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ASD-ROBOT: AN APPROACH THAT TAKES INTO ACCOUNT THE SENSORIALITY IN THE INTERACTION BETWEEN CHILD, THERAPIST AND ROBOT

ASD-ROBOT: UN APPROCCIO CHE TIENE CONTO DELLA SENSORIALITÀ NELL'INTERAZIONE TRA IL BAMBINO, IL TERAPISTA E IL ROBOT

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Abstract
This paper focuses on robots used in educational and therapeutical interventions for children with Autism Spectrum Disorder. Children with autism show a different way of perceiving environmental stimuli, they interpret reality based on the different cognitive and communicative styles that are often a source of discomfort. This work, based on the studies carried out on the interaction between the robot and the child with autism, highlights how robots (properly programmed) can bring benefits to children with sensory problems, and promote social interaction and communication. The aim of the research is to implement the prototype named ASD-Robot already tested, in a first test, at the "Collodi" primary school in Pagani in the province of Salerno, through interventions aimed at supporting children who show difficulties in social interaction, paying attention to different sensory perceptions that characterize children with ASD and helping them to understand the surrounding environment.

Il presente articolo si concentra sui robot utilizzati negli interventi educativi e terapeutici per i bambini con disturbo dello spettro autistico. I bambini con autismo manifestano un modo differente di percepire gli stimoli ambientali, interpretano la realtà in base ai diversi stili cognitivi e comunicativi che spesso sono fonte di disagio. Questo lavoro, basato sugli studi effettuati sull'interazione tra il robot e il bambino con autismo, mette in evidenza come i robot (opportunamente programmati) possono portare benefici ai bambini con problemi sensoriali, e promuovere l'interazione sociale e la comunicazione. Scopo della ricerca è realizzare il prototipo denominato ASD-Robot già sperimentato, in un primo test presso la scuola primaria "Collodi" di Pagani in provincia di Salerno, attraverso interventi volti a sostenere i bambini che mostrano difficoltà nell'interazione sociale, ponendo attenzione alle differenti percezioni sensoriali che caratterizzano i bambini con ASD e aiutandoli a comprendere l'ambiente circostante.

Keywords
Robotics; Autism Spectrum Disorder; Sensoriality; Special Education; Assistive Technologies.
Robotica; Disturbi Dello Spettro Autistico; Sensorialità; Didattica Speciale; Tecnologie Assistive.

Introduction

"Nowadays, in the European Union, assistive technologies (Besio, 2019) developed for students with disabilities (Besio, 2006; 2020) are designed taken into account regulatory, health and demographic aspects (EPRS, 2018a) in line with the International Classification of Functioning, Disability and Health and they follow ICT trends market to be sure that all new technologies can provide a support or relief, in some way, to people with disabilities (EPRS, 2018b)" (Campitiello, Todino & Di Tore, in press).

From a pedagogical point of view, assistive technologies represent an opportunity to change the social representation of people with disabilities and achieve a process called assistive inclusion (When referring to assistive technologies it is possible to consider the classification proposed by Andrich (2015): 1) prosthetic aids; 2) Orthotic aids; 3) Adaptive aids; 4) Environmental aids; 5) Assistive aids; 6) therapeutic aids; 7) Cognitive aids. As regards accessibility, the term "design for all" refers to standard technologies, while an individual assistive solution corresponds to the "design for need" and responds to the targeted needs of individual cases (Bitelli et al., 2016, p.12). "What characterizes more assistive technologies, from a pedagogical perspective, is that they should have intensified the aptitude to find an innovative use of a particular digital or mechanical technology to improve autonomy and resilience in a student profile (Besio, 2020) and they should help us to better understand the amount of rules concerning accessibility of different contexts, places, materials to encourage students inclusion and participation of everyone during lessons at school (Castellano, 2019). in the outdoor activities, school trips, museum visits, homework and so on and so forth." (Campitiello, Todino & Di Tore, in press).

Robotic Assitive technology refers to robots designed to promote the development of skills in people with disabilities (Encarnação & Cook, 2017, p.10) and both "industrial robots" and "personal service robots" belong to this category. which also include assistive robots, robots that favor social interactions and Socially Assistive Robots (Besio, 2019).

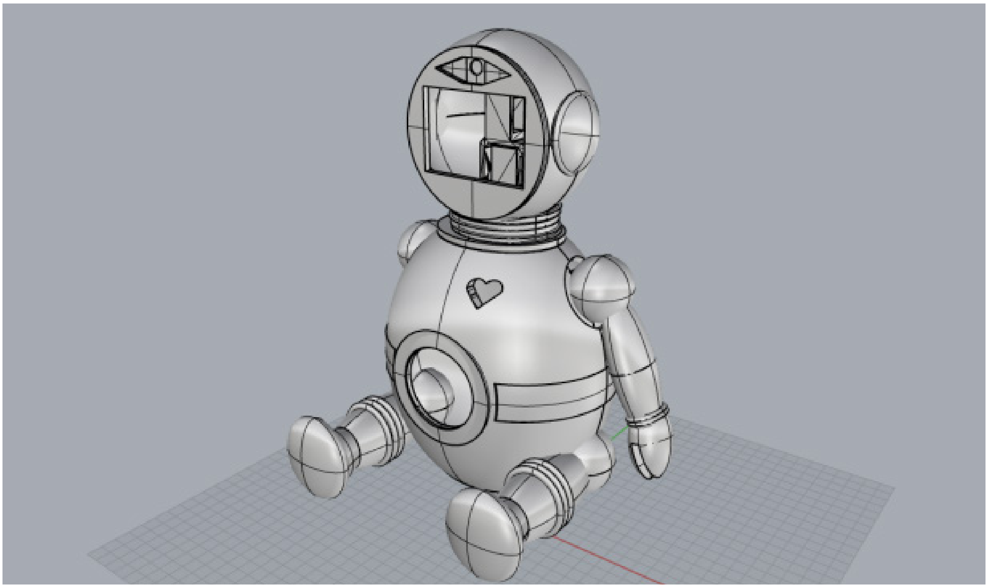
"The introduction of assistive technologies not only requires students to learn how to use them but also necessitates teachers to know how to incorporate them into their teaching-learning processes" (Campitiello, Todino & Di Tore, 2020). At the University of Salerno, many research works study the relationship between robotics and disability, starting with the DISUFFO project (Di Tore, Todino & Sibilio, 2019) taking into account the complexity of man-machine interaction (Todino, 2018).

1. Robotics and Autism Spectrum Disorder (ASD)

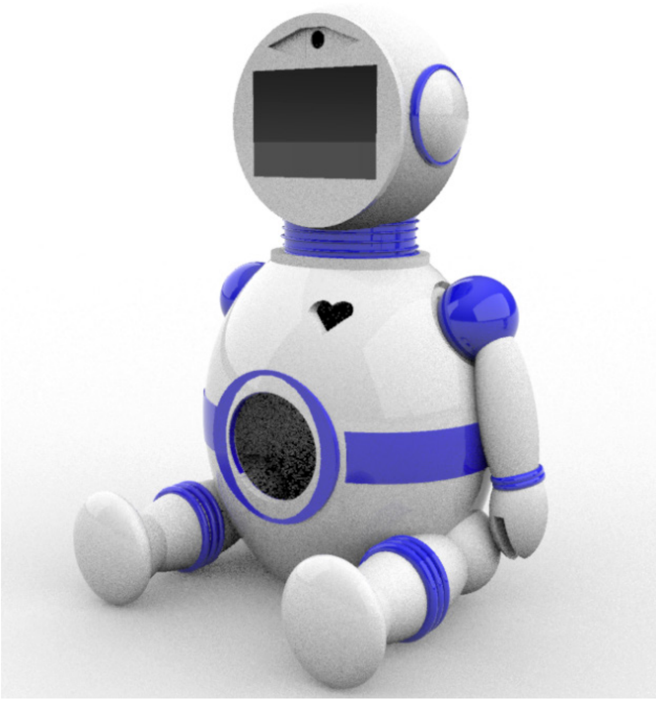
"In recent years, many studies have focused on the application of robotics in the field of disability, in particular on the use of robots for the development of social skills in individuals with Autism Spectrum Disorder (Ricci et al., 2014; Cottini, 2013)" (Campitiello, Todino & Di Tore, 2020). Robots could be able to open a channel of communication with autistic children, favor the acquisition of new social behaviors, becoming an inclusive assistive technology. Some studies show that autistic children prefer to interact with robots than their human partner (De Graaf & Ben Allouch, 2013; Dunst et al., 2013), this is due to the predictability of the robot's actions which makes the interaction reassuring.

Recent studies have shown how the use of robots can bring benefits to children with sensory problems, promoting social interaction and communication. Children with autism manifest an inability to maintain eye contact with the person they are interacting with and this difficulty affects the relationship dynamics but it has been shown that the use of robots in rehabilitation sessions favors eye contact in children with autism (Robins et al., 2005). Robots can also help children in tactile interaction by exploring touch in a controlled manner, as some hypersensitive children refuse to touch their human partner. So robots can act as assistive technologies and take into account the specific needs of each child, fostering the development of social skills in autistic children through daily activities. So robots can act as assistive technologies and take into account the specific needs of each child, fostering the development of social skills in autistic children through daily activities.

On the basis of these assumptions, a robot was designed and built at the Lab-H of the Department of Human, Philosophical and Education Sciences of the University of Salerno with the aim of promoting the development of social skills in subjects affected by autism spectrum. This robot is called ASD-Robot has the purpose of training to recognize and understand emotions through the use of video games in order to encourage social interaction. The robot was designed through the Rhinoceros CAD software and physically built with the use of the Prusa MK3s 3D printer, using a modified PLA as a material to ensure higher mechanical strengths and reduce production costs to be accessible to all users. In fact, the 3D model of the robot will be made open-source on the site of the LAB-H of the University of Salerno, which contains all the information and developments of the robot. As for the hardware and software part of the robot, the Arduino Uno board is equipped to control the movements of the arms and neck of the automaton. In the first version the robot was equipped with LED matrices on the face to be able to express the different emotions, but later they were replaced by an LCD. In the next version, some components of the robot have been taken from another Lab-H project, the DISUFFO (Di Tore, Todino, Sibilio, 2019) robot, which is equipped with an Arduino Uno microcontroller and a Raspberry Pi processor, so that they can be use both cards according to the different needs of users. "It is also possible to customize the robot according to the different problems that a possible child therapist highlights. Furthermore, it is possible to customize the robot according to the different problems that a possible child therapist highlights" (Campitiello, Todino, Di Tore, 2020).



ASD-Robot design



Rendering of ASD-Robot

2. ASD-Robot: first test in primary school in Pagani (Salerno)

A first experimentation of the ASD-Robot prototype was carried out in a primary school "Collodi" in Pagani in the province of Salerno. The trial took place in 2019, in the months of March and April and involved a ten-year-old boy who was diagnosed with autism spectrum disorder. The ASD-Robot prototype was tested in a real environment to understand how it works and to resolve any errors. During the period in which the observation was carried out, the support teacher and the therapist were present in the classroom, in fact, initially the robot only supported the therapist during the daily therapy sessions, and was subsequently also introduced in other activities. Specifically, the child had difficulty in pronouncing and memorizing common names and in understanding the concept of quantity, so even the transcription of numbers took place mechanically. The child was assigned an educational program focused on the acquisition of social rules and the names of various objects in order to be able to formulate simple personal requests. The educational intervention for the child was based on the ABA (Applied Behavior Analysis) method to reduce behavioral problems and encourage the acquisition of new skills. In fact, the child had a systematic organization of the day, the actions he performed were based on the rules previously established by the therapist, with moments of pause in which the child could release all the tension accumulated during the exercises. The first day the robot was introduced into the classroom, the child acted as if he hadn't noticed the robot's presence. When the teacher asked him to express his feelings, the child expressed his curiosity by approaching the robot to touch it and stare at the Leds on the screen. The first approach was positive, as the child continued to be intrigued by the presence of the robot and was also attracted by the Led lights. In the following days, during the therapy sessions, the robot formulated questions suggested by the therapist to observe the child's reaction. At first the child showed difficulty in understanding the words spoken by the robot, probably because he was not familiar with the automaton's voice, but after further attempts he was able to answer all the questions correctly. Although, the introduction of the robot in the therapy sessions generated a change in the child's habits, he immediately accepted the robot's company without showing any annoying attitudes. As for the test on the recognition of different emotions, it was not possible to conduct this experiment, as the child was not able to recognize emotions and facial expressions. Therefore, the Alpha test highlighted a positive aspect in the interaction between the robot and the child, as the robot's support creates innovative situations that seem to reinforce the therapy. The next objective concerns the possibility of extending the tests and making the robot interact with more autistic children to assess whether these problems can vary over time through the support of the robot.

3. Perceptual and sensory development in autism

The ability to correctly perceive environmental stimuli is a central aspect in the social and communicative dimension. Sensory experiences are relevant for perceiving the external environment and operate through specialized sensory organs that are classified into *exteroceptive receptors* (produced outside an organism) and *enteroceptive receptors* (produced within an organism) (Bogdashina, 2016). Further, the exteroceptive sensory organs are divided into distance senses and contact senses. An example of remote exteroceptive sensory organs are hearing, sight and smell, while the exteroceptive sensory organs in contact are taste and touch. Sensory systems are usually divided into: sight, hearing, vestibular system, smell, proprioception and touch. The sensory organs have the task of transforming sensory stimuli into electrochemical signals processed by the brain. For this reason, knowledge of the world comes from our senses through the process of perception that begins with sensation. Sensations vary according to duration and intensity, and can be divided into *affective* (pain and pleasure) and *representative* (taste, touch and smell) (Bogdashina, 2016). The ability to perceive the complexity of environmental stimuli is not innate in the child but develops over time. Gibson (1969) identifies three dimensions of cognitive development: 1) the increasing specificity of discrimination, ie in the maturation phase, organisms restrict their reactions to a stimulus; 2) optimization of attention, as perception changes evolutionarily; 3) increasing autonomy in the collection of information, in which children learn to recognize an object by focusing on a few characteristics.

Although autistic children live in our own physical world, they have a different way of perceiving the surrounding environment and manifest it through apparently meaningless behaviors. This different way of perceiving reality is the basis of peculiar communicative and cognitive styles but also a source of discomfort (Bogdashina, 2016).

Since the 1970s, the different theories on probable deficits in Autism Spectrum Disorder, such as the theory of mind (Baron-Cohen, Leslie and Frith, 1985), the theory of weak central coherence (Frith, 2003) and the theory of deficit of executive functions (Ozonoff 1995), have focused on cognitive development, believing that low-level perceptual processes are intact in subjects with autism (Frith, 2003). In recent years, some researches (Doman 1984; Robbins, 2008; Cass 1996, Gense and Gense, 1994) have highlighted how sensory problems are at the basis of the characteristics of this disorder. Studies on sensory deprivation (Doman 1984; Forrest 1996) have shown how a sudden deprivation of sensory stimulation can cause autistic-like behavior. Cass (1996) highlighted how social interaction disorders and motor stereotypies can occur in a similar way in blind children and in children with autism. In fact, behaviors such as rocking, rotating objects and continually touching them in a room are similarly present in autistic children and children with visual impairments (Gense and Gense, 1994). The causes of these ritual behaviors can be perceptive in nature, since through such behaviors autistic children are able to perceive the surrounding environment and have greater safety. For this reason, much research has focused on sensory differences in autism and how the latter affect behavior, language acquisition and communication and social development (Bogdashina, 2013). Baruth et al. (2010) hypothesize that the sensory gating deficit present in autism spectrum disorders, that is, a disorder of the inhibitory function of the brain which consists in the inability to suppress distracting stimuli towards irrelevant sensory inputs, could be linked to inadequate sensory processing. This lack of filters can lead to sensory overload and lead to self-imposed sensory deprivation with severe long-term psychological damage (Forrest, 1996). The way of perceiving the world of people with autism is different, they have unusual sensory experiences and seem to perceive the world in a literal way without interpretation (Bogdashina, 2016). In addition, people with autism manifest hypersensitivity, many incoming stimuli, or hyposensitivity to sensory, i.e. few incoming stimuli. For this reason, they develop defensive strategies to safeguard themselves from information overload through the acquisition of perceptual styles which are: 1) mono-processing, that is, the brain processes information in only one way; 2) peripheral perception, such as the avoidance of the perception of some sensory systems; 3) the compensation of an unreliable sense, for autistic children a single sense is not enough to give meaning to the environment; 4) resonance, some stimuli are fascinating and a resonance is generated with them; 5) daydreaming, such experiences are common in individuals with autism and are difficult to explain (Bogdashina, 2016). Other sensory disorders may occur in children with autism spectrum disorders such as: synaesthesia, which consists of an involuntary experience that occurs when a sensory modality is stimulated and triggers the perception of multiple senses; prosopagnosia, understood as the inability to recognize familiar faces and also linked to a difficulty in understanding and expressing emotions; central auditory processing disorder (CAPD), which includes hypersensitivity, hyposensitivity and the inability to modulate some sounds; Scotopic sensitivity / Irlen's Syndrome (SS / IS), that is a visual perception disorder that manifests itself with sensitivity to light, narrow field of recognition, attention deficit and fatigue; sensory integration dysfunction (SID), developed by A. Jane Ayres to describe the various neurological disorders and explain the relationship between behavioral deficits and sensory disorders; motor coordination problems, such as motor aphasia, abnormal clumsiness, psychomotor deficiencies and motor language are common in individuals with autism. Usually the educational interventions for a child who receives a diagnosis of autism focus on the development of social and communication skills, leaving out the sensory perceptual problems that can manifest themselves differently in each individual. This is due to the difficulty of detecting these problems in children with autism as they are often "invisible" compared to cases of disability, such as blindness (Bogdashina, 2016). For this reason, the context in which children are placed does not help to face these sensory difficulties, which are different according to the sensory perceptual profile of each individual. The presence of different perceptual profiles in children with autism makes the choice of treatment program difficult, as it could benefit one child but harm another. In the event that adequate treatment is not offered to address sensory issues, the child may implement methods to compensate for this lack, such as stereotypical behaviors, aggression and self-harm (Bogdashina, 2016). Therefore, it is essential that professionals working with autistic children are able to understand the sensory differences of autism, in order to find the most appropriate methods for interventions.

An approach that takes into account the sensoriality in the interaction between child, therapist and robot

In autism spectrum disorders, the diagnosis is often accompanied by an anomaly in sensory processing in terms of auditory, visual and tactile stimuli. In children with autism, these sensory differences affect behavior, social interaction and language acquisition, as well as the way they understand the environment around them.

Furthermore, it appears that children with autism show a strong interest in technologies, and in particular robots, such sensory difficulties can be studied through the use of the robot in a controlled environment. Robots can stimulate curiosity in children in general and in children with ASD in particular (Dunst et al, 2013). These autonomous can reproduce personalized gestures (by the therapist and the educator) and emit sounds (both vocal and musical) to favor the comunication. In this way, the robot could support children who manifest hypersensitivity or hyposensitivity to sensory stimuli, helping them to understand the outside world with specific interventions. This vision of educational therapy is a possible version of didactic action in which robots could be equipped with multisensory effects (such as lights, sounds and movement) and multimedia contents. In this way the robot could act as Assistive Technology (AT) and constantly support therapists and educators during the teaching-learning process. For this reason, the main goal is to redesign ASD-Robot taking into account the different "unusual" perceptual experiences of children with autism. Furthermore, through the Alpha test, done in Pagani, it was possible to test the prototype in a real environment and understand any changes to be made. Specifically, ASD Robot will be implemented with coloured buttons, Led lights and fabric. The coloured buttons have the function of providing an answer based on the activity that the child performs, so just press the button of the right colour to answer correctly. On a technical and visual level, the Led lights that will cover the end of the robot will change the color in reference to the activity and the function will be to offer the child different stimuli to create a multisensory environment. At a sensory and tallile level, the robot will also be covered with fabric that will be soft to the touch, allowing the child to explore the touch. In terms of control and use, the robot can be controlled remotely, via the remote control integrated into a PC, in order to manage the interaction and make the automaton perform the actions at the appropriate time. Regarding the collection, storage and analysis of data concerning the child, the robot will be equipped with software that allows it to collect the child's sensory information, such as eye tracking and recognition of facial expressions; in this way it is possible to monitor the progress of the therapy and offer the opportunity for therapists and educators to observe the child when he interacts with the robot. ASD-Robot will be made customizable according to the different characteristics of the child (and of the educator or researcher), if for example it is particularly sensitive to sounds or light, it will be possible to adjust the sensory information emitted by the robot during the interaction to allow to reduce or expand them according to the characteristics of the child. Besides, the robot will be able to interact with a series of stimuli designed to make the child relive their daily experiences. Children with autism have an extremely inhomogeneous cognitive profile, for this reason any intervention needs to be customized on each of them. Therefore, a custom-made robot can be modified according to the child's therapy and it allows the child to train daily in strengthening her/his abilities.

Conclusions

A first robot's alpha test, intended as an experimentation of the initial prototype and above all of its software and configuration (Campitiello, Todino, Di Tore, 2020), was done and it has allowed to understand that the interaction between the robot and an autistic child, who has made himself available for experimentation, and for this reason thanks his family, he was favorable and the data will be published in the doctoral thesis. More in details, when this robot supports a therapist, it seems to reinforce the therapy and create innovative situations for autistic children. The next goal concerns precisely the possibility of extending this test to more autistic subjects and understanding how these problems, especially at a social level, can vary over time through support and interaction with the robot. The main challenge is to demonstrate the effectiveness of the binomial robotics and autism, if robots are truly able to provide real relief from the isolation that characterizes Autism Spectrum Disorder. ASD-Robot, as showed, was already tested at the "Collodi" primary school in Pagani in the province of Salerno, starting from this point more features will be coding to improve robot capability to support ASD children in sensory perception and helping them to understand the environment around to improve social skills and interaction.

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