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Music Spectrum: a Music Immersion Virtual Environment for Children with Autism

David Lima, Thais Castro*

*Federal University of Amazonas / PPGI / Institute of Computing, Av. Rodrigo Otávio, 3000, Manaus, 69077, Brazil

Abstract

This article reports on Autism Spectrum Disorders (ASD), virtual environments and music therapy, defining and prototyping a virtual environment for assisting children in ASD cope with social situation through music activities. Music Spectrum help the development of communication skills, imagination and social interaction of children with ASD, which is a complex set of social unrest, marked by impaired social interaction, communication and restricted or stereotyped patterns of behaviors and interests. As virtual environments simulate real situations, children can experience overcoming their difficulties in interaction and communication in a more quiet and controlled environment before they are exposed to similar social tasks. Our choice for music is based several parents’ testimony about their children preferences and ways they use to regulate and organize themselves.

Keywords: Autism Spectrum Disorders; Virtual Environments; Social Interaction; Music Therapy; Music Spectrum.

1. Introduction

Despite the importance of communication in the development of children, particular those in the Autism Spectrum Disorders (ASD), as well as some research claiming that music therapy has a positive influence on treatment for cognitive rehabilitation and improvements in communication skills and social interaction, the findings in publications aggregates in the musically Virtual Reality Environments (VRE) are still inconclusive, according to Gattino [1].

For many authors, among them Stuart [2], Ribeiro and Falcão [3], Costa and Carvalho [4], and Rizzo [5], the exploitation of Virtual Reality (VR) presents several advantages over other technologies for cognitive rehabilitation or improvement skills of social interaction with children in the ASD, because they provide an interface that generates a high level of motivation, with features that clarify the understanding of abstract concepts, allowing observation of scenes in different situations, offering them an opportunity to experience in certain situations on an individual and even collaborative basis.

* Thais Castro. Tel.: +55-92-33422118.
E-mail address: thais@icomp.ufam.edu.br.
Therefore, the use of music scenarios in VRE can encourage active participation of children in the ASD, allowing them to participate in procedures to be performed later in the real world, providing a motivating environment for knowledge acquisition and socialization skills.

2. Autism Spectrum Disorders

The concepts of Autism and Pervasive Developmental Disorders (PDD), sometimes called Autism Spectrum Disorders (ASD) has been developed and continuously reviewed by different authors. According to Klin [6], autism or ASD refers to a complex family of disorders with socialization deficits, with early onset and chronic course, which have a variable impact in multiple areas and nuclear development since the establishment of subjectivity and personal relationships, to language and communication, to learning and adaptive capabilities.

The term autism originally came with Kanner in 1943, when it described a group of children who had a rare clinical condition in which the fundamental disorder was the inability to establish affective and interpersonal contact with others [7, 8].

Over the years, there were several authors who studied children with similar pathological symptoms, dedicated to establishing different hypotheses and theoretical positions on autism, dedicated to very specific aspects of the same subjects [4, 6, 9].

The 80s and 90s were marked by several important scientific questions, which sought to clarify whether autism is related only to cognitive deficits or imply the presence of social-emotional deficits.

In this context, the first cognitive theories of autism were developed, which were initially proposed by Frith [10] and Baron-Cohen et al. [11]. For Boulanger [8] and Frith [10], children with autistic spectrum disorder would show a failure to attribute intentional states to others, by presenting a specific deficit in their theory of mind. Such deficit would affect a child's ability to predict the behavior of others and make the world less threatening.

2.1. Characterization

In the absence of a biological nature, the diagnosis of autistic disorder is an arbitrary clinical decision [1], taking into account comments and ratings of Pervasive Developmental Disorders (PDD) in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) by the American Psychiatric Association [12]. The DSM-IV-TR divides the PDD into four subgroups, according to Table 1 shown below.

<table>
<thead>
<tr>
<th>Pervasive Developmental Disorders (PDD)</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autistic Disorder</td>
<td>Classic Autism</td>
</tr>
<tr>
<td>Rett Syndrome</td>
<td>A specific genetic disorder of postnatal brain development, caused by a single-gene defect predominantly affecting girls</td>
</tr>
<tr>
<td>Childhood Disintegrative Disorder</td>
<td>Regression cognitive, behavioral and language between 2 and 10 years, preceded by entirely normal development</td>
</tr>
<tr>
<td>Asperger Disorder</td>
<td>Language development in the expected age without mental retardation</td>
</tr>
<tr>
<td>Pervasive Development Disorder not otherwise specified*</td>
<td>Individuals with some autistic features and do not belong to the above categories</td>
</tr>
</tbody>
</table>

*Autism Spectrum Disorders (ASD)

Autism's main characteristic is a triad of deficits in the areas of social interaction, deviance in communication skills both verbal and nonverbal and absence or poor use of imagination [1, 7, 12].

Yates and Couter [13] claimed that the triad is responsible for a specific behavior and repetitive pattern, but with
intelligence conditions ranging from mental retardation to levels of above average IQ.

Schwartzman [14] states that autism is considered a behavioral syndrome with diverse etiologies of a developmental disorder characterized by a social deficit, visualized clearly by the inability to relate to others, often combined with deficits in language and behavior changes.

Social imitation games or spontaneous play, appropriated to each autistic child's development level are absent [15]. Usually, there is an apparently inflexible adherence to strict and non-functional habits. Another striking feature is the "mannerisms" and the circular motor stereotypies. These children show a persistent preoccupation with parts of objects [12].

Some people in the ASD struggle in overall development of their skills, while others have high skills and abilities in certain areas (e.g., music, mechanics and calculus), showing significant developmental delay in other areas.

2.2. Social Interaction deficits in Autism

According to Passerino and Santarosa [15], from an etymological point of view, social interaction is the idea of action between two people or joint action and interdependent at least two participants that produce changes in both subjects and in the scenario where situation occurs. The process of social interaction is essential for cognitive development of children in the ASD, this process being the result of symbolic mediation procedures that happen in the creation and use of signs within a context. Since the symbol or sign can be represented by some object, whether physical or not, whose significance was established by society.

The interaction is a complex relationship that develops with the participation of subjects and signs placed in the sociocultural context [1, 16]. Several authors studied the deficit of social interaction in autism as a trivial deficit. Among them were Baron-Cohen [17] and Hobson [18]. For Hobson [18], the main feature of autism is the limitation of having a "sense of personal relationship" and to experience such a relationship, or create a meaningful social interaction and consequently participate. However, for Baron-Cohen [17], this limitation is a failure in "representation of the person to be" due to limited understanding of people mental states called Theory of Mind. Both authors agree what concerns the ability limitation in understanding, however, disagree on what they consider the cause of this limitation. Hobson [18] believes that this limitation has an affective character instead of representative capacity [15].

Affected children interaction skills should be interpreted as the context where the child is [1]. Often affected children have bounded ability to interact or relate to others in a socially acceptable way, since they usually have little eye contact, difficulty participating in group activities, limited ability to express their feelings and to show affection to others [1, 4, 10, 15, 19]. An essential aspect in the study of social interaction in autism is that children in the ASD rarely share attention with another person about a particular object or event. They have limited ability to spontaneously focus visual attention with someone else to attract her attention to engage in some activity they can perform together.

Generally, children with ASD have little or no strategy to share the attention with others. Also, try to avoid eye contact frequently, using more perception than direct peripheral [15, 20]. Regarding social interaction in children with autism, Passerino & Santarosa [15] classify them into four groups: Social Isolation, Passive Interaction, Interaction Active-but-strange and Interaction Hiperformal. All these categories are differentiated by the degree of reciprocity in the interaction established with other subjects, in which social isolation presents the most severe grade between the types.

2.3. Bounded capacity in communication and imagination

Padilha [21] states that bounded capacity regarding communication and imagination is the most frequent cause of medical visits in children in the ASD. Going from total absence of language in a child 2-3 years old until the change in pragmatic understanding of language, or social use.

It is characterized by difficulty in using meaningful aspects of verbal and nonverbal communication. As examples is the use of gestures, facial expressions, body language, musicality, rhythm and modulation of the verbal language.

Many children in the ASD are not able to acquire a rich verbal language. When they have, there is a great chance to present echolalia, or repeating words or sounds they learn through conversations with other people. Individuals
with autism typically ignore the presence of objects and events, what removes the possibility of communication and social interaction [1, 22].

Frith [10] believes that by failing to reach meta-representations of signs and concepts about mental states of others, such as desire, need, feeling and emotion, predictability of behavior and their communication would be greatly reduced.

3. Music Therapy and Autism

Music therapy has been struggling to define itself as an area of scientific research for over 50 years [8]. For several diseases such as schizophrenia, dyslexia, Parkinson's and a number of developmental disorders, music therapists have been trying to record and specify the benefits through interventions of music on patients' lives.

However, some authors have questioned the methodology of music therapy, considering the failure, with limited scope, evaluation criteria and the effectiveness of the unjustified use of music to cognitive treatment [23].

Though, to Gold et al. [24], music therapy is a scientific, systematic intervention, in which the therapist helps the patient to promote health, using musical experiences and relationships that develop through them as dynamic forces of change.

The techniques of music therapy include free and structured musical improvisation. The processes that occur within musical improvisation help people in the ASD to develop their social skills, communication skills and imagination [24].

Music therapy has been highlighted in the care of children in the ASD, for facilitating the use of communication channels, both verbal and nonverbal means of musical experiences, providing the development of communication skills, social interaction and learning [1, 25].

For Boulanger [8] before working with music in the process of intervention with autistic users, it is important to understand that the social component of making music is to provide meaningful social participation.

Children with ASD, especially in the early years, may reject or ignore any kind of contact with another person or object, including family members. Music and music therapy can be very effective to enhance and change the social behavior of these children through the use of Virtual Reality Environment [1, 8, 25].

Boulanger [8] states that the whole process serves to establish social roles, and an awareness of the needs of other members in the environment. Throughout the process, the therapist assesses, usually with questionnaire and primarily through observation if the user with ASD changed their behavior inside and outside the group. The use of a virtual reality environment facilitates communication through the process of speech and musically stimulating the thought process regarding the conceptualization, symbolism and understanding. Besides promoting the development of sensory awareness and motor skills, music in virtual environments facilitate social interaction, promoting creativity and emotional wellbeing.

Boulanger [8] states that it is a challenge for designers to design for users in the ASD because symptoms and neural observations vary among related individuals. The intervention in the form of a musical application is appropriate to examine the contribution of the various aspects of cognition to behavior displayed in an individual with autism.

Music activities in virtual environments require various cognitive resources, such as visual processing and verbal memory, auditory and motor programming. It is known that the inability of social interaction is one of the main characteristics of children with autism spectrum disorders. Virtual environments useful resources because virtual people are less threaten than real people and to corroborate that thought Padilha [1] states that the use of virtual reality environments can break the patterns of social isolation and abandonment, contributing to socio-emotional development.

Therefore, to break this pattern and present virtual environments to children in the ASD it is important to overcome cognitive and perceptual difficulties. For its playfulness and entertainment, the environment must provide a means of mutual interest. Instead of threatening, the environment becomes a means of closer social development for these children, improving their communication skills, understanding of objects and the process of imagination [1, 8, 24, 25].

4. Virtual Reality Environments and Music Spectrum
Virtual reality environments are multi-user, navigable through a spatially avatar and mediated by computer, that even though inheriting much of its logic from the real world, they work today as its extension. In order do this, they have graphics (3D), complex scenarios and an ability to host many players in the system simultaneously [3]. There are other definitions of virtual reality environments, but in general, they refer to an immersive and an interactive experience, i.e., a computer-generated simulation of a real or imaginary world [3, 4].

Virtual Reality (VR) has been identified as one of the most promising areas related to information technology [3]. To Singh et al. [26], despite being relatively recent, the VR has permeated different areas, especially medicine, arts, military, entertainment and education. Some of these areas have been targeted for research, especially in the area of cognitive rehabilitation, which involves treating symptoms of ASD, where VR technology presents different approaches for the recovery of patients. For Costa and Carvalho [4], environments developed within VR technologies stand out by providing patients greater opportunities for virtual experiences generalization and transposition to the real world. They affirm that the use of virtual environments has proven to be adequate to support cognitive processes.

Those are the fundaments behind Music Spectrum, which is proposed in this paper to explore the multidisciplinary involved in this scenario. Within the technological possibilities offered by computers to medicine, the VR, through virtual environments, stands out by offering ways to improve the quality of life, socialization training and cognitive rehabilitation [4, 5].

Concerning virtual environments development we ought to note some points, such as defining the interface requirements through the application of interviews with users, project design, prototyping and evaluation. The development process model we used for Music Spectrum is based in Costa and Carvalho [4] and it is shown below in Figure 1.

![Development process model for Music Spectrum.](image)

This model enables users and experts integration during the development, in order to design user-friendly and easy to manipulate interfaces. The process was divided into four phases:

- **Requirements**: It consists of four steps: Definition of users, tasks and types of interactions, the general requirements for Music Spectrum, definition of specific requirements, and prototyping of screens;
- **Project**: Consists of three stages, namely - definition of input and output technologies, definition of hardware and software technologies, and modeling of object behavior and interaction;
- **Implementation**: Definition and preparation of images; Construction of 3D objects; and development of the Music Spectrum version iOS/iPad and OpenSim;
- **Evaluation**: it has three steps, such as: Usability Evaluation through usability inspection; Communicability Evaluation by the Semiotic Inspection Method; Communicability Evaluation Method; and Evaluation of Spectrum Music by users through questionnaire about satisfaction of use.

Music Spectrum will be implemented using the architecture of OpenSimulator (OpenSim), as shown in Figure 2. OpenSim is a multi-user open source platform. It supports 3D collaborative scenarios design. The OpenSim project is under continuous development and its current version (0.7.3.1) provides great stability for the most typical features of virtual worlds like Second Life.

The environment is based on client / server architecture where the server holds all the information about the virtual world and sends updates to the clients that turn data into a 3D reality in real time and can operate in two
modes: StandAlone and Grid, as shown in Figure 2. StandAlone mode is limited to a small number of users as a single process is responsible for the entire simulation, as shown in Figure 2(a) shows. Grid mode now has the potential to be more efficient as the number of users increases, it is possible to distribute services on different machines, besides having to use a database more robust.

Music Spectrum is based in Grid mode, because data services are not part of the process server region, as shown in Figure 2(b) shows. Instead, services are carried in a separate process, in order to run completely different machines, if necessary. In this mode, the OpenSim.exe only acts as the server region, serving one or more regions that communicate with data services separately.

The architecture of Music Spectrum allows the environment to be controlled and simplified to the level of input stimuli tolerated by the user (children). Scenes can be modified allowing the generalization of activities (for example, the act of creating music). Mistakes made in these environments do not create hazards to children with autism. User tracking is individualized by dynamic scenarios that change according to the responses to the environment.

Currently, four screens have been designed for Music Spectrum, but all in 2D, as it was developed initially to tablets and run as an application in order to be fully tested to guide virtual scenarios configuration (shown in Figure 3 and 4).

In Figure 3(a) we show Music Spectrum initial screen with the option to login or register. In the same screen, there is a menu to support and language selection. When the user logs in correctly, the initial screen appears as shown in Figure 3(b). On the Home screen, the user can edit her profile; view her friends; her groups; and all their activities. A figurine present in the environment is similar to concepts found in social networks such as the existence of a real world metaphor for children, ability to interact with other users who are her friends, to be part of certain groups and to do an activity, facilitating the interaction with the children.
It is important to note that children have the opportunity to participate and perform activities. In this case, Violin Spectrum activity is highlighted as it is the first activity that is being implemented from Music Spectrum. When the user selects Violin Spectrum, a new screen appears with new features and interaction, as shown in Figure 4.

Fig. 4. (a) Violin Spectrum screen; (b) Screen option: Play Classic Violin.

In Figure 4(a), the activity Violin Spectrum presents the options available to users. There are four options. Play Classic Violin, where the user can freely use the violin, using her imagination. All the notes the user play will automatically appear in the Score one hand, as in Figure 4(b). In the Music Collection option, the user will have available the entire collection of music registered in the Music Spectrum. Is it possible to follow the music and play at the same time, the choice is up to the user. The third option is learning how to play, where the user will have access to basic information of the violin, like musical notes, the main differences between the styles. This option works as a model tutorial. Finally, the user can create her own music. In this option, she can record, listen to what has already been played, as well as save and send to the Music Collection.

5. Conclusion

Currently, the Music Spectrum is being implemented in iOS, mobile operating system from Apple Inc., with the aim is to test it for gameplay interaction with users and then implement and deploy the environment in its final state on the architecture of the Grid OpenSimulator. The Music Spectrum OpenSimulator will be implemented on the platform, open source platform, multi-user and that allows creation and editing applications and 3D modeling.

The purpose of the Music Spectrum is to awaken the individual with ASD in a more dynamic interaction, real, collaborative, active, where users can safely and gradually develop an understanding of cause, role and effect in terms of various social situations. In the environment, the user is encouraged to explore an instrument and eventually participate in some social group.

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References


