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Inclusion of immersive virtual learning environments and visual control systems to support the learning of students with Asperger syndrome

Gonzalo Lorenzo [a,*], Jorge Pomares [b], Asuncion Lledó [c]

[a] Department of General and Especific Didactics, University of Alicante, Alicante, Spain
[b] Department of Physics, System Engineering and Signal Theory, University of Alicante, Alicante, Spain
[c] Department of Development Psycholoy and Teaching, University of Alicante, Alicante, Spain

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ABSTRACT

This paper presents the use of immersive virtual reality systems in the educational intervention with Asperger students. The starting points of this study are features of these students' cognitive style that requires an explicit teaching style supported by visual aids and highly structured environments. The proposed immersive virtual reality system, not only to assess the student's behavior and progress, but also is able to adapt itself to the student's specific needs. Additionally, the immersive reality system is equipped with sensors that can determine certain behaviors of the students. This paper determines the possible inclusion of immersive virtual reality as a support tool and learning strategy in these particular students' intervention. With this objective two task protocols have been defined with which the behavior and interaction situations performed by participant students are recorded. The conclusions from this study talks in favor of the inclusion of these virtual immersive environments as a support tool in the educational intervention of Asperger syndrome students as their social competences and executive functions have improved.

1. Introduction

It is currently possible to find a large number of research aimed at applying virtual reality (see e.g. Parsons, Leonard, & Mitchel, 2006) and immersive virtual reality (see e.g. Wallace et al., 2010) to the education of students with special educational needs. Virtual reality (VR) is a term that applies to computer-simulated environments that can simulate physical presence in places in the real world, as well as in imaginary worlds. Most current virtual reality environments are visual experiences displayed on a computer screen. However, the goal of immersive virtual reality (IVR) is to completely immerse the user into the computer generated world, giving the user the impression that he/she has "stepped inside" the synthetic world. To achieve this impression, the equipment described in Section 3 is employed. Generally, in the case of children with Autism Spectrum Disorder (ASD), the virtual reality systems make it possible to plan, practice and implement different behaviors and to observe the children's responses in a computer-generated virtual environment.

These systems offer a three-dimensional representation of controlled and safe real environments that can be used repeatedly. It is worth mentioning some previous works where VR has been used with children with ASD, as for example, to improve the understanding of facial expressions (Fabri & Moore, 2005), Street-Crossing for Teaching Skills (Josman, Ben-Chaim, Friedrich, & Weiss, 2008), or to acquire social skills in environments such as a bus or a coffee shop (Mitchell, Parsons, & Leonard, 2007). This last work provides another advantage of these virtual environments: the possibility to develop the student's imagination and the possibility to learn through different roles. These previous studies show that many students with ASD are motivated by VR environments and that the use of these environments is an important support for the improvement and acquisition of certain social skills (Moore & Calvert, 2000; Parsons et al., 2006). Another important aspect of this kind of systems is that they offer the possibility to establish a communication between different users (Passerino & Santarosa, 2008). This aspect helps to practice and to improve different social skills. For example, Cheng, Chiang, Ye, and Cheng (2010) propose a virtual collaborative environment (CVE) to promote acquisition of social skills for students with ASD. In CVE, geographically dispersed users can communicate with each other via their avatar or virtual character. A user can look around a CVE and interact with other

* Corresponding author.
E-mail address: glledo@ua.es (G. Lorenzo).

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avatars and 3D objects in real-time. Goodwin (2008) indicates that the goal of VR is not to evade real-world interaction but to provide extra material which can be used by teachers to improve certain social tasks.

There is no doubt that this type of technologies offers help and support in the education of children with ASD, however, there are still some doubts or questions relating to its application. As indicated in Rogers (2000), certain stimuli acquired through VR, may not be interpreted correctly by the students with ASD. Regarding this aspect, works like (Cromby, Standen, Newman, & Tasker, 1996) indicated the difficulties that could arise when generalizing tasks in the school environment. In the state-of-the-art presented by Parsons and Cobb (2011), they suggest that children can learn from the VR and that they have observed a partial transfer of this knowledge into the real world. However, they indicate that the non-social nature of the computer generated environments can make the socialization even more difficult. These studies show that the students with ASD could be so attracted by the technology that it could lead them to lose even more interest in social interaction in real life. To avoid these problems, Parsons et al. (2006) propose the integration and use of VR as a school task in which the students do not work in isolation. They also have the support of a facilitator. These aspects have been taken into account when developing the proposed system in this study. Another aspect indicated by the researchers who have used VR with ASD students is that the situations and aspects illustrated in these environments are learned literally and repeatedly without considering the social context (Parsons, Mitchel, & Leonard, 2005). This repetition could cause the students to consider the VR environment as a computer game, without seeing a connection with the real world.

Compared to conventional VR environments, in IVR systems the student is completely surrounded by the environment and constantly receives stimuli and has the possibility to interact with it. As indicated in Blascovich et al. (2002) this type of immersive system provides more information about people with ASD. As they also indicated, these systems can be used to create real environments where the ASD students have a chance to address social difficulties in a safe and controlled environment. Furthermore, they found that the high level of stimuli and realism help to avoid some of the problems found in the traditional VR systems as those described in the preceding paragraph. It was found that the use of immersive virtual environments (IVE) can improve the learning of these students because of the possibility to repeatedly reproduce real environments and situations (Wallace et al., 2010). Compared to previous works, this study proposes a new IVR system to improve the learning and to enhance the development of social skills for students with Asperger syndrome. This syndrome is one of the five pervasive developmental disorders also named ASD by the Diagnostic and Statistical Manual of Mental Disorders, DSM-IV (APA, 1994) and (APA, 2000). In Section 2 of this article, we describe the specific characteristics of Asperger students compared to other ASD. This section shows the factors that have been addressed with the proposed IVR system. As indicated in previous research such as those of Mitchell et al. (2007), Asperger children have difficulties to learn independently and they need to be guided when problems arise. For this reason, IVE can become a guide and visual aid that can be adapted to the needs and characteristics of these students, and subsequently transfer the learned skills into the school environment. Tasks that are present in school learning require that students have a set of skills with which to use problem-solving strategies. To do this, students must be able to perform tasks of planning, decision-making, organized search, control of inappropriate responses and flexibility of thought. They must have the capacity to plan and to control answers and to comply with the norms (how to start, what to do, how to do it and steps to take). All these cognitive processes can be associated with what Grattan and Eslinger (1992) identified as executive function. As indicated in Section 2, Asperger children have deficits in executive functions so the IVR will be used, not only to improve social skills, but also to improve the executive functions.

Comparing the proposed IVR system with other previous works using IVR for students with special educational needs, the proposed system has several innovations. On one hand, it is the first specific approach that takes into account the use of IVR for students with Asperger syndrome. A fundamental aspect of the developed IVR system is the data collection that makes it possible, not only to assess the student's behavior and progress, but also to adapt the system itself to the student's specific needs. On the other hand, the IVR system is equipped with sensors that can determine certain behaviors of the students. This information is employed to determine if a given task is correctly developed in the virtual environment. This information is also employed to study the student's evolution. Although there are no previous experiences in immersive systems for improving social skills and the executive functions of Asperger children, one important aspect is to improve the transfer of the skills acquired in the virtual environment into the real world (Wallace et al., 2010). For this, work has been done to recreate realistic environments, with different elements for the students to interact with. These virtual environments are familiar to students (e.g. a virtual recreation of the classroom where they usually attend lessons). This aspect does not only improve the transfer rate of learned skills but also allows a reduction of the time the student needs to adapt to the virtual environment. Finally, it should be noted that the IVR system is dynamic because it can be adapted to the student's behavior and the social skills and executive functions that need to be improved.

In order to improve the immersion of the students into the computer generated world, they are able to manipulate the existing objects in the virtual world. For this purpose, a technology based on visual servoing (Pomares, Chaumete, & Torres, 2007) has been developed, and it allows the representation of real objects in the virtual world. Thus, the student manipulates real objects in the virtual environment but what he is seeing is a virtual representation of the object. This aspect can increase the realism and the subsequent transfer of skills.

The rest of the article is organized as follows: Section 2 shows the general characteristics of Asperger children and the skills that we want to promote by using the proposed IVE, Section 3 describes the components of the implemented IVR system. Section 4 details the methods and development of the research, indicating the procedure of assessing the pedagogical validity of the developed technology. Section 5 describes the main results and conclusions.

2. Asperger and virtual reality

This section describes the characteristics of Asperger syndrome and refers to the known difficulties and the skills that we want to improve by creating and using the IVR. Some time has gone by since Hans Asperger (1944) identified a group of children, with what he called autistic psychopathy, characterized by problems with the use of language with a communicative purpose, pragmatic communication deficiencies, idiosyncratic verbal expression, nonverbal communication difficulties, specific interests, social interaction difficulties and clumsiness despite an adequate language development and a sophisticated cognitive style. Although Leo Kanner (1943) described autism by the abnormal communicative skills, social interaction and affection development disorders, scientists do not standardize criteria when it comes to addressing the differences and similarities between Asperger syndrome and autism. The Diagnostic and Statistical Manual of