Asperger's and virtual reality

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Abstract

Autism Spectrum Disorders (ASD) are characterized by a deficit in social–pragmatic communication and by restricted and repetitive behavior; these disorders are distributed within a "spectrum" of phenotypic variabilities. Virtual reality (VR) is an effective tool for intervention in the health field, and particularly motivating to safely enhance social skills in children with ASD. VR represents "an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment", and it also provides safe and unlimited daily contexts useful for practicing in social scenarios. In this study we compare two types of intervention to enhance social skills: a traditional emotional training, performed individually with the therapist (group 1), and an emotional training achieved via the usage of VR (group 2). Specifically, in this study we compared the two types of intervention, with the scope to identify the intervention with the shorter time of acquisition for the proposed social tasks. Specifically, this work supports the hypothesis that the intervention based on the use of VR allows a faster acquisition of social tasks.

Keywords

Virtual Reality, Autism Spectrum Disorder, Asperger, emotional training, theory of mind

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1. Introduction

Asperger's Syndrome is a diagnostic category classified as Autism Spectrum Disorders (ASD) by the DSM 5 [1], a group of clinical conditions that are initially separated into specific sub-categories. As matter of fact, the Asperger's Syndrome, described by the DSM IV-TR [2] was characterized by a slight deficit of socialization, deficit of the repertoire of activities and interests and deficit of communication, when no clinically significant delays in cognitive development and formal language are observed. DSM 5 defines this category as ASD and the Level 1 qualifier. Difficulties in developing a theory of mind (ToM) appropriate to the age of the subject, represents the most significant aspect of the Level 1 ASD [3]. This deficit involves severe difficulties in the automatic and intuitive of both others and self-understanding of mental functioning, leading to inadequate management of social situations [4, 5, 6]. In subjects affected by ASD Level 1, social is often present, even if partially lower when compared to the peers. However, the way relationships occur can appear eccentric or one-sided due to the ToM deficit [7]. For instance, communication demonstrates deficiency in pragmatic skills, even if conveyed by a formally correct language. Finally, in these subjects there is often a lack of cognitive flexibility that refers to rigid and ritualized behavioural patterns. Especially in the presence of a high IQ, the child with ASD Level 1 can often appear bizarre or eccentric rather than problematic. The contrast between the high IQ and reduced social competence can lead individuals to experience frustration and develop symptoms of depression, anxiety and social withdrawal [8, 9, 10, 11]. Although their intellectual abilities are above average, marked social deficits can cause low self-esteem, and compromise academic performance [12]. Therefore, interventions protocols to improve their interactions and the quality of life, thus to enhance social skills are useful and effective [13]. Several studies observed the effectiveness of Virtual Reality (VR) as a treatment option for individuals with Level 1 ASD [4, 14, 15, 16]. Recent studies have shown the benefits of VR interventions, such as simulations of reality, via computer technology, where individuals with Level 1 ASD can practice either social challenges, either individually or in a more difficult social scenario [17, 18, 19, 20]. VR social training offers several advantages over traditional social skills interventions, such as, simple emotion recognition tasks or role plays. VR also provides safe and unlimited daily contexts, useful for practicing in social scenarios such as finding someone to sit with in the canteen or invite someone to their birthday party [17, 21, 22]. In this study we compare two types of intervention to enhance social skills: a traditional emotional training, performed individually with the therapist, and an emotional training achieved via the usage of VR. In both cases, the intervention proposed the accomplishment of four social tasks, aimed at subjects affected by ASD, namely: a) recognition of primary or basic emotions, b) recognition of secondary emotions, c) emotions and situations linked to primary emotions, d) emotions and situations for secondary emotions. Specifically, in this study we compared the two types of intervention, with the scope to identify the intervention with the shorter time of acquisition for the proposed social tasks. Specifically, this work supports the hypothesis that the intervention based on the use of VR allows a faster acquisition of social tasks.

2. Materials and methods

2.1. Participants (Inclusion criteria)

In this study, 32 subjects diagnosed with ASD Level 1 [1] were recruited and divided into two groups. All subjects came from the same geographic area (city of Caserta) and had parents with an homogeneous socio-cultural background. The family / environmental context was not considered as an influencing factor at educational level in both groups. All subjects undertook the Wechsler Intelligence Scale for Children (WISC IV) [23] to exclude subjects with impaired intellectual abilities and therefore a comorbidity with intellectual disability. Inclusion criteria were as follows: a) age between 9 and 10 years, b) diagnosis of Level 1 ASD (confirmed by the administration of ADOS 2 - module 3) in the absence of nosographically defined comorbidities, c) IQ $\geq$ 97. Following the diagnosis confirmation, and the possibility of inclusion in the sample, we divided the subjects into two experimental groups of

9 subjects each. The subdivision was randomly performed: the subjects included in both groups had the same inclusion criteria and did not have socio-cultural differencies. The two groups underwent two different types of treatment, as will be discussed in the next paragraph. The first experimental group (Gr1) comprised of 16 subjects (10 males and 6 females) with an average age of 9.5 (*M* age = 9.5) and an average IQ of 105.21. The second experimental group comprised of 16 subjects (12 males and 4 females) with an average age of 9.7 (*M* age = 9.7) and an average IQ of 105.72. Therefore, in the two groups, no significant differences were revealed in age or QIT. The data were collected at the FINDS Neuropsychiatry Clinic by certified psychologists, in collaboration with the University of Napoli Federico II, Department of Psychology and the University of International Studies of Rome (UNINT).

2.2. Methods

In this study, the following tests were used to recruit the participants: WISC-IV (Wechsler Intelligence Scale for Children) [23], ADOS 2 - Module 3 (Autism Diagnostic Observation Schedule) [24], K-SADS-5 [25].

WISC-IV: individual clinical test, to evaluate cognitive abilities of children aged between 6 and 16 years. The test allows to compute the Intellectual Quotient (IQ) to score the overall cognitive capacity of the child. Specifically, the IQ is obtained combining four different scores, namely: Verbal Comprehension Index (VCI), Visual Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index (PSI).

ADOS 2 – Module 3: a structured observation consisting of 14 activities and 28 related scores, focusing on important social, communicative, and linguistic behaviour of young subject with fluent verbal skills. The module consists of three main objectives: observing the subjects spontaneous social communication in a scenario providing a stimulus to communicate or interact; evaluating the subjects ability to behave appropriately, according to a situation requiring a specific need (i.e., reading a story, teaching a task); and observing the subject's sense of humour and creativity.

K-SADS-5: diagnostic interview for the evaluation of psychopathological disorders (past and present) in children and adolescents, according to the criteria of the DSM-5. In particular, the interview allows to identify the presence of mood disorders, psychotic disorders, anxiety disorders, attention deficit disorders and disruptive behaviour, substance abuse.

2.3. Procedures

All subjects were assessed via WISC-IV for the evaluation of intellectual functioning (IQ inclusion criterion ≥ 95). For the diagnostic evaluation of Level 1 Autism Spectrum Disorder, we used ADOS 2 - Module 3 and K-SADS-5. Eighteen subjects were randomly selected and divided into two groups receiving two different interventions. The two intervention procedures used in this study were the following:

Individual intervention with the therapist – IIT: emotional training requiring children and adults carried out using 76 photos in sequence. The first 38 sequences were created by recruiting specially trained actors. Photographs were shown to subject with ASD, specifically 14 photographs for the recognition of the 7 primary emotions (2 for each primary emotion, one for the children and one for the adults) and 24 photographs for the recognition of the 12 secondary emotions (2 for each emotion, one for the children and one for the adults). For each sequence, the child was asked to recognize the emotion depicted in each photo by alternating the adults actors with the children actors. Successively, a sequence of 38 photos was administered to subjects with ASD Level 1 who were first introduced to the description of the scenario in the photo, followed by the image depicting the emotion corresponding to the situation (14 photos were associated to primary emotions and 24 photos were associated to secondary emotions).

Virtual Reality Intervention - VRI: in this type of intervention, a 3D viewer was recruited for emotional training and for the projection of two sequences of scenes. The actors that were initially recruited for the sequence of photos of the Gr1 intervention were also employed to film the sequence of scenes featuring. The first sequence included 38 scenes, namely, 14 scenes associated to 7 primary emotions and 24 scenes associated to 12 secondary emotions. The second sequence involved the projection of 38 scenes with 14 scenes linked to primary situations and emotions and 24 scenes for secondary situations and emotions. As previously reported, the scenes were projected with the same scenarios used for the IIT intervention photos.

In both groups, therefore, the same emotional training was performed in different ways: in group 1 (Gr1) the training was individually carried out by a therapist and involved exposure to cardboard images; in group 2 (Gr2) movie scenes were projected through a 3D viewer relating to the same emotions and situations presented in hardcover. To evaluate the acquisition of the skills foreseen by the 4 sequences (recognition of primary emotions, recognition of secondary emotions, primary emotions and situations, secondary emotions, and situations) a weekly test was performed with 38 items (7 for primary emotion recognition, 12 for secondary emotions, 7 for primary emotions and situations, 12 for secondary emotions and situations), via images that varying from week to week 100% correct answers were used as the acquisition criterion. At T0 (pre-training phase), no subject had already reached the acquisition criterion for the 4 trials. A score of zero on all four tasks was the required starting condition for the subjects of the two groups.

3. Results

Data analysis was performed using the statistical survey software SPSS 26.0 [26]. Significance was accepted at the level of 5% ($p < 0.05$). The comparison of the means of the measurements was carried out using an Analysis of Variance (ANOVA) test, a parametric test that allows to compare two or more measurements; the relationship between these variances follows the Fisher F distribution, that allows to examine the hypotheses on the significance of the difference between the variability due to the treatment and the residual one. In this study we performed an ANOVA to compare the scores that emerged from the measurement of acquisition times to the 4 proposed tasks. We described the tasks as follows: PE (primary emotions) task 1, SE (secondary emotions) task 2, PE / S (primary emotion / situations) task 3 and SE / S (secondary emotions / situations) task 4. Both groups at T0 (before the emotional training) did not reach the acquisition criterion in any of the four proposed tasks. Following the literacy intervention (T1), however, significant differences emerged with respect to the acquisition times for the four tasks proposed between Gr1 and Gr2. Specifically, in task 1 no significant differences emerged about the acquisition of the recognition of primary emotions. This shows that the acquisition times of the two groups regarding the recognition of primary emotions were similar; both interventions allow a quick acquisition of knowledge of primary emotions. At task 2 significant differences emerged in group 2; this shows that with the use of the VRI the recognition of secondary emotions occurs in less time than the IIT. Also, in task 3 significant differences emerged in group 2. This shows that exposure to situations that allow the knowledge of primary emotions using VRI guarantees shorter acquisition times, thanks to the direct experience of the subject. Finally, also in task 4 significant differences emerged in group 2. Results demonstrate that VRI secondary emotions training guarantees shorter acquisition times since it allowed to directly experience situations that instead the IIT only allowed commenting through the use of photographs (tables 1 and 2 and figure 1, 2, 3, 4).

Table 1
Comparisons between the two groups at T0

	GROUP 1		GROUP 2	
	T0		T0	
	M	*SD*	*M*	*SD*
PE	4.00	0	4.00	0
SE	6.00	1.41	5.50	0.70
PE/S	3.50	0.70	3.00	0
SE/S	5.00	0	4.00	0

Table 2
Comparisons between the two groups at T1

	GROUP 1		GROUP 2			
	T1		T1			
	M	*SD*	*M*	*SD*	*f*	*p*
PE	7.00	0	7.00	0		
SE	12.25	3.13	8.75	3.13	10.000	.000*
PE/S	19.25	3.13	15.75	3.13	10.000	.000*
SE/S	30.19	3.35	21.88	2.39	65.241	.000*

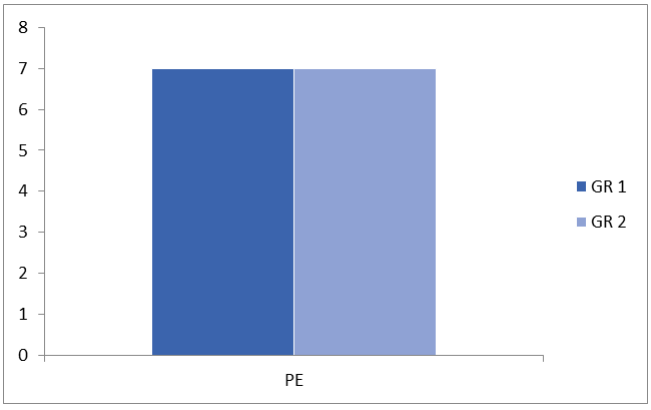

Figure 1: Comparison between the two groups at the PE tasks.

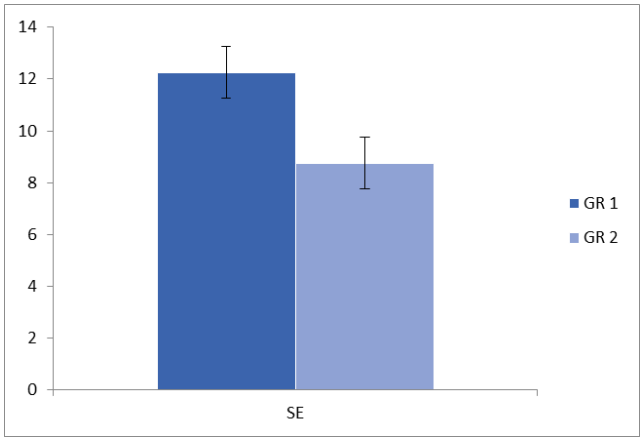

Figure 2: Comparison between the two groups at the SE tasks.

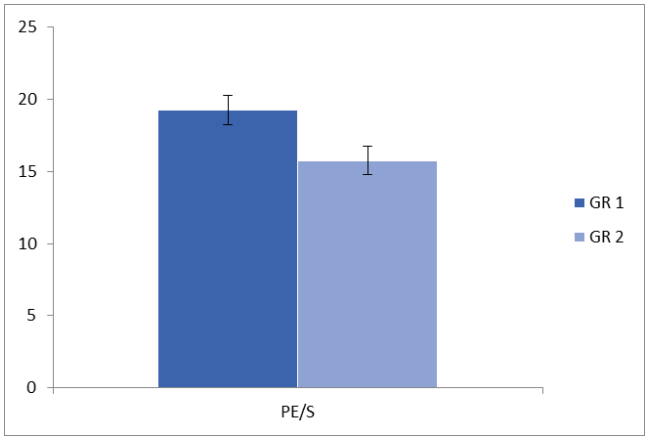

Figure 3: Comparison between the two groups at the PE/S tasks.

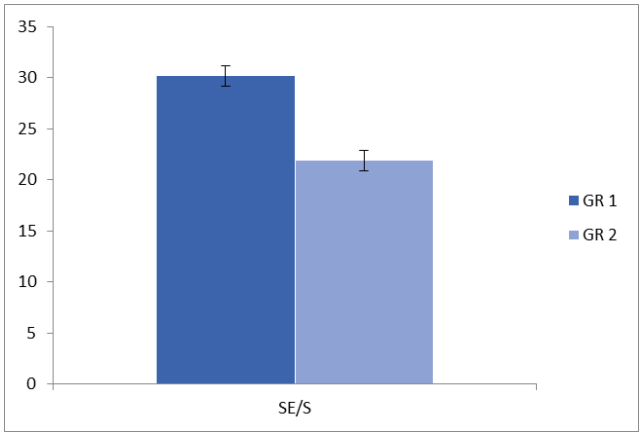

Figure 4: Comparison between the two groups at the SE/S tasks.

4. Discussions

VR provides a supportive environment for individuals with ASD as they can be free to make social mistakes without the intense anxiety or fear of rejection that is commonly associated with social interactions. VR sessions also provide a controlled environment to meet the needs of the individual with the real-time feedback option that can enhance the learning experience. Finally, computer technology is often highly motivating and rewarding for people with ASD [19]. Overall, therefore, virtual reality offers an engaging, interactive, and personalized platform for training and improving social cognition in subjects with ASD. Our study showed that the acquisition times for the recognition of primary emotions were the same in both groups that had used different modes of intervention. While with regard to the tasks that involved exposure to situations for the use of primary and secondary emotions, the acquisition times were shorter with the use of the VRI. This intervention highlighted significant differences in group 2 as the representation of situations together with the 3D experience of the scene helps the subject to develop competence first and a better generalization to daily life also follows. Instead, the simple comment on a photograph through individual intervention with the therapist could not speed up the acquisition of competence. Virtual reality interventions offer the opportunity to repeatedly practice dynamic and constantly changing social exchanges; the therapeutic advantage is that there is less attention to mechanical learning but allows different responses in multiple training sessions since no two social interactions are exactly the same. Furthermore, this dynamic practice carried out in different VR contexts can facilitate the generalization of social skills learned to everyday life contexts [27, 28, 29]. Some authors [16] used a VR coffee with 12 adolescents with ASD aged 13-18 to teach social awareness and then conducted a follow-up study with six adolescents aged 13-18, between 14 and 15 years [14]. At the end of the VR coffee training course, participants showed an improvement in their social understanding in these contexts (for example, choosing appropriate places, knowing when to start a conversation, etc...) as demonstrated by the measurements of their interactions and responses to questions. Subsequently, [30] used a "Junior Detective" computer game to teach emotion recognition and social problem solving and found improvements in emotion recognition in children with ASD. Previous studies [31, 32], which used virtual reality to specifically train emotion recognition, have shown improvements in these skills. One of the main advantages is that virtual reality allows the emulation of situations of everyday life so that the scheduled training can be conducted in a controlled and safe environment. Furthermore, this type of intervention can be developed further to obtain different measurements of the subjects' performance; this allows therapists to follow and analyze the patient's improvements and apply feedback or possible repetitions of activities [33]. Previous studies applied to the rehabilitation of cognitive impairments have indicated that VR interventions have high ecological validity and acquired learning could be transferred to real life [34, 35]. Another advantage is that RF includes the ability to modify and customize tasks, measures, difficulties, situations, and stimuli included in the social environment. The characteristics of the avatars in the environments can also be customized. However, the evidence for efficacy of VR-based treatment in our study is limited. The small sample size and the absence of a follow up on the maintenance of acquired skills limit the generalization of the study. Our study provides preliminary evidence for the feasibility and use of VRI in pre-adolescent subjects with ASD even in the preliminary stages of emotional training. The aim of the following works will be to broaden the sample, evaluate maintenance, establish if there are differences between the emotional training skills acquired in VRI compared to IIT, if any differences also represent different starting points for the acquisition of further skills in training social. Indeed, a more solid generalization of basic emotional literacy skills could favour a more stable and rapid acquisition in terms of acquisition and generalization of further social cognition skills.

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