint attention are important aspects of children’s cultural learning and eventually ToM development. Working with this notion of the SAR as the child’s trusted adult capable of joint attention with the child, we will explore how SARs can encourage ToM development in autistic children.

SARs and Seeing the “Other”

The most direct way to encourage ToM thinking is for the SARs themselves to be the “other” mind that the autistic child has to interpret. Kiwi may spill a cup of coffee on itself and emulate a human crying in pain, then prompt C.J. to help it get some ice to treat the wound. The difference between interpreting from SARs and real people is that in the case of SARs, autistic children are offered more patience and guidance in arriving at the correct conclusion. However, the applicability of this simulation to real social situations hinges on how well SARs like Kiwi mimic human facial expressions and body language. After all, SARs are better able to engage autistic children when they have simpler facial expressions. The autistic children may then

translate their interpretations of Kiwi to interpretations of their peers, allowing them to put what they have learnt into practice, in turn learning more from the cultural participation.

Tomasello's ideas of the importance of parents support this direct placement of an SAR in the position of the "other". He describes how children first learn about themselves as social agents in a cultural environment, they see their parents as the "other". They start referencing their parents' thoughts and beliefs to gain their parents' favour (p. 89). Here, it may be that the children first began referencing the thoughts and beliefs of those they cared about and felt emotionally connected to.

Closer to what the SARs are currently like, the SARs may alternatively be mentors of empathy and play a role similar to traditional behavioural therapists. For instance, when C.J.'s classmate fell, Kiwi may let C.J. know that the injured girl feels pain and sadness. Parallel to how behavioural therapists work, Kiwi can ask C.J. to recall the times when he got injured and felt pain, and then apply the pain to his injured classmate. Continuing down the path of self-reflection, C.J. can be brought through another recollection of how other people reacted when he got injured and apply a similar reaction in the case of his injured classmate.

A simpler way would be directly telling C.J. that the socially appropriate way to react when someone falls is to show concern. Of course, this alternative proposition is less effective since the C.J. does not go through the logical thinking process of why he should show concern for his injured classmate. In the former situation, he was guided in linking the social situation (his classmate fell) and an appropriate reaction (he should show concern to her). The idea behind SARs using the former methodology is to cater to the logical and conceptual thinking skills which tend to be stronger in autistic children. Here, the autistic children may translate their above-average mental capabilities into social situations, to make up for their weaker social skills.

More than just being a personal trainer, the close understanding between SARs and their owners means that SARs can provide the encouragement their owners need. This encouragement is very similar to how Mataric's Bandit SAR encourages stroke patients in their recovery process, by providing continued and varied feedback on how the stroke patient can continue improving. The role of words of encouragement in encouraging stroke recovery attests to the importance of autistic children having an emotional connection with their mentor in their development of ToM. Close emotional connections with their owners may make the SARs' feedback more constructive and relatable for their owner, eventually leading to higher rates of success in picking up ToM thinking.

The Key Software in SARs – Emotional Connection

Whether SARs serve as instructional agents or social facilitators for autistic children, the key idea is that they do have the potential to encourage ToM development in autistic children. In this equation, the autistic children's emotional connection with their personal SAR is key. Strong emotional connections with their SAR could make it simpler for children with autism to interpret the thoughts and feelings of their SARs. When SARs serve as the "other" social participants for autistic children to reference emotions from, they could be designed to lack volatile emotions like most people, so that they are simpler to interpret. Where the autistic children may not directly read the emotions of their SARs, SARs may still be more suitable mentors for them, in contrast to traditional behavioural therapists. The main reason? Emotional Connection between the SARs and their owners.

Are SARs a futile path to take?

Yet, some polemicists may disregard this possibility of SARs encouraging ToM development by highlighting intrinsic neurological limitations in autistic children. Nevertheless, this is a pessimistic view given the nature of cultural learning described by Tomasello. Tomasello describes the picking of social skills as a gradual process that is learned. In fact, experiments used to test for ToM development consistently conclude that children below the age of three do not exhibit ToM thinking (Wimmer and Perner 1983, p.126). The limitations of these young children can be said to be biological, since their brains have yet to fully develop. However, the fact that children can pick up ToM thinking as they grow up suggests that ToM development is a process facilitated by cultural learning, as asserted by Tomasello.

Autistic children may merely be at an early stage of ToM development. The slow development is exacerbated by their relative social isolation, which means that the children are not often put in situations where they have to reference the emotional attitudes of others.

Conclusion

Robotics for use in autism therapy has emerged from its nascent stages, in tandem with the development of advanced robotics. Using Tomasello's ideas of cultural learning, I have suggested ways in which the robots may be programmed to help the children develop Theory of Mind skills.

"If they can't learn the way we teach, we teach the way they learn."

- O. Ivar Lovaas, Autism Treatment Center of America

Though a large part of autism is neurological in nature, I posit that the key emotional connection offered by SARs push them a step ahead in autism therapy, in contrast to traditional behavioural therapy. The ways in which SARs help children with autism may shed light on the nature of autism, forging novel directions in autism therapy.

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