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EXPLORING EMOTIONAL AND IMITATIONAL ANDROID-BASED INTERACTIONS IN AUTISTIC SPECTRUM DISORDERS

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Individuals with Autistic Spectrum Disorders (ASDs) have impairments in processing of social and emotional information. To widen emotive responsiveness, the employment of robotic systems to engage proactive interactive responses in children with ASDs has been recently suggested. Understanding and teaching the processing of socio-emotional abilities is the inspiring principle of this novel approach and could be of tremendous clinical significance. Encouraging studies with robotic dolls, mobile robots and humanoids acting as social mediators have provided important insights and demonstrate the necessity of long term studies. In this study we report on a series of experiments on four subjects affected by ASDs as they interact with a biomimetic android. We assessed both their spontaneous behavior and reactions to therapist presses in correlation with the time course of the physiological and behavioral data, as well as the focusing of attention towards the android's eye movements and the spontaneous ability to imitate gesture and facial expressions. Overall, subjects demonstrated a decrease in dysfunction in the areas of social communication, implying a marked improvement in these areas after interacting with the android.

Introduction

Although symptoms belonging to the Autistic Spectrum Disorders (ASDs) were first described 50 years ago (Kanner, 1943), improved understanding of this complex spectrum of disorders has emerged over the past two decades, and, despite recent intense focus, it continues to be an art and science that is quickly evolving. ASDs refer to a wide continuum of associated cognitive and neuro-behavioral disorders. People with ASDs demonstrate impairments in processing of social and emotional information within core deficits in reciprocal social interactions, verbal and nonverbal communication, and restricted and repetitive behaviors or interests. In addition to being a spectrum disorder, ASD has a marked variability in the severity of symptomatology across patients, and level of intellectual function can range from profound mental retardation through the superior range on conventional IQ tests, which indicates that there may be additional subtypes on the spectrum.

The term ASDs in this work is used to refer to the broader umbrella of pervasive developmental disorders (PDD), whereas the specific term autistic disorder is used in reference to the more restricted criteria as defined by the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2000). Recent publications reported that early in the new millennium the best estimate of current prevalence of ASDs in Europe and North America is approximately 6 per 1,000 (Johnson, Myers, & the Council on Children With Disabilities, 2007). A multi-

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plicity of genetic and environmental factors play a role in ASDs, but the exact cause is still unknown. ASDs are believed to be mainly genetic, but environmental exposures in early gestational life can modulate spontaneous mutations and/or alterations in genetic imprinting following an epigenetic heritable mechanism. Only 10% of ASD cases may be associated with a medical condition or a known syndrome (Johnson, Myers, & the Council on Children With Disabilities, 2007).

In recent years, novel neuropathology and neuroimaging studies have indicated cues for a neurobiological basis of ASD. Fundamental differences in brain growth and organization in people with ASDs were revealed, such as a reduced numbers of Purkinje cells in the cerebellum, an abnormal maturation of the forebrain limbic system, abnormalities in frontal and temporal lobe cortical minicolumns, developmental changes in cell size and number in the nucleus of the diagonal band of Broca's area, and brainstem abnormalities and neocortical malformations (Johnson, Myers, & the Council on Children With Disabilities, 2007).

There are very useful instruments that can create comparability across clinicians and researchers, as well as instruments that can individuate more homogeneous groups for research: Autism Diagnostic Interview - Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994) and Autism Diagnostic Observation Schedule - Generic (ADOS-G; Lord et al., 2000) are complementary instruments currently defined as the "gold standard" diagnostic instruments. The CARS scale (Childhood Autism Rating Scale; Schopler, Reichler, & Renner, 1988) was developed in order to aid in the diagnostic process, but it is also used to assess changes in autistic symptomatology. The CARS scale is subdivided into 15 items relative to the main behavioral areas. It is assigned a variable score from 1 to 4 for every item; a score of 1 indicates a behavior appropriate to the age, while a score of 4 indicates an abnormal behavior. The total score obtained after the CARS test has an undeniable diagnostic and clinical usefulness. By examining the score of the single items of the test it is also possible to characterize other patient behaviors.

Individuals with ASDs have impairments in assessing face and emotion recognition, eye-to-eye gaze, imitation of body movements, and interpretation and use of gestures. Imitation is thought to play a key role in developing theory of mind, and subjects with ASDs have limited and schematic means of processing and reproducing emotions and gestures (Baron-Cohen, 1997; Dawson, Meltzoff, Osterling, & Rinaldi, 1998). Marked impairments in social interaction and communication seen in ASDs are far more complex than presumed and share some similarities with the deficits seen in children with developmental language disorders or specific language impairments. There are few efforts that tackle the problem of how social and physical interactions contribute to the development of the network architecture of the brain, and there are also few that examine what features of the brain are essential to make social behavior possible. Typically developing infants show preferential attention to social rather than inanimate stimuli; in contrast, individuals with ASDs seem to lack these early social predispositions (Spelke, Phillips, & Woodward, 1995; Maestro et al., 2002).

When viewing naturalistic social situations, people with ASDs demonstrate abnormal patterns of social pursuits. For example, healthy children usually imitate the behavior of an interlocutor, whereas children with ASDs do not, and this can have serious consequences. Individuals with ASDs have "mindblindness," deficits in conceiving other peoples' mental states (Baron-Cohen, Ring, Bullmore, Wheelwright, Ashwin, & Williams, 2000). It has been suggested that their difficulty in conceiving of people as mental agents often leads to typically inappropriate reactions or behaviors in a variety of social interactions (Baron-Cohen, 1997). Recently it has been proposed that the social impairments of ASDs can be caused by a dysfunction of the mirror neuron system, speculating that the ability to imitate actions and to understand them could have subserved the underdevelopment of communication skills (Hamilton, Brindley, &

Frith, 2007; Iacoboni & Dapretto, 2006). Following recent studies showing how individuals, particularly those with high functioning autism, can learn to cope with common social situations if they are made to enact possible scenarios they may encounter, it can be hypothesized that the imitation skills of children, and thus their social development, could be enhanced through specifically designed treatments based on imitation (Nadel, Revel, Andy, & Gaussier, 2004).

The abovementioned considerations indicate that robotic technology may be used to help subjects with ASDs because understanding and teaching face recognition and emotion processing could be of tremendous clinical significance. State of the art robot-based therapy has shown the usefulness of the interaction of a robot with autistic patients within a highly structured environment where it is possible to recreate social and emotive scenarios that can be used to incentivize and anticipate actions of a subject (Duquette, Michaud, & Mercier, 2007). People with ASDs focus their attention on specific details; therefore interaction with a robot may allow an autistic subject to concentrate herself/himself on the limited number of communication modalities of the robot. In addition, while the stress of learning with a teacher can often be excessive, interaction with a robot, which young patients often associate with media and/or cinema characters, can reduce the emotional and social pressure of the situation, allowing the child to better learn from the environment at his or her own speed.

Several groups are developing and studying robots for use in the treatment of ASDs (Dautenhahn & Werry, 2004; Kozima, Nakagawa, & Yasuda, 2007). In these studies, robotic artifacts are used to act as social mediators in order to increase the social interaction skills of children with ASDs. Their encouraging studies demonstrate the necessity of more long term studies. An android-based treatment focused on the embodiment of emotions, empathy and interactive imitation represents a cutting-edge technological achievement (Pioggia et al., 2007). In this approach the three dimensional life-like android, FACE, presents emotional information in a structured and stepwise manner in order to engage a child with an ASD in social interaction based on mutual exchange of emotion through reciprocated imitation and learning emotion through the robot's facial expressions and gestures.

This could enhance the capability of the child to process emotions. In this paper we report on four subjects affected by ASDs and their interaction with FACE, while assessing both their spontaneous behavior and reactions to therapist presses in correlation with the time course of the physiological and behavioral data. The focusing of attention towards the android's eye movements and the spontaneous ability to imitate gesture and facial expressions were also investigated.

ASD and robots: social interaction and communication

The use of robotic technology aimed to help autistic subjects in everyday life began in 1976 with the work of Sylvia Weir and Ricky Emanuel (Weir & Emanuel, 1976). They used a mobile turtle-like robot, LOGO, to interact with a person with ASD. More recently François Michaud and his research team (Michaud, Salter, Duquette, & Laplante, 2007) at the University of Sherbrooke investigated the use of mobile robots as a treatment tool. They tested several robots, different in shape, color and behavior, in order to determine the main characteristics that may capture the attention of people with ASD. They obtained important insights for the idea of human-robot interaction in autism, sustaining the robot hypothesis as useful. By involving four children in a pilot study, they showed how a mobile robot can facilitate reciprocal interaction such as imitative play (Duquette, Michaud, & Mercier, 2007). In particular, they found that children paired with the robot mediator demonstrated increased shared attention (visual contact, physical proximity) and imitated facial expressions (smile) more than the children paired with a human mediator.

A more structured approach to the use of autonomous robots is the AuRoRA project (AUtonomous RObotic platform as a Remedial tool for children with Autism; Dautenhahn, Werry, Rae, Dickerson, Stribling, & Ogden, 2002; Robins, Dautenhahn, te Boekhorst, & Billard, 2004a; Robins & Dautenhahn, 2006). AuRoRA represents the first systematic study on a therapeutic approach utilizing robots for autism. In this project, people with ASD are invited to interact in coordinated and synchronized social actions with robots and their environment. The focus is on assessing if and how simple imitation and turn taking games with robots can encourage social interaction skills in children with autism. Moreover, how the robot, assuming the role of a mediator and an object of shared attention, can encourage social interaction with peers (other children with or without autism) and adults is investigated. Behavior-based control architectures and different robotic platforms such as mobile and humanoid robots are used. Examples of mobile robots in AuRoRA are Labo-1, a flat-topped robot buggy equipped with eight infrared sensors and optional heat sensors, and Pekee, an oval shaped robot with a plastic casing, two motorized wheels, and freely rotating caster wheel. Examples of humanoids, which allow the interaction to be based on empathy, are Kaspar, a child-sized robot equipped with a silicon-rubber face and two Degrees of Freedom (DOF) eyes fitted with video cameras, and Robota, a series of humanoid robotic dolls able to drive the arms, legs and head giving one DOF to each. Kaspar is aimed to mimic some human behaviors and to teach social skills; it is able to blink its eyes, to open/close the mouth and smile, as well as to act startled at a sudden gesture, although it is not able to produce subtle facial expressions.

Table 1. Autism rating scale for the selected subjects

Subjects	**Age**	**IQ**
S1	10y6m	105
S2	9y6m	87
S3	8y11m	85
S4	20y6m	52

Robota is the name of a series of doll-shaped mini-humanoid robots developed in a project headed by Aude Billard (Billard, Robins, Dautenhahn, & Nadel, 2007). The possible therapeutic effects of human-Robota bodily interaction, including eye gaze and touch, with ASD children was tested in imitative interaction games. Such games, based on requests for the child to imitate the robot, are important factors in a child's development of social skills and could help children with autism in coping with the normal dynamics of social interactions. Researchers also studied Robota's behavior, appearance, Robota-mediating joint attention, and interaction informed by conversation (Dautenhahn & Billard, 2002; Robins, Dautenhahn, te Boekhorst, & Billard, 2004a; Robins, Dautenhahn, te Boekhorst, & Billard, 2004b; Robins, Dickerson, Stribling, & Dautenhahn, 2004; Robins, Dautenhahn, te Boekhorst, & Billard, 2005; Robins, Dickerson, & Dautenhahn, 2005).

A similar approach inspired Infanoid and Keepon (Kozima, Nakagawa, & Yano, 2004; Kozima, Nakagawa, & Yasuda, 2007) developed by Hideki Kozima at the National Institute of Information and Communications Technology (NICT) in Japan. Infanoid is an upper-torso child-like robot, capable of pointing, grasping, and expressing a variety of gestures, while Keepon is a creature-like robot capable of expressing its attention (directing its gaze) and emotions (pleasure and excitement). They observed that contingency-games with Infanoid could benefit children in learning communication skills (Kozima, Nakagawa, & Yano, 2002; Kozima, Nakagawa, & Yasuda, 2006), and interaction with Keepon facilitates social interactions in 2- to 4-year-old children with ASD (Kozima, Nakagawa, & Yasuda, 2007).

In our study, we adopted a biomimetic approach in order to explore the field of assessment and treatment of subjects with ASD in a dynamic, activity-dependent manner based on embodiment of emotions, empathy, and interactive imitation with a believable android (Pioggia et al., 2004; Pioggia, Igliozzi, Ferro, Ahluwalia, Muratori, & De Rossi, 2005; Pioggia et al. 2006; Pioggia et al. 2007). In our FACE project (Facial Automaton for Conveying Emotions), the recent developments of emotional cognitive architectures and smart materials allowed an embodied interaction scheme based on imitation and empathy to be adopted in a more naturalistic setting in order to help children with ASD to learn, interpret, use and extend emotional information in a social context. The FACE android is used to engage the child in simple interactions based on exchange of emotions and learning emotion through imitation of the android's facial expressions and behaviors. FACE can also be employed in more complex situations, through the recreation of social and emotive scenarios which can be used to incentivize and anticipate actions of a subject. FACE captures expressive and psychophysical correlates from its interlocutor and actuates behaviors with kinesics, a non-verbal communication conveyed by body part movements and facial expressions. Both physiological and behavioral information from the patient is acquired in real time by means of an unobtrusive sensitized wearable interface (life-shirt) during treatment. In the framework of a social therapy, FACE itself, the sensitized life-shirt, and the therapeutic protocol acting between a patient and a trained therapist in a specially equipped room, all represent the FACE-T system (T as in "therapy"). This approach provides a structured environment that people with autism could consider to be "social," helping them to accept the human interlocutor and to learn through imitation. On the basis of a dedicated therapeutic protocol, FACE is able to engage in social interaction by modifying its behavior in response to the patient's behavior. If such learned skills can be extended to a social context, the FACE-T system will serve as an invaluable tool for the evaluation and treatment of ASD. The involvement of FACE-T could also provide the necessary assessments for a robot's effectiveness in socio-emotive exchanging in ASD.

FACE, an embodied interactive social interface

In the FACE-T scheme of embodied interaction between humans and systems, we considered both innovative devices and communications paradigms for the social and physical interface with the human sensory system. We used a new generation of unobtrusive monitoring interfaces known as smart clothing. They consist of electronic sensing textile interfaces as a novel artificial embodiment concept where both vital signs (Paradiso, Loriga, & Taccini, 2005) and/or behaviors in terms of body segment position reconstruction and posture classification (Tognetti, Bartalesi, Lorussi, & De Rossi, 2007), as well as relevant information from the environment can be unveiled. Emerging wearable systems will be able to detect psycho-physiological responses by extracting features from a subset of physiological and behavioral signals needed for the evaluation of an egocentric psycho-emotional, as well as an allocentric status, based on the mirroring of others' emotional reactions within the framework of a visionary interacting emotional prosthesis. While physiological and behavioral signals provide streams of allocentric information, FACE conveys emotional responses, eye movements and bodily gestures, taking into account the actuation of a behavior-based control, as well as an imitative learning strategy. The latest prototype of FACE is shown in Figure 1. FACE's visage is able to express and modulate the six basic emotions (happiness, sadness, surprise, anger, disgust, fear) in a repeatable and flexible way. The strictly humanoid design underlines a high degree of believability in the semblance, placing the socio-emotional relationship domain of the android close to human beings. In fact, FACE consists of an anthropomorphic body equipped with a believable face based on biomimetic principles. FACE's artificial sensing skin provides streams of spatial and temporal information, where-

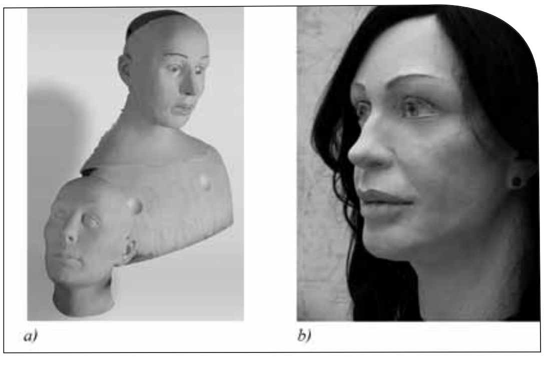


Figure 1. a) the latest FACE prototype; b) a detail of the android

as servomotors allow FACE to modulate facial expressions. The hybrid multisensory signals are generated from a synergy between an android-centered polymorphic perception system (*egocentric sensing system*) and a human-centered one (*allocentric sensing system*). Together they encode both FACE's and the subject's presence as well as their behaviors and emotional states.

The *egocentric sensing system* consists of an artificial sensing skin which accounts for proprioceptive mapping and a visual eye-like system. The FACE artificial sensing skin is three-dimensional latex foam, under which lie sensing layers, connections, and digital pre-processors able to detect the overall shape, stress, strain and localized deformations of the skin. The integral impedance pattern is in fact a function of the overall shape of the sensorized fabric and allows mapping between the electrical space and the shape space. The sensing layer responds to simultaneous deformations in different directions by means of a piezoresistive network which consists of a Conductive Elastomer (CEs) composite rubber screen printed onto a cotton lycra fabric. CE composites show piezoresistive properties when a deformation is applied and can be easily integrated into fabrics or other flexible substrates to be employed as strain sensors. They are elastic and do not modify the mechanical behavior of the fabric. CEs consist of a mixture containing graphite and silicon rubber. In the production process of sensing fabrics, a solution of CE and trichloroethylene is smeared on a lycra substrate previously covered by an adhesive mask. The mask is designed according to the desired topology of the sensor network and cut by a laser milling machine. After the deposition, cross-linking of the mixture is obtained at high temperature. Furthermore, by using this technology, both sensors and interconnection wires can be smeared by using the same material in a single printing and manufacturing process. FACE's artificial eyes scan the environment to track a human face and generate a visual signal which encodes essential information about the interlocutor's expressions, as well as emotional reactions. This signal is pre-processed by a retina-like dedicated unit and then it is sent to a neurocontroller.

The *allocentric sensing system* consists of a biomimetic wearable suit (life-shirt) integrated into the FACE-T system, for the unobtrusive acquisition of physiological and behavioral signals from the interlocutor. The life-shirt integrates smart sensors within a garment together with on-body signal conditioning and pre-processing, as well as the power supply and the wireless communication systems. Three key points make up the life-shirt: the fabric electrodes based on interconnecting conductive fibers, a piezoresistive network, and a wearable wireless communication unit. Electrodes and connections are interwoven within the textile by means of natural and synthetic conductive yarns. Their suitable positioning provides real-time acquisition of the electrocardiographic signal as well as skin temperature and electrodermal response. Simultaneously, intelligent reading strategies of unobtrusive piezoresistive networks developed by direct screen printing of CEs and physiological modeling allow human kinematic variables and breath rhythm to be acquired. The integrated and processed outputs are observable patterns of activity emerging from interactions. Predefined stereotypical behaviors of activity can be represented in terms of FAPs (Fixed Action Patterns) followed by a continuous interaction. FAPs can be classified according to the action schemes they belong to. Gestures and stance can be coded in terms of FAPs by means of the life-shirt. Such a code can enable the recognition of the interpretation of the individuals' activities. Due to subject variability of FAPs and the novel FAPs emerging from the usual motor actions within the environment, instruments such as adaptive artificial neuronal networks are devoted to personal gesture recognition and interpretation, as well as FAP classification.

Acquired signals are transmitted to a common framework that performs the processing tasks. The great variety of the sensory signals acquired by all the interfaces are input to a neurocontroller in the form of an integrated signal. This represents a challenging task both in signal processing and in data mining, which is managed by an ad-hoc developed framework architecture. The framework manages and synchronizes data and signals from all elements of FACE's embodied interactive interfaces in order to perform their comprehensive dynamic integration to generate an input for FACE's neurocontroller.

FACE's control strategy during the sessions follows a behavior-based approach supervised by a therapist. An essential prerequisite to emulate imitation in a robot is a connection between the sensory systems and the motor systems such that percepts can be mapped onto appropriate actions. Through imitation, FACE will get the necessary training to encode the patient's emotional expressions, and through the feedback and actuation described, it will be able to reproduce them to imitate the interacting subject's emotions. FACE's emotional expressions can also be structured on the basis of the clinical treatment protocol or tailored to each subject. During the clinical trials, the therapist can also directly control FACE's emotional expressions in real-time. Moreover, through the presentation of different social situations within the experimental set-up, FACE can contribute to enhance the pragmatic use of emotions. The cognitive architecture of FACE is shown in Figure 2. The external world is sensed by FACE and the different stimuli are extracted in terms of neural group activities.

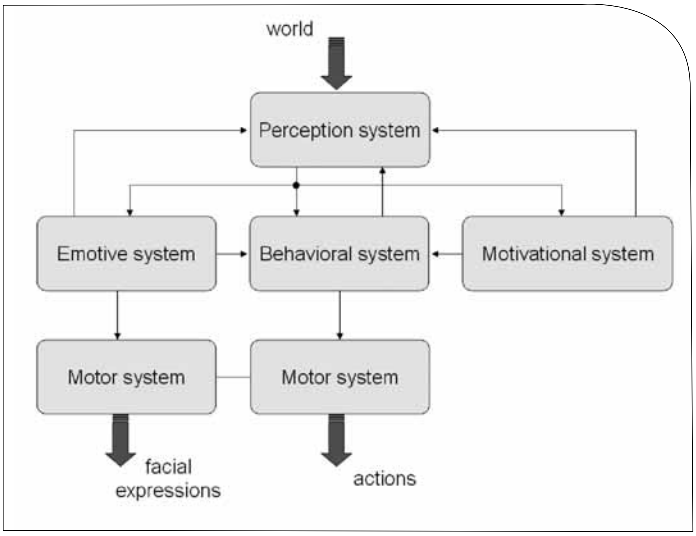


Figure 2. FACE's cognitive architecture

In the Perception System, these activities are bound by threshold controlled processes that encode the current set of beliefs about the internal and external state of the android and its relation to the world. The result is a set of response-specific thresholds that serve as antecedent conditions for specific behavioral responses. The Emotive System sends feedback to the Perception System in order to participate in the evaluation of the stimulus, to the Behavioral System in order to participate in the selection of the behavior selection, and to the Motor System to activate the facial expression consistent with the emotion. The Motivational System is aimed at influencing behavior selection.

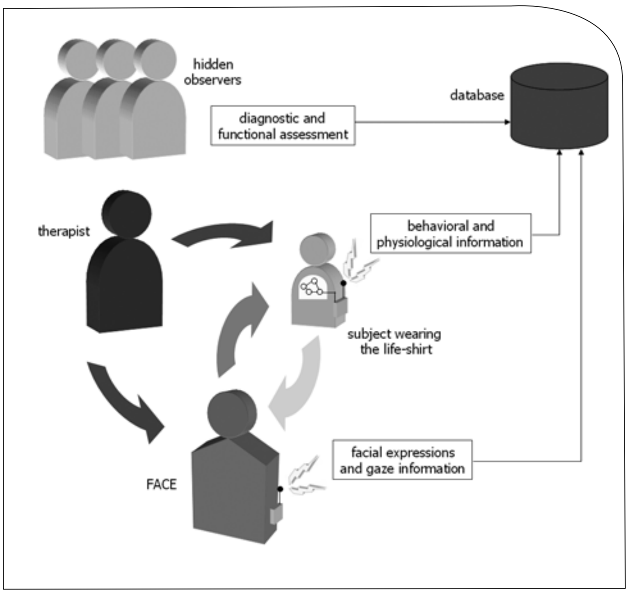


Figure 3. FACE-T set-up diagram

FACE - people with ASD interaction: experimental results

The FACE-T system (Figure 3) consists of a spe-

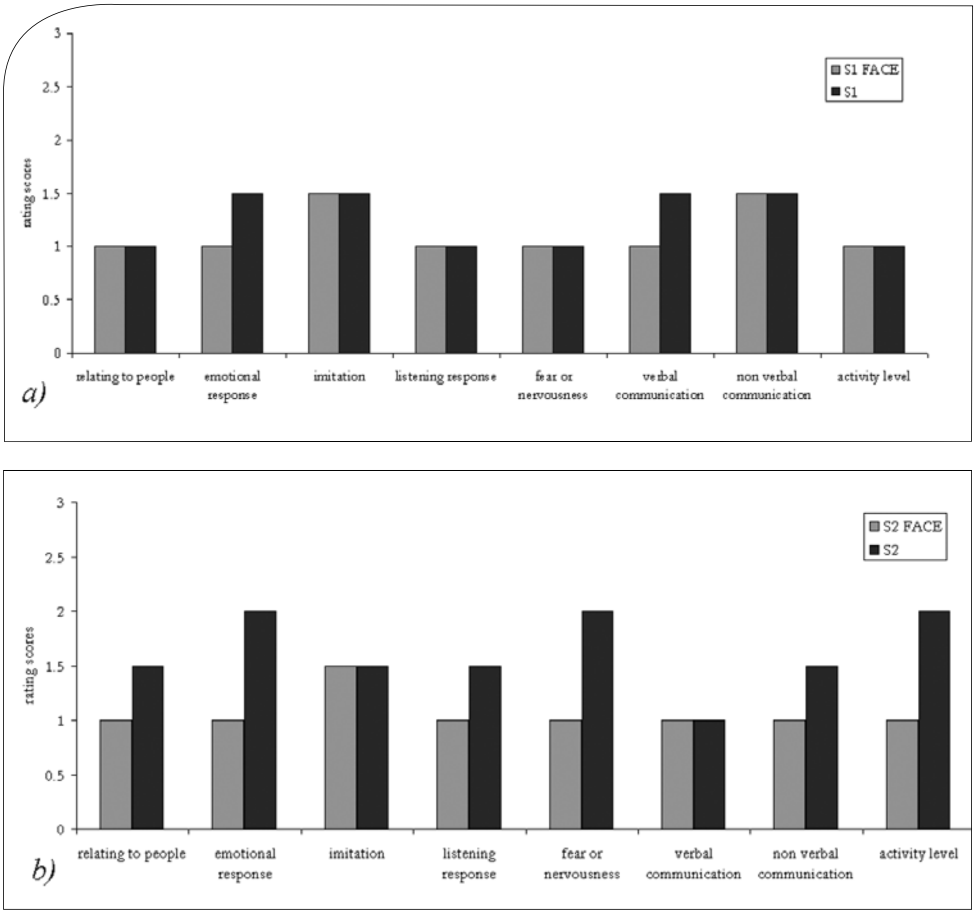
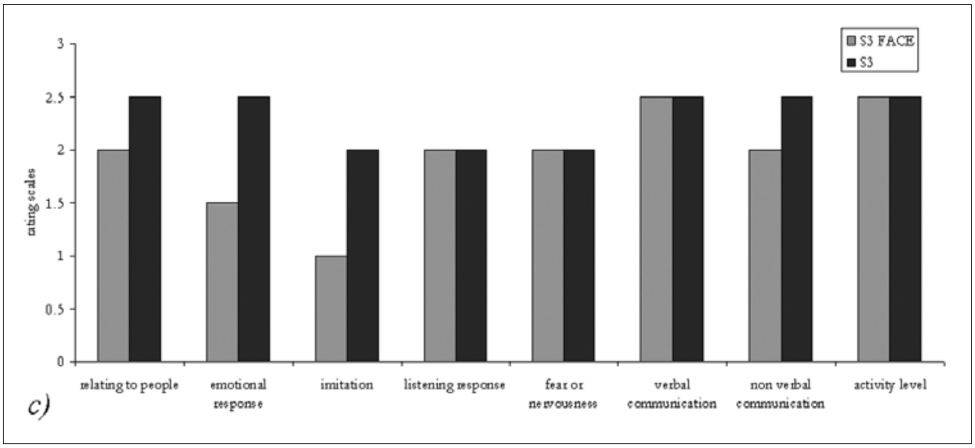
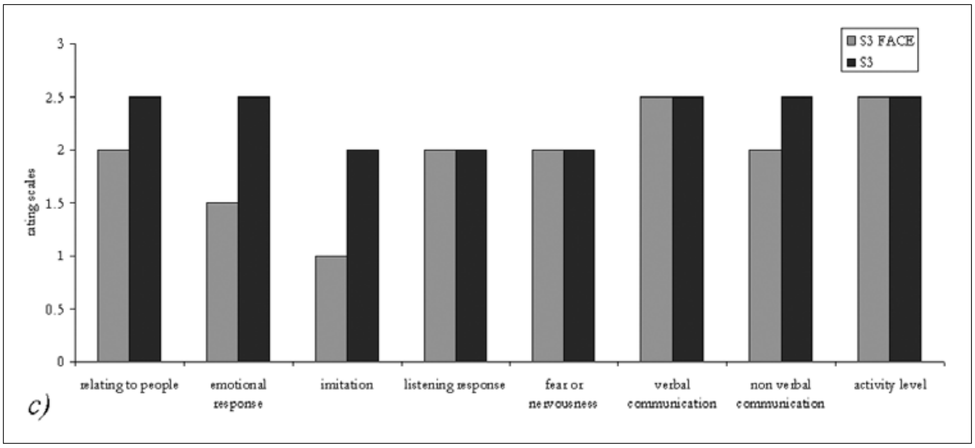


Figure 4. CARS score obtained from the experimental session with FACE (Sx FACE) and CARS score obtained from the observation of session with psychological tests (Sx); a) Subject 1 (S1) ; b) Subject 2 (S2); c) Subject 3 (S3); d) Subject 4 (S4).

cially equipped room with two remotely orientable video cameras, in which the child, under the supervision of a therapist, can interact with FACE. The subject wears the life-shirt for recording physiological and behavioral data. The database also contains data from the audio visual recording system present in the room. Other therapists or hidden observers compile evaluation sheets during sessions, and the data scanned from these will also be added to the database and used for successive analysis.

In order to obtain a preliminary evaluation of the behavior of children affected by ASD when exposed to FACE, we set up experimental sessions in which the reactions of four subjects (three male and one female) between 7 and 20 years old, were monitored and compared. In these sessions, a technician was also present to monitor the android's functioning and troubleshoot if necessary. The technician did not speak and was completely passive throughout the





sessions. The children with ASD had been diagnosed using ADI-R and ADOS-G with high functioning autism, and are currently under treatment at the Stella Maris Institute (IRCCS) in Pisa, Italy. Experiments were carried out in order to study the interaction with FACE during twenty minute sessions. Each session had a duration of about an hour and varied from individual to individual according to their reactions. We structured the session in five phases in order to examine specific aspects of the subjects' behaviors and reactions to FACE:

- spontaneous behavior of the child when the android and the therapist are present;
- shared attention of the child, i.e. the capacity of the child to focus the therapist's attention on the android;
- ability of the child to imitate gesture and expressions of the android upon the therapist's request;
- spontaneous ability of the child to imitate gesture and expressions of the android;
- verbal presses to the child to solicit interpretation of the behavior and facial expressions of the android.

In general, we observed that all the subjects were not afraid of FACE, but rather were attracted to the android. Some subjects walked up to touch FACE, whereas others remained seated but with their eyes on the android. We observed that none of the subjects paid any attention to the technician, as if this person did not exist. This behavior confirms the relevance of robots for social interaction in people with ASD. The evaluation of the sessions as described above

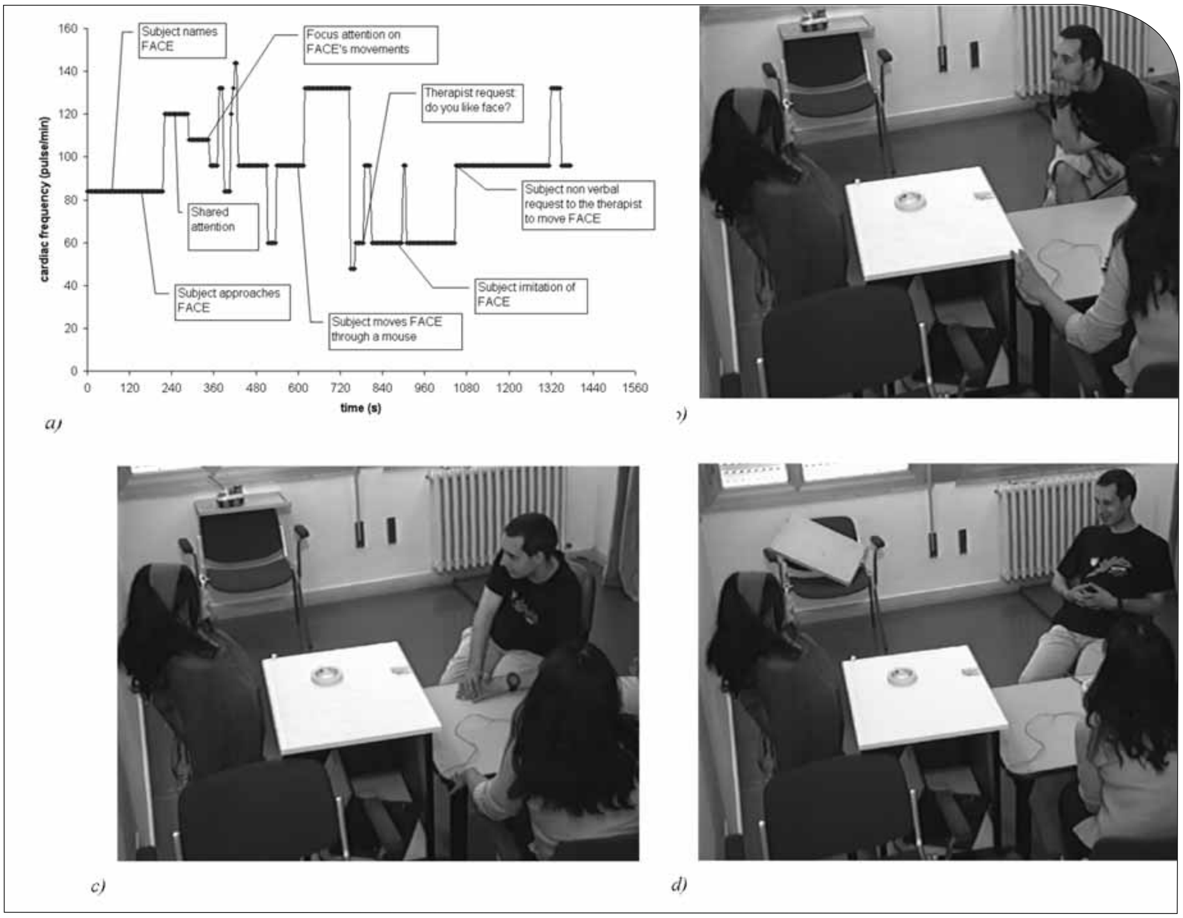


Figure 5. Experimental sessions; a) typical trace of a subject's heart rate during the treatment; b) focus of attention on FACE (S4); c) spontaneous approaching for eye contact with FACE; d) non verbal requesting through conventional gesture (S4).

was performed using eight relevant items from the CARS scale. Figure 4 supplies a graphical comparison between the score obtained in items of CARS scale in previous interactions during psychological assessment and the one obtained with FACE. In particular, we observed that the CARS score decreased or remained the same for all items in Subjects 2 and 3 after the therapy session. Only Subject 4 (the oldest, with the lowest IQ and highest ADOS rating) showed an increase of 0.5 points for listening, fear, and verbal communication. More importantly, all the subjects demonstrated a decrease in the score of emotional response in the CARS scale of between 1 and 0.5 points, and imitation in 3 out of 4 children, implying a marked improvement in these areas after interacting with FACE.

Even though these are the first set of clinical trials, it is clear that the presence of FACE in a therapeutic environment can lead to improvements in the areas of social communication and imitation. As shown in Figure 5a, the cardiac frequency of the patient increases after his or her attention is focused on the robot, and remains fairly high until he or she is forced to focus on his emotional relationship with FACE. Figures 5b, 5c and 5d show snapshots of an experimental session. In Figure 5b the subject is shown to completely focus his attention on FACE. Figure 5c illustrates spontaneous approaching of the subject to make eye contact with FACE. Figure 5d shows the non-verbal requesting of the subject through a conventional gesture (a wink). All four subjects (as well as controls) show no fear in the presence of FACE, and all subjects with ASD showed some improvement in CARS scores, particularly regarding imitation, communication and emotional response. Future work in this direction will focus on identifying specific criteria for evaluation of subject response, conducting a larger range of trails, and repeating treatment to monitor signs of progress in patients. These initial results illustrate the validity of the android-based FACE-T approach in social and emotive treatments for ASDs. We believe that its potency lies in the fact that FACE is based primarily on learning by imitation, and imitation is one of the core deficits implicated in ASD.

Conclusion

The interactive FACE-T scenario provides a novel semi-naturalistic tool that is able to engage in emotive exchange with subjects with ASD. This could be conveniently used to support cognitive behavioral therapy in order to enhance comprehension and expression of imitation, shared attention, and facial mimicry in people with ASDs. We carried out a series of trials on subjects affected by ASD, assessing both spontaneous behavior of the participants and their reactions to therapist presses in correlation with the time course of the physiological and behavioral data, as well as the focusing of attention towards FACE's eye movements and the spontaneous ability to imitate gesture and expressions of the android. Overall, subjects demonstrated a score decrease in the areas of social communication, implying a marked improvement in these areas after interacting with FACE. Our hypothesis is that treatment with FACE could develop pragmatic emotional responsiveness in several social scenarios.

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