Multimodal Human-Robot Interactions: the Neurorehabilitation of Severe Autistic Children

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Abstract—**In the context of human-robot interactions, we studied quantitatively and qualitatively the interaction between autistic children and a mobile toy robot during free spontaneous game play. A range of cognitive nonverbal criteria including eye contact, touch, manipulation, and posture were analysed, firstly in a dyadic interaction and secondly in a triadic interaction. Once the cognitive state between the child and the robot established, the child interacts with a third person displaying positive emotion. Both dyadic and triadic interactions of autistic children and a mobile toy robot suggest that the mobile toy robot in an ecological situation such as free, spontaneous game play could be used as a neural mediator in order to improve children's brain activity**.

Keywords-multimodal interactions ; severe autism ; mobile toy robot ; spontaneous free game play ; neural mediator.

I. Introduction

Different kinds of computer based technologies such as robots and virtual reality, i.e., human-machine-interactions (HMI), are being put to effective use in the education of autistic children. The studies we developed aimed to analyse the multimodal interactions of severely autistic children, during free game play with a mobile toy robot in both dyadic and triadic situations.

Autism is a severe neurocognitive disorder. Because the effects of autism can range from severe to mild, autism is considered to be a spectrum disorder [1]. Severe autism is characterized by repetitive and stereotypical behavior apparent by 3 years of age, impairment in verbal and nonverbal processes, emotional and social interaction. Its genetic and neurocognitive aetiology is unknown; different hypotheses have been and continue to be discussed. Autism is considered a complex multifactor disorder involving many genes [2], [3], [4]. These findings have given rise to new insights into neuronal circuits relevant to autism disorders. As would be expected, a large number of functional neuroimaging studies have demonstrated that different brain regions are involved in autism. In particular, these studies show that the neural substrate underlying cognitive, social and emotional impairment involves multimodal areas such as the exterior superior temporal sulcus [5], the interior temporal lobe, amygdala included [6], as well as the ventral part of the prefrontal cortex, i.e., orbital frontal cortex [7]. In addition, autistic children also show aberrant brain connectivity and disruption of white matter tracts between temporal regions [8] which disrupt verbal and nonverbal acquisition, consolidation as well as social interaction [9], [10], [11], [12]. Taken together, the aforementioned studies provide the basis for concluding that in autism the more impaired cortical areas are those that are involved in complex cognitive functions such as perception, language, social interaction and emotion. Such complex expression of autism necessitates a more generic consideration of this disorder at the neural level.

From a developmental viewpoint, the most widely accepted hypothesis in autism is the theory-of-mind deficit [13]. Even if this theory cannot account for the whole spectrum of autistic disorders, it raises many issues which not only involve mental representation of others but also social skills such as posture [14], eye contact [15], touching [8] and manipulation [16] that express social interaction [17].

Game play is a very important feature of early childhood and is of particular importance for children with autism. Play in children with autism is more like "learned routine" rather than "spontaneous" [18]. Autistic children show difficulty in their play activities which could be associated with their deficit in cognitive, and emotional development. Free game play characterized by spontaneity could allow children with autism the possibility to express themselves and engage in satisfying social activity which in turn could lead to development of their cognitive skills.

Different approaches are currently being utilized to better understand the capacity of autistic children to interact with a robot [19]. The Aurora project investigates the use of robots (Labo-1, Kaspar, Robota doll, for example) in game play. The aim is to create a tool based on an autonomous robot that convinces autistic children to engage in a process of interaction [20], [21], [22] [23]. The interactions are tested through the analysis of visual contact, joint attention, avoidance or fleeing, visual pursuit, and whether the child imitates the robot [24]. Using a variety of modalities for interaction such as music, colour and visual contact, a sensitive robot named Tito was employed in social interaction with autistic children [21], [25]. A very small fixed robot named

Keepon can capture and maintain visual contact with the child, drawing its attention and initiating some element of conversation [21], [26]. Roboto uses the form of an animated face (mouth, eyebrows, eyes) that can cause behaviour imitation from the part of the autistic child [27].

Regardless of the child's mental age, all these studies have reported dyadic interaction between the autistic child and the robot. Even though (because of the pathology) the number of the children participating in these experiments is limited, the dyadic interaction is reflected in attention [22], imitation cognition [27], visual contact [28], touching and verbal conversation [25], manipulating and posture [22]. All these studies have shown that animated robots, humanoid or not, using different stimulation encourage interaction in autistic children. In other words, HMI, i.e., robot in our case, could be used to improve autistic children's behaviour. In the above studies, the focal point of the analysis was on a single mode of interaction. Even if quantitative metrics of social response for autism diagnosis including robots were developed [29]; only one study has used a quantitative technique for analysing dyadic interaction for autism therapy [30]. With the exception of Labo-1 in the Aurora project, and Roball in Michaud's project so far, only fixed robots have been utilized reducing the child's spontaneity and self–expression in game play.

We used a mobile toy robot named "GIPY 1" (Fig. 1) which incites the child to engage in interaction. On the hypothesis that autistic children will be in quasi-constant interaction with the robot, the cognitive behavior of autistic children in interactive activities with a robot, i.e., dyadic interaction, during spontaneous game play using multimodal criteria was analyzed. In addition, we hypothesized that once dyadic interaction is established, the child could use the robot as a mediator to initiate the interaction with the third person, an adult, and express emotion, i.e., triadic interaction. This cognitive and emotional interaction of the autistic child with a third person was investigated, once again, in spontaneous, free game play by means of a multimodal approach.

The structure of the paper is the following : first we will give the method for both dyadic and triadic interactions ; then, we will analyse the results for both interactions ; finally, we will develop the discussion, the conclusion and the future work.

II. Method

A. Participants

- Dyadic interaction

Four children (3 boys and 1 girl) participated in this study. Their chronological ages ranged from 7 to 9 years old (mean 8.3 years). Their developmental age ranged from 2 to 4 years old. The children were diagnosed according to the D.S.M. IV-TR criteria of autism [31]. The C.A.R.S [32] had been administered at the age of 6 years by an experienced clinical psychologist. The C.D.I [33] was used to estimate intellectual disability (Table 1). At the time of the experiment all of the children were attending special education classes or autism.

Table 1. General characteristics of population
a) Childhood b) International Classification of Diseases

Children	Chronological age	Sex	C.A.R.S (a)	C.D.I (b)
1	7y 11m	m	46.5	20 to 34
2	8y 6m	m	35.5	35 to 49
3	9y 5m	f	31.4	20 to 34
4	8y 2m	m	43.5	20 to 34

- *Triadic interaction : Case Study*

"A" is a right-handed young boy. He exhibits mental retardation as per the C.D.I. [33]. His chronological age is 8 years old and his developmental age is 2 years old. The child was diagnosed with autism when he was 3 years old and still displays all characteristics of autism according to the D.S.M IV-TR [31]. In addition, the C.A.R.S. [32] has shown severe autism with a score of 43 points. "A" has deficits in reciprocal social interactions and communication (speech and language), stereotyped behaviour and restricted interests and activities. At the time of the experiment he was attending special education classes for autism.

B. Material

- *Room*

The room was 4.56 m by 3.34 m. A chair, a small wardrobe and a table on which the equipment needed for the framework of the study was placed (laptop and joystick), were used. In order to reduce the presence of disruptive elements and so as to avoid autistic bend, the room was left bare [34].

- *Robot*

A mobile robot, called "GIPY-1", which is cylindrical-shaped with a diameter of 20 cm and a height of 30 cm, was created for use in the experiment. A representation of a neutral facial expression constitutes the cladding of the robot: the round eyes and nose triangle were dyed olive green and the elliptical mouth was dyed red (Fig. 1). Everything was covered with a transparent plastic sheet. The simplicity of the robot was driven by the preference of autistic children for simple and predictable toy design [35]. An operator manipulated the robot via a wireless remote control using a joystick connected to a laptop. The robot could move forward, backward and turn on itself at low speed. These movements were constant.

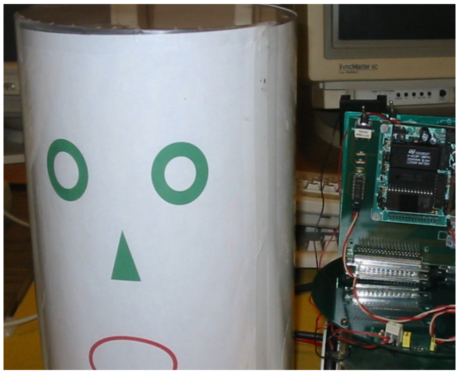

Figure 1. GIPY 1

- *Protocol for the dyadic and the triadic interactions*

The duration of the session was 5 minutes. The robot was placed on the ground beforehand, in the center of the room, its stylised face toward the entrance. The game play session began as follows: when the child and the adult entered the room, the tele-operated robot carried out three movements (move forward, move back, 360° swivel). As in real social interaction, the child and the robot altered their responses. If the child approached, the robot moved back and conversely. If the child moved away from the robot, i.e., ignored the robot, the robot followed the child in order to attract its attention. If the child remained motionless, the robot approached or turned itself around in order to focus the attention of the child. All movements were standardised.

- *Analysis for the dyadic and the triadic interactions*

Two independent judges unfamiliar with the aim of the study completed the observations of the game play skills. Both performed the analyses of video sequences with Elan software. Prior to assessing game play improvement, inter-judge reliability was assessed to ensure that both judges who analysed videotapes were consistent in their analyses. Inter-judge reliability was assessed using intra-class coefficients to make the comparison between them. The inter-judge reliability was good (Cohen's kappa=0.63).

The dependent variable was the time of child-robot interaction for the dyadic interaction and the time of child-robot and adult for the triadic interaction. Accordingly, we calculated the duration of all the characteristics of each criterion. This was defined as the duration between the onset time and the offset time of each child's behaviour toward the robot. Four criteria were defined for the dyadic interaction: 1) eye contact (looking at the robot), 2) touch (touching the robot without manipulating it), 3) manipulation (operating the robot), 4) posture (changing corporal position toward the robot). Based on the hypothesis that cognitive interaction could be lead to the expression of an emotional state, a n additional fifth criterion was defined for the triadic interaction. This criterion was: the positive emotion (display of enjoyment) (5). The duration of each criterion was calculated in seconds and was considered independent of the others. Concerning, for example, the characteristic "s/he looks at the immobile robot" ("eye contact") the onset time corresponded to the time when the child looked at the robot and the offset time to the moment when the child looked away from the robot. We calculated the duration of all the characteristics of each criterion. We summed up the duration corresponding to each criterion. Only the total duration is presented in the results section.

III. Results

- *Dyadic interaction*

The mean time of dyadic interaction was 238.7 sec. In other words, the children spent nearly 80% of their time (156 seconds for the first, 289 seconds for the second, 269 seconds for the third and 241 seconds for the forth child) playing with the robot. The duration of each robot-child interaction is presented in Fig. 2. The duration of "eye contact" is similar for all the children. However the analysis of the duration of "touching", "manipulating" and "posture" possibly reflects inter-individual differences related to different forms of autism. This analysis also showed how autistic children's behavioral interaction with the robot changes over a period of time. This suggests that a mobile toy robot could help autistic children to reduce repetitive and stereotypical behavior.

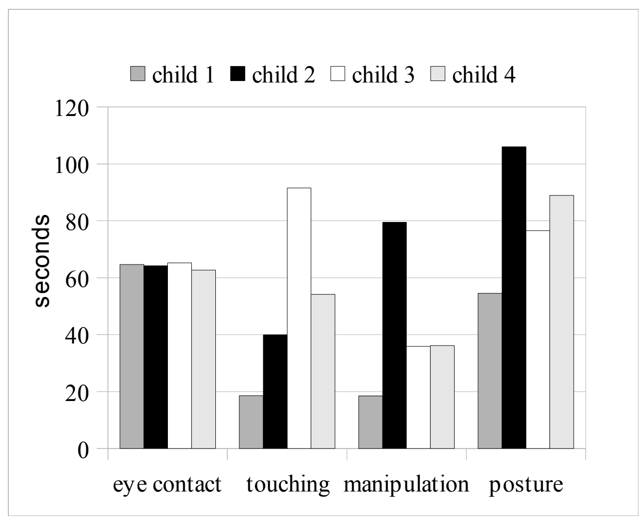

Figure 2. Duration of dyadic interaction for each criterion

- *Triadic interaction*

The mean time of dyadic interaction was 25 sec; the mean time of triadic interaction was 30 sec. In other words, the child spends half the time playing with the robot and the half the time playing with the robot and the adult.

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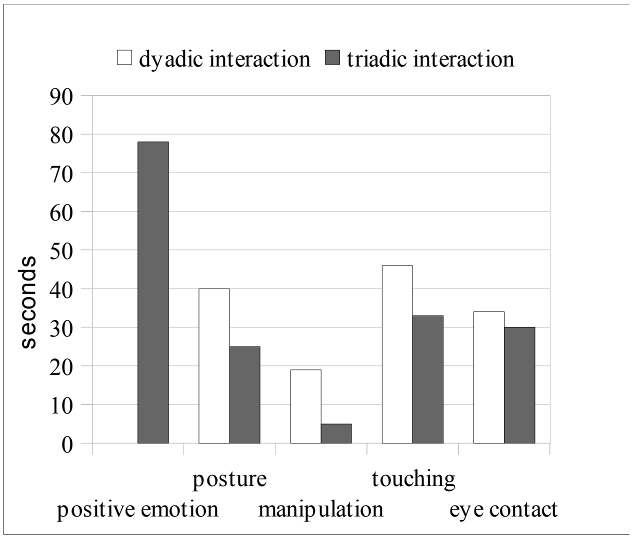

Figure 3. Duration of dyadic and triadic interactions for each criterion

The duration of dyadic and triadic interaction is presented in Fig. 3. The duration of "eye contact" and of "touching" is similar in both situations. However the duration of "manipulation", of "posture" and of "positive emotion" differ between the two situations. As we can observe, positive emotion is more easily expressed when the child interacts with the adult and the robot than when the child interacts only with the robot. This difference reflective of the changes in autistic child behavior with the robot over a period of time also tells us that a mobile robot could be used as a mediator for social and emotional interaction. This is an encouraging conclusion with regard to the potential of human-to-human interaction.

IV. DISCUSSION

- *Dyadic interaction*

The aim of the first study was to analyze the interaction between autistic children and a mobile toy robot in free, spontaneous game play. Consistent with our hypothesis, the children are quasi-constantly in interaction with the mobile robot using a variety of ways.

As autism is a spectrum disorder where a large variation in abilities and interests among autistic children is apparent, the interaction of children and robots was evaluated on the level of each individual child. Consistent with various studies, the present study shows that the use of robots engages autistic children in interaction [20], [24-27], [36-39]. We have calculated the duration of robot-child interaction during free, spontaneous game play.

More precisely, the behavior of autistic children vis-a-vis the robot based on four criteria ("eye contact", "touching", "manipulation" and "posture") has been analyzed and a temporal quantification of dyadic interaction with respect to the duration was performed. The analysis revealed that the duration of eye contact behavior was similar for each child. Inter-individual differences were identified for the duration of "touching", "manipulating" and "posture" behavior. These differences might be related to different forms of autism. This data demonstrated that the autistic children not only visually explored the robot [30] but also engaged in different kinds of play with the robot. In other words, the autistic children clearly took an interest in playing with the mobile robot.

In all the studies we have mentioned above, only fixed robots were used, with the exception of Labo-1 [22] and Roball [21]. In our study as with Labo-1 and Roball studies, the autistic children were invited to interact with the robot during free, spontaneous game play. Taken together, these studies have shown that autistic-children use a variety of behavior when playing with a robot in free game play.

It seems that free game play could be a relevant ecological situation where an autistic child spontaneously interacts with the robot. Moreover, mobile toy robot could help autistic children to reduce repetitive and stereotypical behavior.

These findings also reveal that free, spontaneous game play with robots is possible with severe autistic children and could better facilitate the transfer of social and learnt abilities to real life.

But what is important to demonstrate is whether and how autistic children can generalize learnt abilities during play with the robot to aduts, i.e., proving that the robot could be used as a neural mediator tool for the enrichment of child-human interaction.

- *Triadic interaction*

In this case study, we analysed the ingredients of child-robot two-pronged interaction and child-robot-adult three-pronged interaction. Consistent with our hypothesis, the child first establishes a relationship with the robot and then uses the robot as an "instrument" to initiate the interaction with the adult. At first glance, our results are compatible with recent findings according to which HMI i.e., presence of a robot, are more effective than other environments in allowing autistic children to express social interest towards the robot [22-23], [25], [28], [35], [40-41]. In these studies, researchers have used robots for treating autistic children. However, the relationship between robot and child has been studied solely based on the analysis of a single mode of interaction. Furthermore, the studies have been conducted using fixed robots. Our results go beyond these findings because we have demonstrated, as far we know for the first time, that in spontaneous, free game play, an autistic child uses the robot to interact with the adult and to express positive emotion. As such, on the one hand, we have shown that the dyadic interaction is based on a cognitive state and, on the other, that the child uses the robot as a mediator to express positive emotion playing with the adult.

More precisely, in our study, the interaction between robot and child was analysed using different criteria such as eye contact (looking at the robot), manipulating (operating with the robot), touching (touching the robot without manipulating it), posture (changing postural position toward the robot). Consistent with our previous studies [42-45], we have demonstrated that visual, haptic, tactile perception and posture, i.e., multimodal perception, are on the basis of the interest the child displays towards the robot. This is because, in our approach (as in Quinn & Eimas approach [46]), perception and cognition are considered to be a single domain rather than two distinct entities. The criteria we have chosen are assumed to represent the state of the child's cognitive processes, as expressed by the interest the child exhibits towards the robot in spontaneous, free game play. As our second study has shown, once this state is established, the child develops a triadic relation i.e., with the robot and the adult, thereby displaying enjoyment, which is a positive emotion. The expression of positive emotion could be related to the emergence of a cognitive state, which is multimodal in our case. This expression appears when the child interacts with the adult using the robot. This is a very important finding when we consider that the subject of our case study "A" exhibited a score of 43 which corresponds to severe autism. Individuals with severe autism exhibit very limited social skills. They don't express emotions. They don't respond well to behavioural therapy and in fact tend to show few, if any, signs of improvement after such therapy is undertaken. However, as we showed in our study, "A" is in constant interaction with the robot, expressed by a multimodal cognitive state which, according to us, allows him to express positive emotion with the adult.

V. CONCLUSION AND FUTURE WORK

Considering the above studies, it would be fair to conclude that autism therapy using robots seems to be effective, safe and convenient. What is important is the "passage" from dyadic interaction to triadic interaction. Indeed, when "A" interacts with both the robot and the adult, he changes his behaviour. What causes this behavioural modification? We think that the robot as a mediator could bring about neurocognitive improvements to the autistic child. As the results have shown, the extent of that improvement seems to be smaller when the child interacts with the robot than when he interacts with the adult. We believe that the child's reactions to the robot are very important in establishing child interest and are of paramount importance in robot therapy. In fact, this dyadic interaction could be thought of as the building block from which the relationship among humans may be developed. Consistent with this interpretation may be the fact that positive emotion is expressed only when the child interacts with the adult via the robot. Positive emotion is quasi-absent when the child interacts with the mobile robot on a standalone basis. It seems thus reasonable to infer that the three-pronged interaction i.e., child-robot-adult could better facilitate the transfer of social and emotional abilities to real life.

Moreover, in both studies, the findings tell us that free game play, i.e., an ecological situation, encourages an autistic child to interact with the robot in a spontaneous manner and could reduce repetitive and stereotypical behavior. They also reveal that free, spontaneous game play with robots is possible with autistic children and could better facilitate the transfer of learnt abilities to real life.

One limitation of these studies is the small number of autistic children which makes impossible inferential analysis. Additional studies are required with typical and autistic children. Longitudinal follow-up of the same children is necessery to examine the efficiency of mobile robots in improving the neurocognitive skills of autistic children. This is what we're developing currently. In addition, with a new study we analyse the embedded multimodal nonverbal and verbal interactions between a mobile toy robot and autistic children using a new paradigme.

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Multimodal human-robot interactions: the neurorehabilitation of severe autistic children

My talk draws from my recent work which concerns the multimodal interactions in typically and atypically developing children.

From my viewpoint, multimodal interactions (which mean different informations coming from different sources) express the complex relationship between brain, mind and environment (natural/physical or artificial environment).

Multimodal interaction is the foundation of the brain.

The individual history of a neuron can be summarized as following: a neuron creates direct and/or indirect connections with other neurons (via synapses). Biological in nature, this operation seems to contribute to the formation of a multimodal neuron. This seems to affect the future development of brain areas. The individual history of a brain area depends on its direct and/or indirect connections with the contiguous cortical areas. This constitutes the neural environment also known as the 'natural or physical environment'.

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In typically developing children the realization of a given neurocognitive task such as verbal or nonverbal, social and emotional is possible because of a wide cortical network. The neural environment.

In atypically developing children such as autistic children the emergence of social and emotional behavior interaction could be possible because of a mobile toy robot, an articifial environment.

In order to study this hypothesis, we created an artificial environment using a mobile toy robot and we analyzed multimodal interactions in free game play with autistic children and that robot in dyadic and triadic situations.

Autism:

Autism is a neurocognitive disorder. Because the effects of autism can range from severe to mild, autism is considered as a spectrum disorder (Bowler, 2012). Autism is characterised by repetitive and stereotypical behavior apparent by 3 years of ages; deficits in verbal and nonverbal processes; deficits in emotional and social interaction.

Its genetic and neurocognitive aetiology is unknown. However different hypotheses have and continue to be discussed.

Autism is considered a complex multifactor disorder involving many genes.

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Neuroimaging studies have demostrated that different brain areas are involved in autism. These studies reported aberrant brain connectivity and disruption of white matter tracts between temporal regions. They also shown abnormal activity in the exterior, the interior temporal and in the orbital frontal cortex (ventral part of the prefrontal cortex).

This data could provide the basis for concluding that in autism the more impaired cortical areas are those that are involved in complex cognition functions such as perception, interpersonal interaction and emotion, disorders which characterize autism.

Artificial environment such as robots have been used in the education of autistic children. They seem to be more effective than real environments.

Different projects exist.

The Aurora project study investigates the use of robots (Labo-1, Kaspar, Robota doll, for example) in game play. The aim is to create a tool based on an autonomous robot that convinces autistic children to engage in a process of interaction. The interactions are tested through the analysis of visual contact, joint attention, avoidance or fleeing, visual pursuit, and whether the child imitates the robot. Using a variety of modalities for interaction such as music, color and visual contact, a sensitive robot named Tito was employed in social interaction with autistic children. A very small fixed robot named Keepon captured and maintained visual contact with the child, drawing his attention and initiating some element of conversation.

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Roboto used the form of an animated face (mouth, eyebrows, eyes) that, can cause behavior imitation from the part of the autistic child. Pleo is a dinosaur whic is used to encourage social interaction.

All these projects have reported dyadic interaction between the autistic child and the robot. They have shown that animate robots, humanoid or not, using different stimulations, encourage interaction in autistic children.

Even if quantitative metrics of social response for autism diagnosis including robots were developed, only one study has used a quantitative technique for analysing dyadic interaction. With the exception of Labo-1 in the Aurora project, and Rollball (Michaud's project) so far, only fixed robots have been utilized reducing the child's spontaneity and self – expression in game play.

The aim of our studies was to analyse multimodal interactions of severely autistic children during free spontaneous game play with a mobile toy robot named «GIPY 1» both in dyadic child-robot situation and triadic child-robot-adult situation.

DYADIC INTERACTION

In the dyadic situation, we hypothesized that the autistic child will be in quasi-constant interaction with the robot.

The experimental set up was the following: The robot was manipulated by an operator via a wireless remote control using a joystick connected to a laptop. The robot could move forward, backward and turn on itself at low speed. These movements did not vary from child to child. The duration of the session was 5 minutes. The game play session began in exactly the same way for each child. When the child and tutor entered in the room, the tele-operated robot carried out three movements (move forward, move back, 360° swivel). As in real social interaction, the child and the robot altered their responses. If the child approached, the robot moved back and conversely. If the child moved away from the robot, i.e., ignored the robot, the robot followed the child in order to attract his/her attention. If the child remained motionless, the robot approached or turned around in order to focus the attention of the child. All the movements were standardized across the children.

4 children were observed during five minutes.

In this study, we analyzed the time of child-robot interaction (dyadic interaction). This time was defined as the duration between the onset time and the offset time of each child's behavior toward the robot. Four criteria were defined. These criteria were: 1) eye contact (looking at the robot), 2) touch (touching the robot without manipulating it), 3) manipulation (operating the robot), and 4) posture (changing corporal position toward the robot).

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The duration of each criterion was calculated in seconds and was considered independently of the others. Concerning, for example, the characteristic "s/he looks at the immobile robot" ("eye contact") the onset time corresponded to the time when the child looked at the robot and the offset time to the moment when the child looked away from the robot. Accordingly, we calculated the duration of all the characteristics of each criterion. We summed up the duration corresponding to each criterion for each child. Only the total duration is presented in the results section.

Our results show that the children spent more than 79% of their time (156 seconds for the first, 289 seconds for the second, 269 seconds for the third and 241 seconds for the fourth child) playing with the robot.

As autism is a spectrum disorder where a large variation in abilities and interests among autistic children is apparent. At an individual level, the duration of "eye contact" is similar for all the children. However the analysis of the duration of "touching", "manipulating" and "posture" possibly reflects individual differences among the children. This analysis also showed how autistic children's behavioral interaction with the robot changes over a period of time. In other words, this suggests that a mobile toy robot could help autistic children to reduce repetitive and stereotypical behavior.

It seems that free game play could be a relevant ecological situation where an autistic child spontaneously interacts with the robot.

These findings tell us that an ecological situation, i.e., free game play, which is very closed to a real life situation encourages an autistic child to interact with the robot in a spontaneous manner. They also reveal that free, spontaneous game play with robots is possible with autistic children and could better facilitate the transfer of social and learnt abilities to real life.

What is important to demonstrate is whether and how autistic children can generalize learnt abilities during play with the robot to therapists and parents, i.e., proving that the robot could be used as a neural mediator tool for the enrichment of child-human interaction.

TRIADIC INTERACTION

This is what we tried to analyze in a third case study involving triadic child-robot-adult interaction.

We used the same criteria as above.

Based on the hypothsesis that cognitive multimodal interaction could be leed to the expression of an emotional state an additional fifth criterion was defined for the triadic interaction. This criterion is: positive emotion (display of enjoyment).

The above children were observed for 5 minutes of free game play.

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The results show that the child spends half the time playing with the robot and half the time playing with the robot and the adult.

The duration time of “eye contact” and of “touch” is quite similar in both situations. However the duration time of “manipulation”, of “posture” and of “positive emotion” differ between the two situations. Positive emotion is more easily expressed when the child interacts with the adult and the robot than when the child interacts only with the robot. This difference reflective of the changes in autistic child behavoir with the robot could be used as a mediator for social and emotional interaction.

The robot, i.e., the artificial environment, seems mediate the interaction between autistic child and adult once the robot-child interaction is established.

In other words, cognitive and emotional multimodal interactions could also play a role in autism neurorehabilitation.

Robot neurorehabilitation might have high potential for improving the brain activity of child with autism. In this context, the robot could be considered as a « neural orthesis ».

In other words, artificial environment rendered possible through the use of mobile toy robots could lead to the neurorehabilitation of autistic children or atypically developing children.

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Certainly, a robot could be considered as a orthesis (όϱθεσις) used as a social stimuli mediator, with the ability to activate the same brain areas sensitive to humans in order to reduce the impairment of skills related to social and emotional information processing.

Thank you for your attention

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