Acquisition of Social Abilities Through Musical Tangible User Interface: Children with Autism Spectrum Condition and the Reactable

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Abstract
This study assesses the potential of the Reactable, a musical tangible user interface, to help in the acquisition of social interaction abilities in children with Autistic Spectrum Condition (ASC). With this purpose, nine children with ASC participated in the research; the sample being its own control group, and a simple subject design was developed. The type of design was ABA (Basic Withdrawal). In addition to the statistical analysis, this study used qualitative methodological tools for analysis of outlier subjects and detection of atypical behavior for future research. The results show an increase in social interaction during the sessions, even for the non-verbal subjects.

Author Keywords
Autism Spectrum Condition (ASC); Collaboration; Behavior Therapy; Music Therapy; Tangible Interface; Social Skills Training.

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces - Interaction styles;

General Terms

Experimentation, Human Factors.

Introduction

Autism is a condition that affects approximately 1 in every 155 people worldwide. Out of this population, 60% are below 50 IQ points on a scale of 0 to 100. Below this threshold, the person is considered to have moderate to severe disability. Classic autism and Asperger's syndrome share three features in their diagnosis: social communication difficulties (reading the meaning of body language, inability to attribute intentions to others, inability to understand metaphors, absence of joint attention, etc.), unusual interest in specific areas of knowledge (obsession with certain topics, sometimes called islands of knowledge), repetitive and ritualistic behavior. This study is based on the idea shared by Peeters, Riviere and H. Asperger, that an appropriate educational intervention improves the quality of life of people with Autistic Spectrum Conditions (ASC), even if their IQ is below 50 points [2,24,29]. Among the major development impairments that affect children with ASC, one of the variables that limit communication development is social competence (SC). The absence of SC creates states of social aloofness, inability to maintain communication sequences, separating children with ASC from their peers. There is evidence about the acquisition of social competence for children with ASC in music therapy interventions and therapy game. Therapies associated with play facilitate the acquisition of social competence through the creative use of objects and give better results for long-term acquisition of SC [13].

Just as they have difficulties in the social and communication areas, people with ASC have strengths in their development that may enable them to develop alternative communication strategies. The present study focuses on two of them. On the one hand, people with ASC have a qualitatively different development with the use of objects compared to those with typical development (TD). This involves the exploration of objects through taste, smell and caress [30]. On the other hand, even when people with ASC have difficulties in understanding emotions in typical social communication, they can process affective information through music. Furthermore, they have better processing and pitch memory than TD people [11,12].

Tangible user interfaces (TUIs) enhance cooperative and associative play sequences in children with ASC, reducing the duration and frequency of solitary activities [7]. The Reactable is a TUI that allows the intuitive and collective creation of complex musical pieces. Hence, the present study investigates the Reactable because it is a tangible tool in addition to being a musical instrument, and it has previously been tested in typically developing children returning positive results [14].

This paper makes two contributions to the autism communication and technology field:

- Developing an exploratory study about musical TUIs and the acquisition of social abilities in children with ASC, returning statistical significance even with non-speaking participants.
- Using qualitative tools to collect information for new studies on collaborative work with therapists and non-typical behavior from a random sample.

Social Competence in children with ASC

One of the most significant features of children with ASC is that they lack strategies to cope with social communication with peers. Even for those adults with autism who have developed a functional language similar to that of people with typical development (High Functional Autism and Asperger's syndrome), understanding and maintaining social communication with peers can be frustrating because of the amount of non-verbal information that is transmitted during interaction [3]. This, together with their rigidity and lack of perspective, make social development much more difficult for people with ASC. Thus, for children in preschool age or with a cognitive capacity that does not allow any non-verbal communication, their social competences can be made explicit in the ability to initiate or join sequences of play with peers and respond positively to sequences of turn-taking [20]. The control of turn-taking skills is important as it helps the child to wait and be attentive to the needs of others, thus enabling them to make decisions to interact with their peers. The anxiety generated by the absence of this variable on the behavior of a child with ASC, makes it difficult for children to interact with their peers.

Successful interventions have been carried out, such as game therapy and music therapies, which have shown positive results with an impact on the life of the child in learning social competence [6,7,18].

State of the Art

Music Therapy Applied to ASC

The appreciation of music, in the same way as language, requires a dedicated brain organization. This includes visual-spatial processing, memory, auditory and verbal processing [25]. People with ASC can process affection to a musical stimulus, in comparison with the information associated to verbal language or social behavior [10]. There is evidence that people with autism have better processing and pitch memory than typically developing people, and this can be translated as a skill in the development of musically related tasks [11]. Therefore, it can be argued that people with ASC are prepared to develop musical skills and to become involved in activities where music is a means of communication [12].

Music therapy applied to autism has a tradition of more than forty years. Little research work has been carried out with large samples, or including follow up on the children’s development outside of the music therapy, that is, evaluation of whether improvements in children have been replicated subsequently in other areas such as at home or at school. Any intervention with a person with autism, because of the syndrome’s own nature, requires a long-term adaptation of the child. The work with children with autism is so complex that music therapy follows the path of adapting in children, with their own rhythms and emotional needs, as opposed to behavioral therapies in which structures, objectives and timeframes are imposed by the therapist. Music therapy, then, stands as a methodology flexible for the child [32].

Object Interaction and Therapy in ASC Children

Children's interaction with objects reflects an understanding of how these play a social role and / or function within the world around them. The manipulation of objects, the way objects are accessed and how attention is shared around them, positions the self and the object [33]. Children with ASC have a

different development regarding the use of objects. Not only is it a delay with respect to the acquisition of skills both functional and social, but also a qualitative difference in their relationship with them. From a qualitative point of view, people with ASC tend to use objects in a ritual, repetitive way, without functional use and often obsessively. Additionally, they prefer an approach to objects with a predomination of exploration of through taste, smell and caress [30]. Understanding the development of children with ASC and their relationship with objects allows focusing the interventions on game therapy and toy use, which can help in the development of social skills.

One of the most interesting interventions developed in the last ten years related to the learning of social skills is the work of Daniel LeGoff. The author turns LEGO© sets into tools for group work in children with Asperger's syndrome and highly functional ASC children (HFASC). The results of the intervention were positive, showing an improvement in social skills for all children outside the controlled playing space [18]. Thus, the study gives evidence that interventions related to play, collaborative work and objects can generate an improvement in long-life acquisition of social competences.

Technology and Social Intervention with ASC Children
People with ASC make an extensive use of technology, as it becomes a filter that allows them the appropriation of the world from two levels. On the one hand it allows sorting the stimuli, generating a structure that is easy for them to interpret; on the other hand, it becomes a perfect mediator that generates the lag required to process and interpret the large amount of information they receive from people with typical development [3,26].

Tangible user interfaces (TUIs) have proved to be more accessible and intuitive for young children compared to other technologies. TUIs can improve the learning process, as they are more entertaining, and also facilitate collaborative work processes. In the latter regard, TUIs allow sharing space between users, promoting imitation games, increasing the visibility of actions, enabling the possibility of monitoring other participant's work [19, 28]. W. Farr tested and compared two types of interventions: LEGO© therapy and the use of a tangible and programmable toy called Topobo©. The results of the study show that playing with TUIs reduce solitary play sequences, facilitating collaborative and associative play [7].

Musical User Interface Applied to ASC
Within the musical technologies designed to help people with various disabilities, mainly two have been tested with ASC population. The Soundbeam, an invisible keyboard expanded, is an ultrasonic beam that sends sound messages each time the user moves the body or the fingers. This technology has been tested as therapy in children with ASC for seven years, finding positive results in the area of social behavior and communication. The research was conducted through longitudinal case studies and no studies with large samples exist [6].

Keepon is a social robot designed for nonverbal interaction with children. It was tested several times with ASC children eliciting a motivation to share mental states through the creation of rhythmical play. Longitudinal observation of ASC children with Keepon

shows that this population was able to establish physical and social contact not only with the robot, but furthermore with caregivers [16].

The MEDIATE (A Multisensory Environment Design for an Interface between Autistic and Typical Expressiveness) is an interactive environment that generates real time stimuli (visual, aural and vibrotactile). This technology was designed for children with severe autism and no verbal communication. In a study with ninety ASC non-verbal children, the results show the children do not need external motivation to interact with the technology [23].

Methods: Design and Development Criteria and Strategies

The Reactable is a tabletop TUI and a collaborative musical instrument that enables the collective and intuitive creation of complex musical pieces. Studies have shown the capacity for these types of tools to promote teamwork in children with typical development. The system is a circular table top, where users can interact, both through direct contact with the table, and through objects called pucks grouped in four categories: generators, sound effect (audio filters), controllers and global objects [14].

The Hypothesis

This research was designed to test the following hypothesis: The collaborative use of the Reactable improves ASC children's social skills.

Measures

The Early Social Communication Scales (ESCS) [21] as well as LeGoff [18] parameters for his studies about game and social communication, were used in the ABA measurement. To validate the hypothesis, a composite variable was measured: social interaction. This variable was formed by a group of target behaviors. These target behaviors are variables for the future development of social interaction in the child.

The Early Social-Communication Scales (ESCS) is a structured measure for non-verbal communication skills [21]. This clinical tool uses three categories to classify the skills of a non-verbal child. For the purpose of this research, the definition of the variables was based on the measurement of social interaction behavior. The target behavior that was measured for Social interaction ability was based on Initiating Social Interaction (ISI) and Responding to Social Interaction (RSI). For the scope of this research, LeGoff's description of self-initiated social contact was used [18]. Finally for ESCS, the RSI variable is related to the tendency to respond to turn-taking sequences. The target behaviors that were measured for social interaction composite variable were:

1. Initiating Social Interaction (ISI)

Self-initiated social contact: It involves either verbal or non-verbal communication or a clear attempt to communicate with the therapist. It is not a reciprocal response to the therapist's approach. Type of measure: Frequency.

2. Responding to Social Interaction (RSI)

Turn-taking: An event involving a sequence of playing turns alternating between the child and the therapist. These are only taken into account if the children need no help with their turn-taking. Type of measure: Frequency.

Experimental Design and Set-Up

PARTICIPANTS

Seven boys and two girls with an ASC diagnosis, who had no previous experience in music therapy or play therapy, were recruited from EIR-Niu school, AMPANS and Centro CIEL in Barcelona and Manresa cities (Spain). Parents gave informed consent for their children to be involved in the study. The participants had a mean chronological age of 9 years old (age from 5 to 11 years old) when they entered the trials. Six children were non-verbal; the remaining three were verbal with a varying degree of language skills.

PROCEDURE

A Single subject design was used to validate the two hypotheses. The type of design was ABA (Basic Withdrawal). A repeated measures comparison design within subjects was used. The no-intervention baseline phase (A) was 20 minutes of free play session in their regular school space. The intervention phase (B) was three sessions guided by a therapist with the Reactable. The frequency of the sessions was once per day for six participants, whereas the three remaining children had one session per week. The no-intervention withdrawal phase (A) was 20 minutes of free play session with the same condition than the no-intervention baseline. Each child had a previous personal ten-minutes training session with the Reactable. This session was not taken into account for the results, as one of the main characteristics of Autism is that changes, new tasks or spaces can prove very stressful for the child, and each child needs special personalized attention in the approach to new experiences. During the sessions, each subject worked with their own personal therapist; in all cases, these had been working with the children enough time for participants to feel comfortable. Each therapist had received a twenty-minutes training session with the Reactable prior to the experiments (see Figure 1).

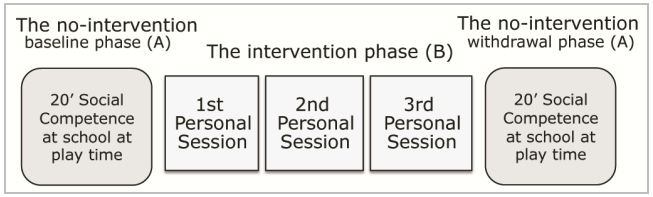

Figure 1. Sessions conducted for each subject.

SESSIONS

Play sessions for six children were conducted during one week, on a daily frequency. The remaining three children participated during one month, with sessions every week. Standardized instructions were given across the three sessions. Each session was programmed for a maximum time of thirty minutes. Eight participants had an ASC with IQ impairments, ranging from not speaking at all, to a low level of oral functional communication. The structure of the sessions was the following:

1. Directed activity: The first fifteen minutes were guided by the therapist. The therapist gave instructions regarding turn-taking and interaction with the Reactable. Her role was to define objectives around taking decisions for music creation, and additionally give orders such as "now we work together", "it is your turn", "choose your piece".

2. Free activity: the remaining time in the session was free time for the participant to explore and initialize interaction with the therapist. In this section, the

therapist worked as a facilitator, helping the child only when it was needed.

Quantitative Tools
Correct automated capture data is an important component in future analysis of behavior with children with ASC, especially nonverbal subjects [9,15]. VCode software was used for video coding. Two researchers analyzed the target behaviors related with a social interaction. A total of 108 hours of video analysis (18 h recorded x 6 h analysis) were carried out by each video coder.

Qualitative Tools
In addition to the video material recorded for statistical analysis, this research used qualitative methodological tools. The objective for the use of these tools was to gather qualitative information on the children's behavior to analyze outliers and identify behaviors unrelated to the study's target behaviors that could nevertheless provide information for future studies about communication in non-verbal subjects [27].

To achieve this objective, the following tools were used:

- Fieldwork: Extra information was coded in video analysis (about speaking or non-verbal communication when the child needed help, felt frustrated or was playing with their peers or therapist).
- In-depth interviewing: Extra information about children was collected through an interview with their own therapist.

Results

The totality of the recorded material was analyzed in order to elaborate the research results. Each subject went through a total of five sessions, two sessions of social play in a family and peer environment (SB – session baseline and SW – session withdrawal) and three intervention sessions with the Reactable (T1, T2 and T3). Additionally, the primary observer took notes on the behavior of the sample during the experiments. The results of the five children with more dissimilar behaviors are reported in the single subject analysis section.

Quantitative Analysis
Two separate tests were conducted for each group and target behavior: intervention session analysis (session 1, session 2 and session 3), and baseline vs. withdrawal comparison. The objective was to test if Social Interaction composite variable give statistically significance inside the two states of measure.

BASELINE VS. WITHDRAWAL
A Wilcoxon signed-ranks test was conducted to evaluate the difference in medians for social interaction between baseline (*Mdn* = 6.00) and withdrawal (*Mdn* = 4.67) sessions for all subjects. The test was not significant, indicating that the median for social interaction did not differ significantly between baseline and withdrawal sessions.

REACTABLE SESSIONS ANALYSIS
An ANOVA repeated measures was conducted to evaluate the effect of the collaborative use of the Reactable on social interaction for all subjects. The test was significant, $F(2,16) = 5.36$, $p = .017$. Post hoc tests using the Bonferroni correction revealed that

social interaction increased, as Figure 2 shows, **between session T1 (***M* = 33.78, *SD* = 20.93) **and session T3** (*M* = 48.49, *SD* = 21.20), *p* = .046.

These results indicate that **Ha hypothesis is supported**: the collaborative use of the Reactable improves ASC children's social skills for all subjects within the Reactable session.

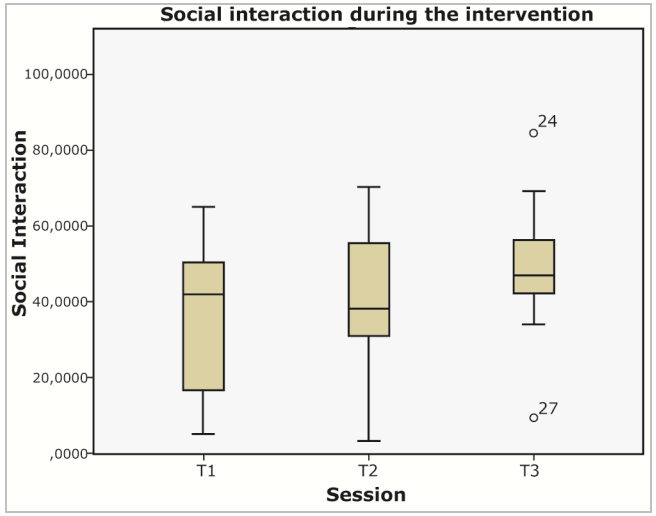

Figure 2. Frequency of the composite variable social interaction for all subjects.

THE TURN-TAKING TARGET BEHAVIOR

The only individual variable that presented statistically significant positive results was turn-taking. As shown in Figure 3, there is an increase of the frequency of turn-taking variable during the Reactable sessions. An ANOVA repeated measure was conducted to evaluate the effect of the collaborative use of the Reactable on turn-taking for all subjects. The test was significant, *F*(2,16) = 7.16, *p* = .006. Pairwise comparison post hoc tests with Bonferroni correction were conducted, indicating that **turn-taking increased from session T1** (*M* = 28.76, *SD* = 16.80) **to session T3** (*M* = 42.69, *SD* = 16.59), *p* = .047. Turn-taking increased as well **from session T2** (*M* = 32.18, *SD* = 16.61) **to session T3** (*M* = 42.69, *SD* = 16.59), *p* = .019.

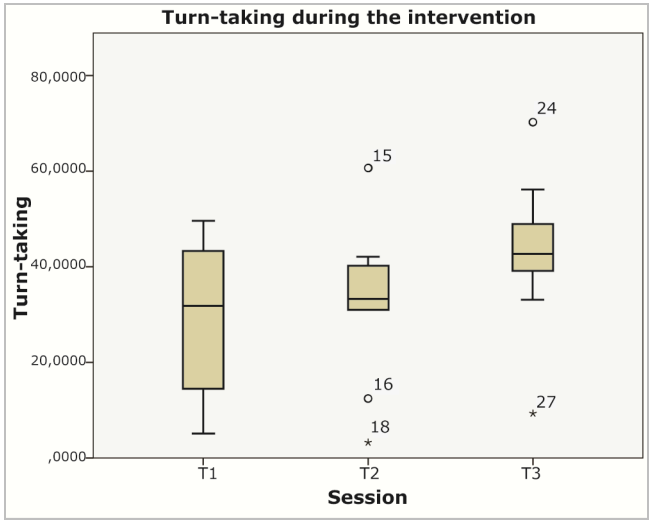

Figure 3. Frequency of the turn-taking target behavior for all subjects**.**

INTER-RATER AGREEMENT

For **turn-taking variable**, the level of agreement was found to be good during the Reactable sessions (ICC level 0.69), and excellent for baseline and withdrawal sessions (0.91). For **self-initiated social contact**, the level of agreement was found to be good during the Reactable sessions (0.63), and fair for baseline and withdrawal sessions (0.42) [4].

Single Subject Results

SUBJECT 1: S1 (11 YEARS OLD)

S1 has ASC and is fully non-verbal. Even if she is learning to use the word "Yes", the child has no functional or symbolic language allowing her to communicate. Tutors consider S1 to have the cognitive capacities to develop some sort of communication; however, she is still in a learning process. S1 has not developed play skills with other children, and does not explore toys or people out of her own initiative. In the video analyzed during the initial play session, S1 keeps working in solitary activities, without paying attention to any of the other two present children. Tutors report she suffers anxiety symptoms when facing random objects, turning the introduction of new activities unpredictable, and very often leading to self-injure. This forces teachers to work very slowly with her, requiring extra time and resources to initiate any type of new activity.

00:05:24 "She takes your hand, if she wants something that is very far, [...] if she wants to go to the bathroom"[...]

00:05:47 "Always the same routine, the same behavior. When she can't do something she tries to do, that's when she starts hitting herself [...] She doesn't even look at you, she doesn't point."

00:06:35 "What she verbalizes is the frustration."

During the interventions, S1 went from self-injuring out of anxiety, to enjoying the experience, by notably improving her social interaction skills. Significant improvements between session T1 and T3 during the Reactable intervention can be observed. Figure 4 shows an evolution in turn-taking and self-initiated social contact (SISC) with a 22.63% and 60.76% improvement, respectively.

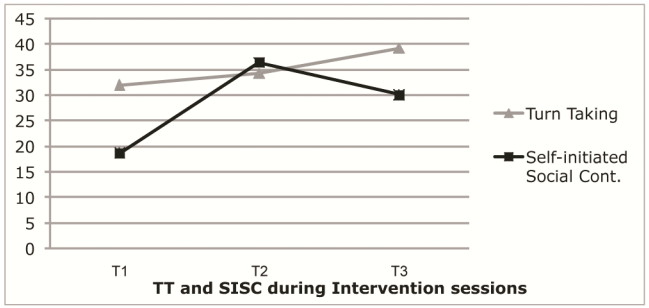

Figure 4. S1, improvement in all target behavior within the Reactable sessions.

In addition, a 366% improvement in the SI composite variable was observed for S1 during the sessions pre and post-intervention. It is interesting to note that after the analysis of the video material for post-intervention (SW), S1 showed a behavior previously undetected by therapists: the child initiates turn-taking sessions with another child through a musical toy. This behavior was also observed in two other subjects (subjects 2 and 6).

SUBJECT 2: S2 (11 YEARS OLD)

S2 has ASC and is fully non-verbal. She does not have functional or symbolic language skills. During the pre-intervention session, she does not establish any kind of communication or contact with the other two children sharing her playing space. During the Reactable sessions, from the beginning, S2 does not show rejection of the new activity, and shows her intention to explore. The therapist explained during the interview that S2 has a high willingness to explore objects:

00:06:56 "She likes plastic material. If she likes the object, she finds it hard to control herself. She seeks and explores things."

The results on the acquisition of SI skills for S2 are very suggesting and encouraging for an intervention with only three sessions, as the turn-taking frequency increased by 82.7%.

The video analysis shows that the frequency of occurrence of the SI variable is low compared to other children. However, the difference in behavior between sessions pre and post-intervention play (SB and SW), and the Reactable intervention is high: 408% increase for SI during the intervention sessions, compared to a 131% increase from pre to post-intervention play in SI. (see figure 5).

Figure 5. S2 starts a turn-taking sequence with a peer.

SUBJECT 3: S3 (11 YEARS OLD)

S3 has ASC and is fully non-verbal. He does not have functional language skills, nor does he elaborate any word, as his therapist reports, he only produces random sounds. S3 shows an obsessive behavior with objects, but his main problem is attention deficit. In tasks in which he shows interest, his therapist reports an average attention span of 3 minutes. Therapists have tried giving medication to help with this problem, but this has not been feasible. S3 has a predilection and skills for computers, although he cannot use them as a means of communication. During these play sessions, S3 showed interest in other children, however, he did not participate nor tried to establish communication. On the other hand, during the Reactable sessions, S3, as S2, had a significant increase in SI variables: 330% increase in turn-taking (see Figure 6).

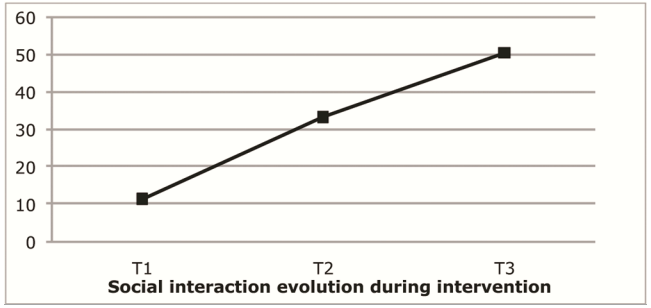

Figure 6. S3, improvement in SI composite variable within the Reactable sessions.

Although S3 has no verbal language skills, during the intervention with the Reactable he showed a non-verbal communication attempt with the therapist, in an effort to explain to the therapist the functioning of the Reactable. Such behavior can be observed in session 3, 00:22:50 (Figure 7). S3's computer skills allowed him to understand the technical functioning of the Reactable (00:04:41 in session 2 shows how he explores the table, while observing the behavior of the laptop connected to it).

Figure 7. S3 working with the Reactable.

Finally, the improvement in the composite variable SI (343%) from session 1 to session 3 of the intervention is encouraging for future interventions.

SUBJECT 4: S4 (7 YEARS OLD)
S4 has a diagnosis of pervasive developmental disorder (classic autism, for DSM-IV). His language skills, as his therapist reported, are reduced, non-functional and his communication is not spontaneous. He is learning to recognize letters, and he attends one day a week at a typically developing children school. S4 has no symbolic play skills. His therapist reported:

00:05:12 "[...] I have never seen him play with a toy car, he has no significant symbolic play. No little cars game or city game [...]".

During the Reactable Sessions, S4 showed an improvement in target behaviors: 45% increase in turn-taking. In the composite variables, the improvement is of 29.8% in social interaction S4 showed an exceptional behavior during the Reactable sessions. He established symbolic play sessions with his therapist around the sound "cartoon water" that had been randomly assigned to session 1. The therapist reported in the interview that this type of play had not been found in the kid before. This behavior is being reported as, albeit anecdotal, and it could be important for future studies.

Discussion and Conclusions

In the design and implementation of the experiment, difficulties related to working with a complex and heterogeneous population were encountered. To prevent this from interfering with the outcome, the collection of qualitative data was included, and the sessions were designed with flexibility for better adaptation of the intervention with children with ASC. In order for future researchers to be able to replicate the experiment performed, the strengths and opportunities identified in the development of the experiment are reported in this section.

The Experiment Design Flexibility
One of the characteristics in the behavior of all people with ASC is fear of change. This implies they are not flexible to the environment, and thus the assimilation of new tasks, situations or people can trigger episodes of stress and anxiety. To feel comfortable with a new activity, each child with autism requires a different amount of time and personalized assistance. These variables are related to the degree of autism as well as the IQ. For this reason, the experiments were designed with a maximum duration of 30 minutes. This implied, in practical terms, that the duration of each session with the Reactable was flexible. Thus, the therapist had the power to control the duration of the Reactable sessions, ending them when the child was showing interest in leaving the work room or if there was evidence of stress or anxiety. This decision was positive for the development of the sessions, since the children were certain they could end the session whenever they wanted. This flexibility allowed children who

participated in the study to carry out the experiment successfully. The end result gives an average duration of 20.89 minutes for the sessions with the Reactable, and a statistically significant improvement in the variables related to the acquisition of social skills.

Work with Therapists

The ASC is a set of features in the development of communication and social skills that cover a spectrum of people. Dealing directly with a child with fully non-speaking autism or with no functional language skills is extremely complex. Knowing when children need to go to the bathroom, whether they are afraid, or if a scream is an expression of happiness or anxiety, is part of a long-term learning process by the therapist. In a non-verbal child without joint attention, communication of orders, rules and structures of behavior is done through repetition and pattern; this is usually a lengthy process. Understanding the needs of a child with ASC involves months or even years of daily work. For this reason, and to achieve the objectives of this research, close work with therapists and teachers of each recruited child was carried out during the experiment. All children in the sample worked with their usual therapist during sessions with the Reactable. Each therapist had from 6 months to 3 years of experience in working with the children before the start of the sessions with the Reactable. The latter facilitated the children's positive approach to the research activities. All therapists involved in the research were specifically trained in the use of the Reactable. This training was focused on two areas: Use of the tool and assignments and directions to be given to children involved in the experiment.

However, personalized training sessions of 20-30 minutes training was insufficient for some therapists to understand how the Reactable works. The therapist's difficulties with technology created a frustrated interaction with children in some cases. To avoid this behavior, 10 minutes before each session the basic concepts of the Reactable use were reminded to the therapists. In this sense, the fieldwork carried out outside the Reactable sessions with therapists facilitated the exchange of information. In this respect, qualitative research methodology played an important role both for the collection of extra information and for identifying potential needs of therapists and children. Anecdotally, evidence was gathered of the capacity of one of the non-verbal subjects (S3), in the use of the Reactable system, and how after a therapist's error, the subject tries to instruct the therapist on what she should do.

Musical Material and Symbolic Play

One of the strengths of working with the Reactable and with children with ASC was that the material was composed especially for the sessions with the Reactable. Three songs were created, divided in loops grouped by percussion, bass, melodies, cartoon sounds, glitches. These loops have the same rhythmic structure, facilitating the combination of pieces in harmony. Thus, all the interaction of children with the Reactable generated musically pleasing results. This facilitated the children's exploration of the elements during the intervention. But also, cartoon sounds were especially used by tutors to draw the attention of children when they had trouble focusing on the activity. Anecdotally, but not less important, one of the children, in the sample, showed an incipient symbolic play: S4 (7 years old) initiated symbolic play with the therapist

around water-related cartoon sounds. It is worth noting that the therapist said in an interview later that S4 suffers from fears related to learning to swim. However, S4 enjoyed the play with the Reactable, he wanted to "drink" and "immerse" in the Reactable like it was a swimming pool. Future studies related to the sound can be directed toward investigating the possibilities in learning symbolic play and imagination in children with autism, although the experience of this research recommends this area of study for populations of children with high functioning autism and Asperger's.

Conclusions from the Results

Studies about play therapy interventions (LEGO therapy) returned positive results in the improvement of social competence (SC) in samples of children with ASC verbal and / or Asperger's or HFA [18]. However, in this study with the Reactable, the sample consisted of a random group of children with ASC school age, with a high degree of language disability (sample of 9 children, 6 of them completely non-verbal and with no joint attention skills). The population with ASC is very diverse, for instance, 90% of them differ at the perceptual level (vision, hearing, touch) [5, 17] and 60% have an IQ below 60 points [24]. Working with a random sample of population that is very diverse and complex could be an added difficulty for the purposes of research. However, quantitative analysis results showed there was a statistically significant improvement in the composite variable social interaction during sessions with the Reactable. This data is relevant, not only because of the characteristics of the sample but also for the duration of treatment, since statistically significant improvements were observed in just three working sessions. Therefore, for future studies related to the Reactable or similar tools, more work sessions should be scheduled.

THEORETICAL TURN-TAKING IMPROVEMENT IMPLICATIONS

Of all the target behaviors observed, only turn-taking as an individual variable improved significantly during treatment sessions with the Reactable. Although these results cannot be considered conclusive given the size of the sample, there is evidence that collaborative use of the Reactable facilitates the acquisition of non-verbal and social abilities in turn-taking. The absence of spontaneous engagement in social imitation limits the ability of people in the development of social communication. If that is generated, the child has the ability to engage in turn-taking sequences, develop non-verbal communication and then initiate social communication [31]. The acquisition of turn-taking, then, becomes a milestone in the development of children and their future learning abilities. The development of turn-taking skills is also related to the awareness of "the other one". In order to correctly perform a sequence of turn-taking, it is necessary to infer the intentions, as well as to anticipate the behavior patterns of "the other one" [22]. Future studies should investigate about the facility in learning sequences of turn-taking and the possible structuring of communication and understanding "the other one" in people with non-verbal ASC.

THE USE OF OBJECTS WOULD REDUCE THE STRESS OF STARTING COMMUNICATION IN TD PEOPLE AND THEIR PEERS.

Children with ASC have qualitative differences around the use of objects with respect to typically developing children. This includes everything from non-symbolic use of objects to a more intimate exploration, through oral examination for example [30]. It is worth

mentioning that the use of objects allows to display and to define the subject's relation to their environment, hence the importance of building theory around the possible use of objects as triggers in communication. During the recording and subsequent analysis of material collected through qualitative methodological tools used, 4 of the 9 subjects in the sample were found to use musical objects (toys) to start non-verbal communication with peers, after the Reactable sessions. The subjects S2 (11 years old) and S1 (11 years old) initiated turn-taking sequences using a musical toy spontaneously after three days of work with the Reactable. In a later interview, the therapist recommended to continue working with the Reactable for a longer period of time, since S1 had never developed spontaneous game strategies with peers, and S2 had not got involved in turn-taking sequences with her peers before working with the Reactable. On the other hand, Subject 6 (10 years old) established turn-taking sequences in response to the interaction of the therapist outside of the Reactable sessions, which included waiting for the interaction to mimic the behavior of his peer, without any given directions. In the material recorded before the use of the Reactable, Subject 7 (5 years old) exhibited use of musical toys to engage in turn-taking sequences with his peers, but it was after the use of the Reactable that the use of the toy to initiate interaction with his peers was detected. After that, Subject 7 used the musical toy with a clear intention to provoke his peers through sound.

This recorded data demonstrates that the sound becomes a space invader, allowing to break the solitude of game. Any sound interaction breaks the confinement of a child with autism, calling his attention to the other's behavior. The sound presence of the therapist or a peer invades the sound space of the person with ASC, calling their attention and making them understand that the presence of another person has implications for their own space [1]. The behaviors observed during the investigation may give evidence of a limited learning about the presence and the calling to the "other", outside of a previously structured context. However, to validate this information, further studies with a larger sample of subjects with ASC, should focus their research on how sound, together with the shared or not shared use of the object, can facilitate communication of non-verbal population.

Finally, even if the sample (n = 9) is small to consider the results to be conclusive, and the randomly recruited sample implies a high diversity amongst children, the results of the present research give statistical significance in the social interaction composite variable. The outcome is encouraging for future studies of musical TUIs and children with ASC, even for non-verbal subjects. To compensate for the lack of data that would help explain possible outliers, qualitative material was collected. The used methodological strategy showed noteworthy information on the most interesting behaviors at a theoretical level. For both reasons, it is recommended to future researchers in the Autism Spectrum Condition to include in their samples non-verbal individuals and to measure new variables related to new ways to learn social abilities trough low cost technologies.

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