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Virtual Technologies in Intervention Programs for Autistic Children

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ABSTRACT: **Autism is a developmental disorder with increasing prevalence across the globe. There are several treatments including intervention programs. The effect of using collaborative virtual environments during intervention programs for children with autism was explored. Behavioral studies were conducted on responses to emotional recognition and theory of mind aspects of social cognition. Studies were done before the intervention program and after the intervention program and compared responses with and without collaborative virtual environments. Results suggest that the introduction of emotional expressiveness as part of virtual environment helped children with autism to communicate without fear and hence recognize others emotions.**

Keywords*:* Collaborative Virtual Environment, Autism, Emotions, Theory of Mind.

I. INTRODUCTION

Autism is classified as a neuro-developmental disorder that manifests in delays of "social interaction, language as used in social communication, or symbolic or imaginative play," with onset prior to age 3 years, according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR fourth edition). Autism is one of five disorders that fall under the umbrella of Pervasive Development Disorders (PDD).

Different approaches have tried to define the anatomical and functional correlates of emotional processing and theory of mind. Abnormalities have been consistently reported in individuals with autism. Baron-Cohen [2] found that most of the children with autism that he studied were unable to predict the ideas of others correctly. Another deficit related to ToM for people with autism is that of emotional understanding [3].

Social cognition of some sort characterizes many species. Many scholars believe that what sets human social cognition uniquely apart from that of other animals, even other primates, is having a theory of mind; that is, construing behaviors as caused by mental states such as beliefs, desires, intentions, and emotions [7, 10]. A hallmark of this mentalizing ability is evident in reasoning about false beliefs.

When children, and adults, predict mistaken behavior on the basis of a person's false belief, there is evidence that they understand actions as based on actors' representation of the world rather than on the reality of the world itself. However, theory of mind is severely and specifically impaired in individuals with autism, and this has led researchers to suggest that there may be distinct neural systems that support reasoning specifically about mental states [4, 6].

It is in fact well documented that individuals with autism have impairments in processing social and emotional information. This is particularly evident in tasks assessing face and emotion recognition, imitation of body movements, interpretation and use of gestures and theory of mind [1]. Recent studies have shown that individuals can learn to cope with common social situations if they are made to enact possible scenarios they may encounter in real life.

A Collaborative Virtual Environment (CVE) is a computer-based, distributed environment, in which people can meet and interact with others; each user in the CVE is represented by their individual "avatar".

Virtual Environments offer the potential for users to explore social situations and experience different behavior responses for a variety of simulated social interactions. It has been suggested that Virtual Environments (VE's) may be particularly useful for people with autism and may provide the ideal method for social skills training.

The shared features between virtual and real worlds may facilitate the generalization of skills from the former to the latter. The main benefit of VE's is that users can practice skills safely, without experiencing potentially dangerous real world consequences and the stimuli the user receives can be controlled.

Literature suggests that people with autism feel comfortable in predictable environments, and enjoy interacting with computers [14].

The purpose of this study is to examine the effect of using collaborative virtual environment (CVE) during intervention program to children with autism. In this paper we described two experiments, one with emotional recognition after intervention program with CVE and the other with theory of mind (ToM). In both these experiments we studied the behavioral aspects of the children with autism before and after intervention. Emotion recognition is responding to the emotions by recognizing them and theory of mind judging the beliefs.

II. MATERIALS, METHODS AND RESULTS

Experiment 1: Emotion recognition

Materials and Methods

Subjects: Two groups of children participated in this experiment. Ten Control group volunteers (age 7-19 years; all males; mean age 10.6 years) and ten autism group children (age 8-19 years; nine males and one female; mean age 11.6 years) are part of these groups. Diagnosis of autism was defined as meeting criteria for Autistic Disorder on the ADOS-G and ADI-R and meeting DSM-IV criteria for Autistic Disorder based on clinical judgment. All the subjects are dextral. All participants had normal or corrected to normal vision. The Institutional Psychology ethics committee of the National Institute for Mentally Handicapped approved the study, and all participants and parents gave written informed consent.

Stimuli: The visual stimuli were digital pictures of faces of different models. Pictures of a neutral and happy expression from each model were used. The pictures were converted to 256 (bits) grayscale images. The stimulus presentation was controlled with BioTrace+ program (Nexus32). Total 80 Pictures (60 neutral and 20 happy) are used and these pictorial presentations of a single face would be the target event to which subjects should respond. The stimulus frames were 640 pixels wide by 480 pixels high and were presented for 500 ms. Faces were presented on the monitor at a size of 16 cm by 12 cm.

Procedure: Subjects sat in a room, and a computer screen was placed at a viewing distance of 70 cm. Stimuli were presented at the centre of a computer screen by software package protocol designed using oddball paradigm. The experiment consisted of 80 trials, showing the stimuli in each trial for 500ms with an inter stimulus time of 1.5 s. Subjects asked to respond to happy faces by pressing a customized key board. The key board exposes only space-bar key and rest of the key board is covered to avoid distraction in subjects. Subject responses are recorded by the observer.

This same procedure was repeated for autism group after the intervention program. For the intervention program the autism group is again divided into two groups. The first group was trained manually for 6 months following conventional standard special education class room methods. Some of them include the flash cards for emotions and faces on toys. The second group trained for the same time using a collaborative virtual environment system. This system displays different emotions on the screen and the user communicates with the remote observer by expressing and recognizing the emotions. Various scenarios on the screen are presented and the user trained on judging the outcome.

Results: The correct responses for the target event i.e., happy face, are recorded for every session and the average number of correct responses for the control group and experimental group before intervention are shown in the tables table 1 and table 2 respectively.

Table 1: Average # of correct responses to target event by control group.

Subjects	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**	**CS9**	**CS10**
Average # of correct responses to target event	20	20	20	20	20	20	20	20	20	20

Table 2: Average # of correct responses to target event by experimental group before intervention.

Subjects	**ES1**	**ES2**	**ES3**	**ES4**	**ES5**	**ES6**	**ES7**	**ES8**	**ES9**	**ES10**
Average # of correct responses to target event	5	4	14	5	6	7	6	5	6	6

The average number of correct responses for the experimental group after manual intervention and experimental group after CVE intervention are shown in the tables table 3 and table 4 respectively.

Table 3: Average # of correct responses to target event by experimental group after manual intervention.

Subjects	**ES1**	**ES2**	**ES3**	**ES4**	**ES5**
Average # of correct responses to target event	6	4	16	5	8

Table 4: Average # of correct responses to target event by experimental group after CVE intervention.

Subjects	**ES6**	**ES7**	**ES8**	**ES9**	**ES10**
Average # of correct responses to target event	15	16	8	8	17

The grand averages for the experimental group before intervention, experimental group after manual intervention and experimental group after CVE intervention are 6.40, 7.80 and 12.80 respectively.

Experiment 2: Theory of Mind

Materials and Methods

Subjects: Two groups of children participated in this experiment. Eleven Control group volunteers (age 8-28 years; all males; mean age 13 years) and twelve autism group children (age 8-28 years; eleven males and one female; mean age 12.5 years) are part of these groups. Diagnosis of autism was defined as meeting criteria for Autistic Disorder on the ADOS-G and ADI-R and meeting DSM-IV criteria for Autistic Disorder based on clinical judgment. None have additional psychiatric or neurological diagnoses. Control group does not have the history of special education. All the subjects are dextral. All participants had normal or corrected to normal vision. The Institutional Psychology ethics committee of the National Institute for Mentally Handicapped approved the study, and all participants and parents gave written informed consent.

Stimuli: A cartoon animation is prepared to show a story of grandmother standing behind two boxes and drops a toy in each box as shown in the Fig. 1. The toys are a teddy bear and a joker. Grandmother then walks in front of the boxes and she cannot see the boxes. The toys then come out of the boxes and then either go back to the same box they belong (10 trials) or they interchange the boxes (30 trials). After this story, subjects were then asked to make a reality judgment and a think judgment. For a reality judgment, subjects were asked to judge really where one of the toy was by showing a question on the monitor "Where is this toy?", followed by showing one of the toys. Subjects need to respond by clicking on the box. For a belief judgment, subjects were asked to judge where the grandmother thinks one of the two toys is by showing a question on the monitor "Where does grandmother think this is?", followed by showing one of the toys.

Procedure: Subjects sat in a room, and a computer screen was placed at a viewing distance of 70 cm. Stimuli were presented at the centre of a computer screen by software package protocol designed using a variant of oddball paradigm. The experiment consisted of 40 trials, showing the animation in each trial, which presents the story to the subjects for 10 seconds. It asks a reality question and shows a response picture at 10^{th} second for 2 seconds which is the stimulus for reality event. Then it asks belief question and shows another picture at 15^{th} second for 2 seconds which is stimulus for belief event. Next trial starts after 3 seconds. Subjects' responses to judgment questions are recorded by the observer.

This same procedure was repeated for autism group after the intervention program. For the intervention program the autism group is again divided into two groups. The first group was trained manually for 6 months following conventional standard special education class room methods. Some of them include the flash cards for emotions and faces on toys. The second group trained for the same time using a collaborative virtual environment system. This system displays different emotions on the screen and the user communicates with the remote observer by expressing and recognizing the emotions. Various scenarios on the screen are presented and the user trained on judging the outcome.

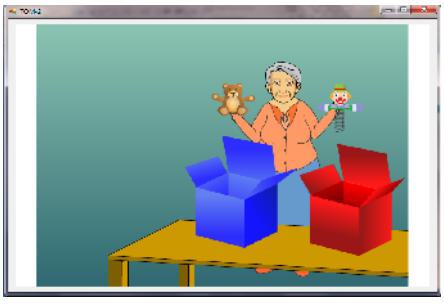

Fig. 1: Story portion of the experiment.

Results: The correct responses for the reality and belief judgments are recorded for every session and the average number of correct responses for the control group and experimental group before intervention are shown in the tables table 5 and table 6 respectively.

Table 5: Average # of correct responses to judgment questions by control group.

Subjects	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**	**CS9**	**CS10**	**CS11**
Reality-40	38.5	40	39	40	40	40	38	39	40	40	40
Belief-40	40	39	39	40	39	39	40	39	38	40	39

Control group Reality response grand average: 39. 5
Control group Belief response grand average: 39.27

Table 6: Average # of correct responses to judgment questions by experimental group before intervention.

Subjects	**ES1**	**ES2**	**ES3**	**ES4**	**ES5**	**ES6**	**ES7**	**ES8**	**ES9**	**ES10**	**ES11**	**ES12**
Reality-40	38.5	38	40	40	40	40	40	40	39	40	40	40
Belief-40	8	0	2	17	5	38	7.5	0	0	29	0	0

Experimental group Reality response grand average before intervention: 39.625
Experimental group Belief response grand average before intervention: 8.875
The average number of correct responses for the experimental group after manual intervention and experimental group after CVE intervention are shown in the tables table 7 and table 8 respectively.

Table 7: Average # of correct responses to judgment questions by experimental group after manual CVE intervention.

Subjects	**ES1**	**ES2**	**ES3**	**ES4**	**ES5**	**ES6**
Reality-40	37	36	39	40	40	40
Belief-40	6	4	5	16	7	32

Experimental group Reality response grand average after manual intervention: 38.67

Experimental group Belief response grand average after manual intervention: 11.67.

Table 8: Average # of correct responses to judgment questions by experimental group after CVE intervention.

Subjects	**ES7**	**ES8**	**ES9**	**ES10**	**ES11**	**ES12**
Reality-40	40	38	39	36	40	38
Belief-40	27	22	19	33	26	22

Experimental group Reality response grand average after CVE intervention: 38.5

Experimental group Belief response grand average after CVE intervention: 24.83

III. DISCUSSION

In emotion recognition experiment children with autism group before intervention has a Mean value of 6.40 with 95% confidence interval for Mean: 3.883 thru 8.917. Standard Deviation = 2.80 with Hi = 14.0; Low = 4.00 and Median = 6.00. The Average Absolute Deviation from Median = 1.40. Children with autism group after manual intervention has a Mean value of 7.8 with 95% confidence interval for Mean: 4.240 thru 11.36. Standard Deviation = 4.82 with Hi = 16.0; Low = 4.00 and Median = 6.00. The Average Absolute Deviation from Median = 3.00. Comparing these results with the Children with autism group after collaborative virtual environment intervention has a Mean value of 12.8 with 95% confidence interval for Mean: 9.240 thru 16.36. Standard Deviation = 4.44 with Hi = 17.0; Low = 8.00 and Median = 15.00. The Average Absolute Deviation from Median = 3.40. These results show that the improvement in emotion recognition in children with autism group has significantly improved when they used Collaborative Virtual Environments during their intervention program.

Also further analysis with ANOVA on the average # of correct responses to target event yielded a significant main effect of stimulus [$F(2,17) = 4.866$, $p = 0.021$], and post behavioral tests showed significant differences between the responses of all three categories. The probability of this result, assuming the null hypothesis, is 0.021 and as the $p < 0.05$, we assume that there are deviations in the data. i.e., emotion recognition data before intervention, data after intervention again between manual intervention and CVE intervention, there are deviations. This suggests that there is an effect of CVE intervention program.

Direct comparison of mean values of the belief judgment responses for theory of mind (ToM) experiment (mean response before intervention: 8.88; mean response after manual intervention: 11.7 and mean response after CVE intervention: 24.8) shows that there is a significant improvement in autism group with CVE intervention. An ANOVA on the average # of correct responses to belief judgment yielded a significant main effect of stimulus [$F(2,21) = 4.416$, $p = 0.025$], and post behavioral tests showed significant differences between the responses of all three categories. The probability of this result, assuming the null hypothesis, is 0.025 and as the $p<0.05$, we assume that there are deviations in the data. i.e., ToM data before intervention, data after intervention again between manual intervention and CVE intervention, there are deviations. This suggests that there is an effect of CVE intervention program.

IV. CONCLUSIONS

Both the experiments conducted on emotion recognition and theory of mind on children with autism showed results that are supporting the fact that the intervention programs with CVE are more effective.

The emotions experiment can be extended for different emotions. The CVE group responses during training also can be recorded to further enhance the hypothesis.

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