Teaching environment mediated by Robot-Assisted Autism Therapy (RAAT) to improve soft skills

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Abstract

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition. It is characterized by inability to acquire social skills, repetitive behaviours and failure of speech and nonverbal communication development [1].

Technology application, in educational background, has the potentiality to adapt teaching tools to the brain functioning of students with ASD, it allows to gain some new competences. Over the past several years, Robot-Assisted Autism Therapy (RAAT) has been infiltrating the soft skills teaching environment. RAAT conforms itself to Neurodiversity of ASD, so it demonstrates its adequacy for the development of social and relational skills. This reflection review recognises state of the art about new advancements made in demonstrate benefits of RAAT to children with autism. RAAT's benefits discussed by this paper are: (1) increased interaction and spontaneous verbal communication; (2) improvement of relational skills and empathy; (3) willingness to physical proximity. Therefore, we explain the effects of RAAT in children with ASD about improving soft skills.

Keywords

Autism, Soft Skills, Robot-Assisted Autism Therapy, teaching environment

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1. Introduction

Autism spectrum disorder (ASD) is a complex developmental disability that affects an individual's capacity to communicate and interact with others and it is also characterized by a wide range of behavioural problems [2]. Impairment in social functioning is the defining feature of this disorder, so youth with ASD are at increased risk for social isolation [3].
Impairment in communication and social interaction cause suffering, stress, reduced autonomy and reduced school and job opportunities.

In 2018 the *ISTAT* report identifies a predominance of children with ASD equal to 0.84% of the total number of pupils in Italy in school year 2016/2017, which is an increase figure compared to the previous year. In the USA the last report published by the *Centers for Disease Control and Prevention* [4] estimates that nearly 1.5% school-age children are affected by ASD. Also, the number of cases is confirmed to be constantly rising.

The number of pupils with ASD is quite significantly in schools, thus the situation cannot be ignored and needs the right evaluation, in order to start the process of inclusion in the group of mates, and the improvement of their unexplored skills. The school should manage to facilitate growth and learning, to promote socialisation, to reduce maladaptive behaviours, to train and support the families.

Technology is contributing to the evolution of Education through the development of individualised learning plans suitable for students with ASD. The health emergency from Covid-19 has imposed a process of sudden digitization of learning environments by taking transliteracy. The actors of the school institution were forced to convey communication, teaching and learning through technology. The study by Toto and Limone [5] showed that the impact of digital technologies, during the pandemic, is negatively correlated with both perceived stress and motivation. The advantages of e-learning (sharing of materials, facilitating access to information and uptake of ICT) are therefore associated with low motivation: it is essential to develop virtual rooms for interactions between participants and to adapt the training of teachers and students to their needs in order to counteract resistance and opposition to use of technologies [6]. Technological innovation has established itself in the socio-cultural context for several years, however in the school context it is a process still under development and now teachers are facing the related changes.

Robot-Assisted Autism Therapy (RAAT) is one of the innovative tools which can be used in schools; it offers the opportunity to treat and teach both soft skills[1] and curricular learning content. The learning environment is mediated by the relationship with an educational robot that can be zoomorphic or humanoid. The innovation consists in combining the brain functioning of children who have ASD with soft skills taught by a robot – children's trouble with social relationships is associated with a possible interaction with technological tools.

It is necessary to clarify that it is difficult to make generalizations out of the results obtained with RAAT, because robots must be specifically and wisely personalized according to the sensory preferences of the children, their psychological, neurological, relational and intellectual characteristics [7].

2. Sensorial processing and human relationships

RAAT takes advantage of research made about neurodiversity, typical in individuals with ASD, in order to act effective interventions. It is important to know how the brain works during human interactions in order to develop soft skills. It is widely assumed that the biological underpinnings of social impairment are neurofunctional alterations in the "social brain," a neural circuitry involved in inferring the mental state of a social partner. The present contribution will explore two fundamental processes for the regulation of human relationships: human motion processing and emotional stimuli elaboration.

Successful social behaviour requires the accurate detection of other people's movements: typical observers showed enhanced visual sensitivity to human movement while observers with ASD did not [8]. It

[1] Soft skills refer to transversal skills that concern the aptitudes and intuitions of the person. The main ones are: empathy and communication, collaborative, social and relational skills.

suggests that the visual systems of individuals with ASD may not be tuned for the detection of socially relevant information such as the presence of another person. This means that in people with ASD there is an effective brain activation for the elaboration of the object motion but not for the human motion. This condition affects precision and speed in coding another human being's action.

The studies about emotional evidences elaboration report that children with ASD fixate less on faces in comparison to controls so they need to gaze not only at faces but also at actions, gestures, body movements, contextual details, and objects [9].

Another evidence is that the percentage fixation time to the eye region for the TD (typically development) group increases with age, whereas the one for the ASD group did not. In the ASD group, duration of gaze at the eye region increases up to approximately 10 years of age and thereafter tends to decrease. The ASD group gaze more briefly at people than did the TD group [10].

Han et al. [11] recorded eye-tracker during visual exploration of emotional stimuli displayed by a human face. Evidence came that people with ASD process the movement more than the emotional signals when facing facial expressions.

The diversity in processing movement and emotional signals coming from other human beings causes impairment of the soft skills. RAAT provides the necessary tool to overcome this obstacle and to produce the development of social and relational skills.

3. Development of soft skills through RAAT

A robot is a mechanical or virtual agent capable of moving independently and performing complex actions. A humanoid robot is a robot with its overall appearance based on that of the human body instead a zoomorphic robot is a robot with animal-like.

RAAT combines speech, pictures, words, and animation in interactive ways to structure concepts that suit the level of understanding of learners and their interest [12]. Such learning opportunities stimulate everyday life situations thus providing situated learning.

The value of this technological device resides in being more flexible and suitable to the children and their therapeutic needs, compared to the standard therapies. The robot tutor provides extraordinary results.

The robot's colours, clothes and behaviour are decided according to the child's preferences so a process of identification is started and any overstimulating sensorial system details will be avoided: the voice should be soft in nature and sound friendly not to scare them; sentences should be short to facilitate comprehension; speed of speech must be slow; the behaviour must be coherent, simple with no complex movements acted together with speech. An individualized plan of intervention is set up: games, interactions, learning outcomes and timing to enhance the difficulties of teaching are tailored for each child. It is extremely important to combine the child's motivational characteristics with the robot's interactive and playful strategies [13].

Another crucial factor is the individual level of functioning: a high-functioning level predicts a higher development of soft skills; a low functioning, instead, seems to be associated to a lower development. However, it is difficult to define precise guidelines and quantitatively comparable results due to the great variety of neuropsychological features and of RAAT.

Here below will be presented the effects of several interventions, based on RAAT, implemented on children aged 2 to 12.

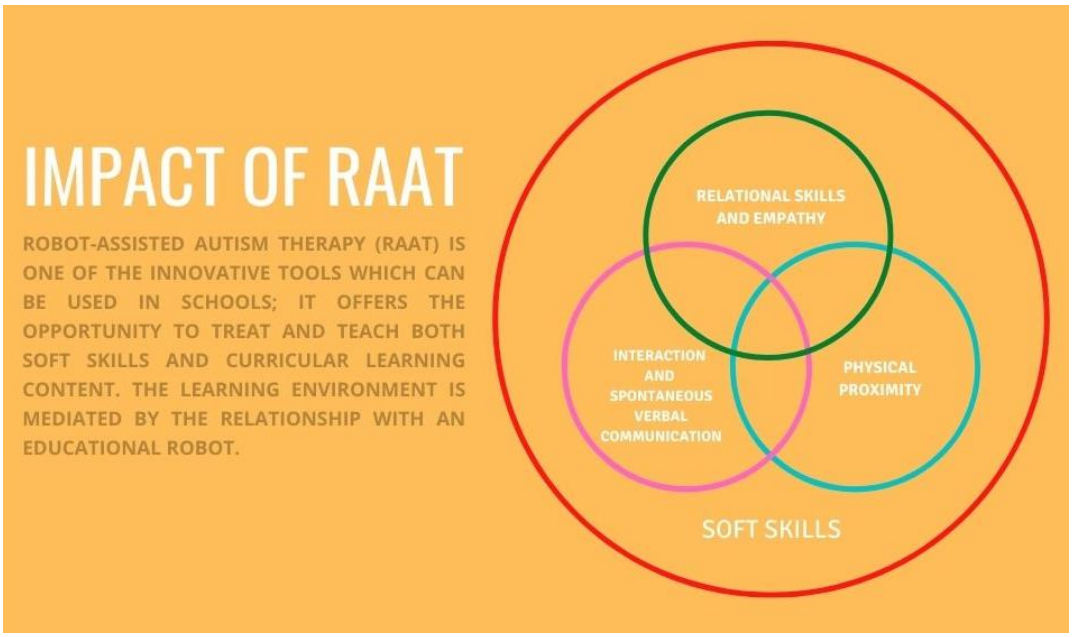

Figure 1: diagram represents the effects of RAAT on soft skills.

3.1 Increase of interaction and spontaneous verbal communication

Research gives evidence of the development of the relationship between the child and the robot and the further increase of verbal communication: here follows an outline of the most important results.

Bharatharaj et al. [14] have made experiment with the robot KiliRo inspired by parrots. The results show signs that children with ASD were attracted and were happy to interact with the parrot-inspired robot [15]. DiPietro et al. [15] also found positive results using humanoid robots: the robot's humanoid physical aspect and its communicative skill mediated by intonation affect positively children with ASD, providing them a higher level of happiness and interaction.

Srinivasan et al. [16] focused on social skills training through interventions based on movement thanks to NAO robot. It reported that rhythmic and whole-body interpersonal synchrony games led to high levels of social attention. Improvement of joint attention has been reported also in the research made by David et al. in 2018 [17]. Joint attention is the first step of sharing and nonverbal communication testifying the children's wish to be in relationships with others.

Taheri et al. [18] observed significantly increased verbal communications of paired-groups following a robot-assisted group games program. In particular, the research made by Saadatzi et al. [19] shows the presence of empathetic verbal communication answers: children thanked and congratulated the robot mate (for example a participant said "good job") and some of them also imitated the robot's positive gestures. The result of gesture production can be seen also in So et al. [20] which shows how early childhood babies reduced their gestural delay.

Simut et al. [21] implementing an intervention mediated by social narrator robots, refer the presence of children asking spontaneous questions, thus showing increase of motivation to communicate.

The results claim the effectiveness of RAAT for the development of communication in children with ASD; yet it is vital to adapt the intervention to the features of the participant and to consider the extent of the outcomes associated to the starting level of functioning.

3.2 Promotion of relational skills and empathy

The main feature of RAAT robots is autonomy: the artificial intelligence allows robots to build relationships without be remote-controlled. The autonomous robot, differently from the controlled robot, is able to generate a different behaviour and consideration: the child with ASD assigns him sensitivity, wishes

and particular physical states. The way in which technology is introduced mediates the awareness of other people's emotions and social relationships [22]. The more the robot is autonomous the more the child is involved; instead, as said before, empathy is not revealed during human interactions because of sensory overstimulation.

However, adopting a robot is only an intermediary step which develops the child's desire and skill to interact and emotionally understand other people. If the child-robot relationship is well established, it also promotes the intrinsic motivation to interact with human carers: children with ASD have been observed while adopting spontaneous behaviours of sharing fun and requests with the experimenter [23]. Moreover, the robot shows the potentiality to encourage children to collaborate with their peers in playful situations [24] and is able to teach perception, expression and understanding their own and others' emotions.

The humanoid robot *Zeno* is very expressive and, during working sessions, is able to implement empathetic learning. Zeno asks the child to recognize some facial expressions represented on cards, and to match them to his own face; also, he asks to express his emotion and tell verbally how he is doing [23]. The consequence has been seen in the development of social skills which, however, were strictly dependent on the child's level of functioning, so the higher was the level of functioning, the better were the results.

Kumazaki et al.'s study [25] confirms that individuals with ASD exhibited higher motivation when interviewing with an android robot than with a human. The motivation was negatively related to the impression of the humanness of the android robot. The designed robots should have less details and should be less complex than humans, in accordance with the brain functioning associated to ASD.

Rudovic et al. [26] have tested the use of the humanoid robot NAO, they have adapted the interactions to multi-modal sensory input (video, audio and autonomic physiology) generated by the child's monitoring. The robot's ability to calibrate its behaviour to the child's answers allowed to adjust positively the levels of the child's affective states and engagement. An increase in the child's involvement and the development of a positive relationship with the robot is guaranteed by the continuous reorganization of the robot's behaviour.

KASPAR is a semi-autonomous minimally invasive humanoid robot developed by the Adaptive Systems Group of the University of Hertfordshire (UK). Huijnen et al. [27] claim that it contributes to positive results in the area of increasing body awareness, encouraging collaborative skills, prolonging children's attention span, mediating and encouraging social interaction, and learning appropriate physical interaction.

It is demonstrated, thus, that RAAT overcomes the relational impairment of the child with ASD developing empathy towards the robot and paving a new road towards the involvement of other human beings in the relationship.

3.3 Disposition to physical proximity

The research made by Saadatzi [19] previously mentioned, has pointed out the development of verbal communication and also of behaviours tending to proximity: one of the participants consistently greeted the robot and hugged it when the session was completed. Another participant began imitating the robot's happy gestures.

The study of Kim et al. [28] choses NAO robot with "walking with the robot" as the social context. The expected social situations in the given scenario were (1) the robot walking, and (2) the robot falling; the desirable prosocial behaviours of the children were (A) helping the robot to walk, and (B) helping the robot stand up after it fell down. Several video cameras and the *Smile Reader Apparatus* have monitored the children's behaviours and smiles. Overall, children with ASD smiled more and exhibited fewer prosocial behaviours than typically developing (TD) children.

The study found that the smile's duration of children with ASD is related to more prosocial behaviours in the condition (1) the robot walking. In the condition (2) of the robot falling, three children with ASD out of six helped the robot to stand up. The same percentage can be seen among TD children.

One difference is interesting to be noticed: at the robot falling the TD children turned their face to the caregiver to seek advice in the non-familiar situation, which did not happen among the children with ASD.

Increased physical proximity has been observed also in the research by Fachantidis et al. [29]: the robot Daisy causes the pupil to display proximity behaviour in the activity. Children get close to the robot more easily and interact with the robot more than with a human being.

Hypothesis are made that the presence of physical proximity is due to the robot's emotions easy to be recognized, so the children do not get bored and do not feel overwhelmed by the other interlocutor's stimuli. However, the robot is just a tool to mediate learning skills that should be used later in everyday life.

4. Conclusion

Doctors, teachers, caregivers, psychologists and health carers are offered social robots in order to interact, work, learn and treat people with ASD.

The asset consists in implementing the intervention on the child with ASD in his real-world avoiding tools out of context. In this case there will be a high probability of generating true skills for everyday life and expanding the competence in different social environments.

RAAT is producing promising results not only in the area of rehabilitation but also in schools: it mediates not only the acquisition of soft skills but also curricular knowledge. Educational robots should be used in learning environments in order to guarantee effective and pleasant teaching and the development of a group-community where all students live in harmony.

Although scientific research is advancing, the diffusion, of technological tools designed for the school context, does not follow the same pace. Teachers do not have an adequate level of knowledge and skills in the use of assistive technologies and require pre-service and in-service training to increase their general knowledge of technological aids and to plan effective actions for students with disabilities [30].

We hope that the praxis will be spread in order to develop the precocious empowerment of people with ASD.

The aim is to let the rhythm of development of the individual with ASD close the gap with the development of the normotypic and reduce the impairment produced by the disorder.

What has been stated here does not support the idea that normality is a value; instead, the development of social and psychological skills is a useful equipment to lead an adaptive life able to fulfil the potentiality of the person despite the expectation of normality. RAAT seems to provide the useful tools to cancel the disability, being the relation between individual and environment, promoting the removal of barriers which hamper the autonomy of people with ASD.

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