



Efficacy of Collaborative Virtual Environment Intervention Programs in Emotion Expression of Children with Autism

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Exploratory empirical studies on Collaborative Virtual Environments (CVEs) were conducted to determine if children with autism could make basic emotional recognition effectively, with the use of CVEs as assistive technology. In this paper we report the results of electro-physiological study of two groups of autistic children after an intervention program with and without using Collaborative Virtual Environment. The group trained with CVE showed better results compared to the group trained without Collaborative virtual Environment. There is an emphasized early emotion expression positivity component at around 120 ms latency for CVE trained group which clearly distinguishes the CVE untrained group. Also there are differences observed in Event Related Potential component at about 170 ms latency after the stimulus. Results indicate that the Collaborative Virtual Environments are effective in training Autistic children.

Keywords: Collaborative Virtual Environment, Event Related Potential, Autism, Emotions, N170.

1. 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). 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

Previous studies on ERP correlates of face recognition reported the early emotional expression effect.^{8–10} N170 is a face-specific component which is traditionally associated to the structural encoding of the facial stimuli,¹¹ but not to encoding of emotional expressions.^{5,12–17} However, there are also studies which have shown a modulation of N170 to the emotional faces.^{6,7,18,19} Different approaches have tried to define the anatomical and functional correlates of emotional processing. Abnormalities have been consistently reported in individuals with autism. Baron-Cohen² found that most of the children with autism that he

studied were unable to predict the ideas of others correctly. Another deficit related to people with autism is that of emotional understanding.³ Recent studies have shown that individuals can learn to cope with common social situations if they are made to enact possible scenarios that they might 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.⁴

With this background, it is interesting to perceive the effect of emotion expression on early emotion expression positivity and on N170 in children with autism and whether the intervention program with collaborative virtual environments bring any deviations in these components. Therefore, the primary aim

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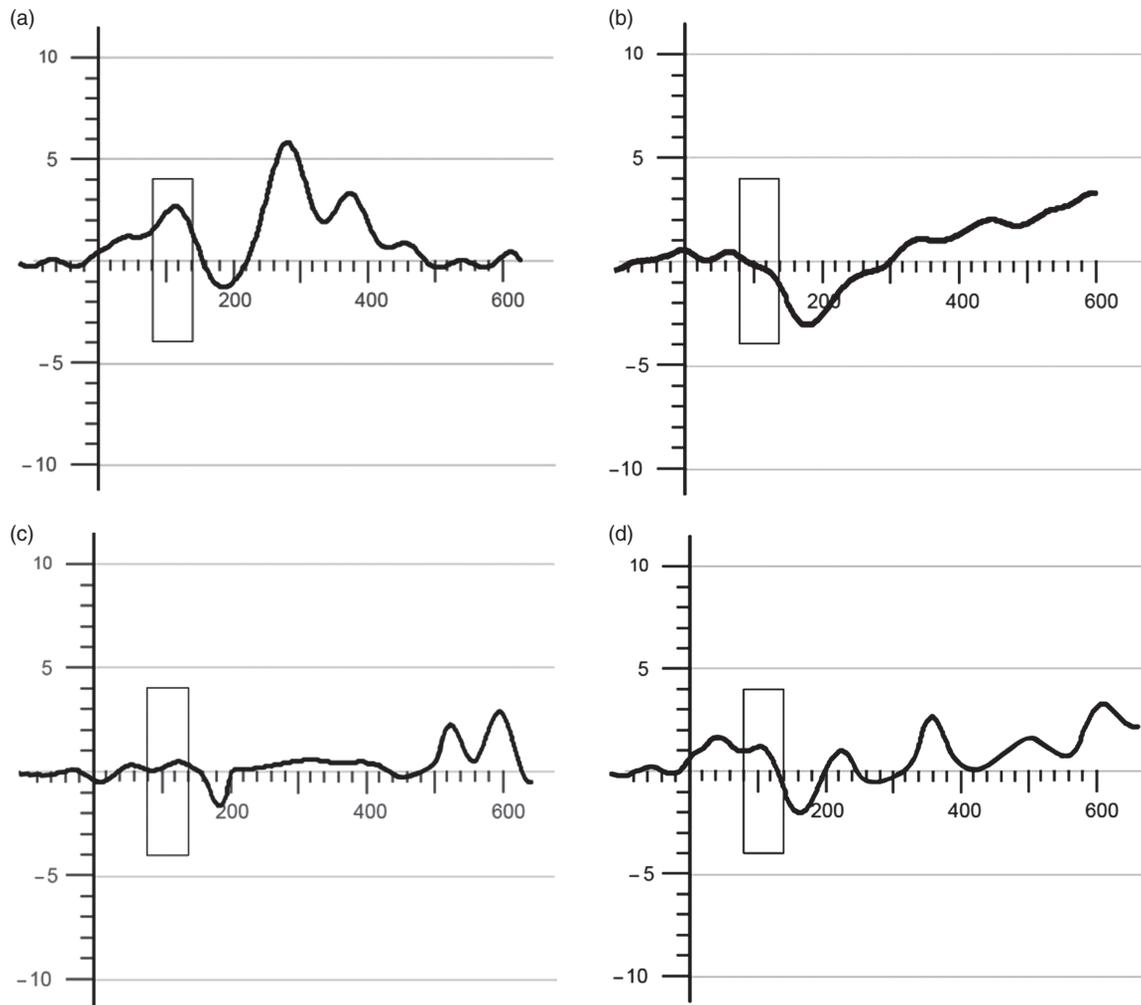


Fig. 1. Grand averaged ERPs to the happy deviants. Early emotion expression positivity in the 80–140 ms window. (a) Control group (b) Autism group before intervention (c) Autism group after manual intervention (d) Autism group after CVE intervention.

of the present study was to investigate the emotion expression effect on early emotion expression positivity components and the face-specific N170 in autistic children. A second and equally important objective was to test whether the collaborative virtual environment supported intervention program for children with autism has any effect on the investigated components. We know that certain ERP components are sensitive to different facial expressions,^{6,13} but no study has examined this for children with autism after intervention programs. In the current experiment, we compared both the early emotion expression positivity and N170 before and after intervention program using collaborative virtual environments for autistic children.

2. MATERIALS AND METHODS

2.1. Subjects

Two groups of children participated in this experiment as 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). 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.

2.2. 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 (Nexus 32). Total 80 Pictures (60 neutral and 20 happy) are used and these pictorial presentations of a single face would be the event to which the emotion condition ERP data to be time-locked. 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. Pictures on the system will serve as the stimuli for emotion recognition

2.3. 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 500 ms with an inter stimulus time of 1500 ms. Subjects asked to respond to happy faces by pressing a customized key board. The key board exposes only spacebar key and rest of the key board is covered to avoid distraction in subjects. EEG recording were made from Ag-AgCl electrodes and linked-earlobe reference at Fz, Cz, and Pz (according to the 10–20 system). Electrode impedance was kept <5 k Ω . Amplifier band pass was 0.1–25 Hz. EEG and EOG were sampled with a digitization rate of 256 Hz.

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. ERP analyses were conducted relative to a 100 ms pre-stimulus baseline, and were restricted to non-repetition trials. Trials with eye blinks, lateral eye movements were excluded. ERP mean amplitudes were analyzed separately by repeated measures ANOVAs at post-stimulus time interval of 80–140 ms. for early emotion expression positivity component and at 140–225 ms. for N170 component. A paired t -test was conducted to compare the three groups. Further to repeated measure ANOVA, a Tukey-Kramer method applied for multiple comparisons.

3. RESULTS

Both the components, early emotion positivity and N170, showed a significant differences among groups. ERP mean amplitudes for early emotion positivity were analyzed by repeated measures ANOVA within a post-stimulus time interval of 80–140 ms. as shown in Figure 1. Repeated measure ANOVA analysis on early emotion positivity showed a significant main effect of intervention [$F(2, 18) = 4.72, p = 0.022$] among the groups before and after intervention. Children with autism group before intervention has a Mean value of -0.25 with Standard Deviation = 0.6455 . The 95% confidence interval for group Means is shown in Figure 2. Children with autism group after manual intervention has a Mean value of 0.2 with Standard Deviation = 0.1972 . Children with autism group after CVE intervention has a Mean value of 0.375 with Standard Deviation = 0.8186 . Tukey-Kramer method pair wise comparisons were made and it was found that the data between the group before intervention and the group after CVE intervention is only significant. The data between autism group before intervention and after manual intervention is non-significant showing that there is considerable change in the autism group after CVE intervention in recognizing the emotions. This is further supported by paired t -tests on the 3 pairs. The t -test values for autism before intervention and autism after manual intervention are insignificant ($t = 2.02, p = 0.07$) compared to the significant values for autism before intervention and autism after CVE intervention ($t = 5.24, p = 0.001$).

For N170, ERP mean amplitudes were analyzed by repeated measures ANOVA within a post-stimulus time interval of

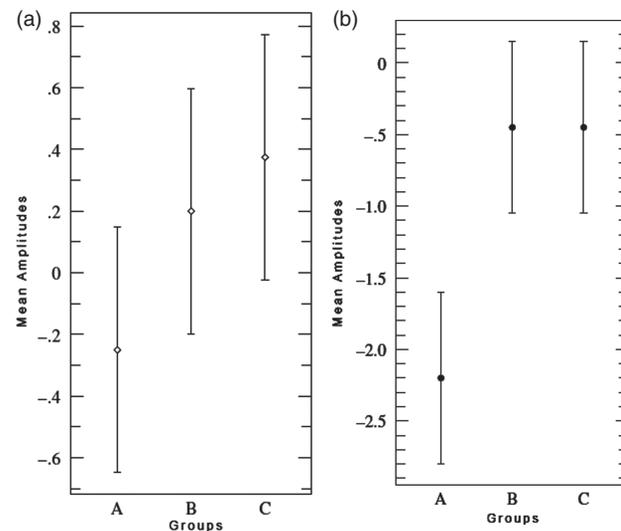


Fig. 2. 95% confidence interval for group Means. Group A is children with autism before intervention; B is after manual intervention; C is after intervention using collaborative virtual environments. (a) is for early emotion expression effect and (b) for N170.

140–225 ms. as shown in Figure 3. Repeated measure ANOVA analysis on N170 showed a significant main effect of intervention [$F(2, 18) = 18.85, p = 0.001$] among the groups before and after intervention. Children with autism group before intervention has a Mean value of -0.22 with Standard Deviation = 0.71 . Children with autism group after manual intervention has a Mean value of -0.45 with Standard Deviation = 0.64 . Children with autism group after CVE intervention has a Mean value of -0.45 with Standard Deviation = 1.28 . Tukey-Kramer method pair wise comparisons were made and it was found that both the data between the group before intervention and the group after manual intervention and the group before intervention and the group after CVE intervention are significant. This shows that there is a significant change in the autism group before and after intervention in recognizing the emotions. This is further supported by paired t -tests on the 3 pairs. The t -test values for autism before intervention and autism after manual intervention are significant ($t = 13, p = 0.001$) and also for autism before intervention and autism after CVE intervention ($t = 4.58, p = 0.001$).

4. DISCUSSION

In the current experiment, changes in facial expression, i.e., happy deviants, elicited differential ERPs for all the three groups, i.e., autism group before intervention, autism after manual intervention and autism after CVE intervention in two analysis windows. Early emotion expression positive shifts were observed in the first window at 110–140 ms and a negative N170 shift in the second window at 165–205 ms post stimulus. As mentioned in our aims in the beginning, we found an anterior positivity at 80–140 ms post-stimulus for all the groups. Where this was more positive to autistic group after manual intervention compared to before intervention, the group with CVE intervention has the most positivity. A frontal positivity in ERPs to emotional expressions relative to neutral ones are found in earlier studies on ERPs to facial expressions.¹³ The same corresponding latency

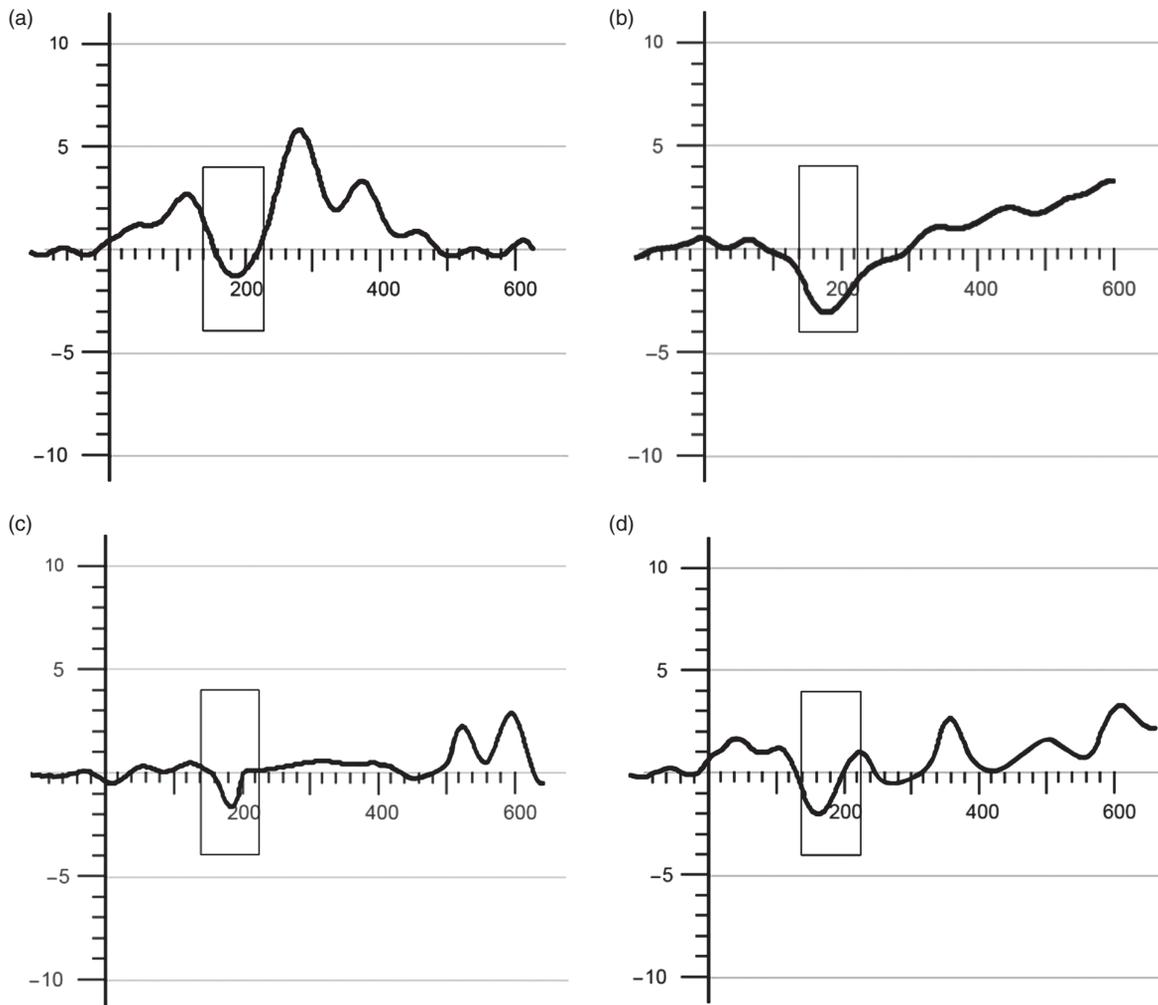


Fig. 3. Grand averaged ERPs to the happy deviants - N170 in the 140–225 ms window. (a) Control group (b) Autism group before intervention (c) Autism group after manual intervention (d) Autism group after CVE intervention.

was observed in the present study. One possible functional explanation for this deflection is that the fronto-central positivity is associated with early directing of attention towards emotionally significant events.²⁰ These findings suggest that the children with autism group that were trained using collaborative virtual environments have best responded to the emotions compared to the other groups.

Measures of the amplitude of the N170 also revealed interesting differences between the groups. The results on N170 shows the significance among groups and the mean amplitudes for autistic group after intervention are more positive compared to before intervention. We observed the N170 consistently appearing for all the groups. Though there are deviations appear in the latencies of N170, we are not able to conclude that they are related to emotion effect because of their latency pattern. The compared time course differences of the early emotion positivity and N170 for the happy deviants were shown in Figure 4. These analyses revealed that, autistic group before intervention responded slowly with a latency of 140 ms and after manual intervention the response was quicker compared to the before intervention group with a latency of 130 ms. The group with CVE intervention has

the quickest among the groups with a response time of 110 ms after the stimulus onset.

The present ERP data demonstrate that the emotional facial expression has occurred rapidly. A frontocentral positivity was

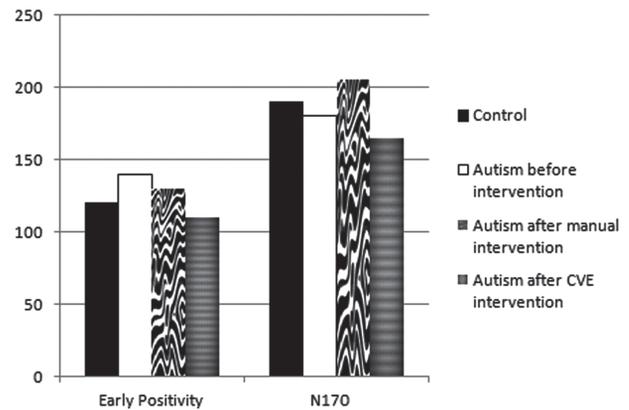


Fig. 4. Graphical presentation of the latency responses between the four groups for early emotion positivity and N170.

elicited by happy faces within the first 120 ms after stimulus presentation for normal group. This early emotional expression effect was smaller or almost nil and delayed by about 20 ms for autistic group before intervention, suggesting that autism results in a delay or miss of the initial analysis of emotional facial expression. The early emotional expression effect observed in this study preceded previously reported ERP correlates of face recognition^{8–10} by about 200 ms, suggesting that the detection of facial expression does not depend on face identification.

To conclude, results suggest that the detection and analysis of the emotional significance of faces consists of an initial rapid registration of facial expression (reflected by an early frontocentral positivity). The early emotional positivity might reflect the rapid activation of prefrontal areas involved in the detection of emotionally significant events. These results show that the emotion recognition in children with autism group has significantly improved when they used Collaborative Virtual Environments during their intervention program. An important question that has to be clarified in future research is whether the early emotional expression effects observed here are specifically elicited by happy faces, or whether other types of emotional facial expressions similarly elicit rapid brain responses in autistic children after intervention.

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