



# EEG Analysis of the Construction of Empathy Towards People with Schizophrenia, After Exposure to Virtual Reality Environments

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## Abstract

Schizophrenia is considered a complex syndrome, with multifactorial neurodevelopmental alterations. Empathy is a complex fundamental component of human emotional experience, which influences one's emotions and behavior. On the Electroencephalogram, an activation of the dorsolateral prefrontal cortex is characterized by a decrease in alpha activity. The main objective of this work is to understand if the immersive tools of Virtual Reality influence the electrical activity of the brain and the heart. The two immersive tools were able to increase empathy, mainly by altering prefrontal brain activity as well as heart rate.

## 1 Introduction

Schizophrenia is considered a complex syndrome, with multifactorial neurodevelopmental changes and has an average prevalence of about 1% in the world population (Kahn et al., 2015).

Empathy is understood as a complex fundamental component of the emotional experience of the human being, which influences one's emotions and behavior and covers a wide spectrum, from creating feelings of concern for other people or feeling or knowing what the other is feeling (Decety & Jackson, 2006; Paananen et al., 2022). One of the most important brain structures in mediating empathy is the dorsolateral prefrontal cortex (DLPfc), which is closely linked to valence theory, which describes that positive emotions are linked to the left hemisphere and negative emotions to the right hemisphere. In the electroencephalogram (EEG), this greater activation of a certain brain region is characterized by a greater desynchronization of electrical activity and, therefore, a decrease in alpha activity (Alimardani et al., 2020; Papousek et al., 2014).

Virtual Reality (VR) can represent environments that induce responses, reactions and emotions equivalent to what certain real-world situations provoke in an individual. This fact makes VR a valid tool for the evaluation and treatment of psychiatric pathologies (Papousek, et al., 2014).

## 2 Objectives

The main objective of this work is to understand whether immersive tools (VR or 360° environments) influence brain and cardiac electrical activity and, consequently, whether they can reduce stigma by increasing empathy towards individuals with schizophrenia. Nevertheless, we also intend to try to understand if it is possible to identify the best tool to use.

## 3 Methods

The sample consisted of 37 individuals (26 females and 11 males), aged between 18 and 33 years, divided into 2 groups (360° and VR groups).

The volunteers completed the empathy pre-intervention questionnaire. Electrodes F3, F4, Fz, C3, C4, Cz, P3, P4, Pz, Ground electrode in Fpz and a Reference electrode (G2) in CPz were placed, according to the literature (Alimardani, Hermans, & Tinga, 2020). Special attention was paid to electrodes F3 and F4 due to the proximity to DLpfc. To the Electrocardiogram (ECG), 2 electrodes were placed on the chest in an adapted DI lead. EEG and ECG were continuously recorded throughout all experience.

First, the 2 groups saw a simple explanatory video about schizophrenia. At the end of the video, a period of 1 minute was performed, with eyes open, fixed on a point. Then, the VR goggles were put on and it was explained that they would visualize a simulation that mimicked the symptoms of a psychotic outbreak of person with schizophrenia, as a 360° or VR environment. At the end of the simulation, the goggles were removed, and the eyes were open for 1 minute, fixed on a point. Finally, they were asked to fill in the post-intervention questionnaire.

The physiological variables under study are the Laterality Coefficient (LC) obtained through the brain activity recorded on the F4 and F3 and the mean heart rate obtained through the adapted DI.

## 4 Results

In EEG, we see that there are only statistically significant differences ( $p > 0.05$ ) between intervention moments. When comparing the groups and the interaction between the two factors – time and group – we cannot say the same. However, there is a clear tendency to decrease the LC, from the pre-intervention moment to the moment during the intervention.

In ECG, we see that there are statistically significant differences ( $p < 0.05$ ) for all the factors evaluated, that is, considering only the intervention moments, only the groups or the interaction between the two.

To que questionnaire variables, there are only statistically significant differences in the three dimensions when only the intervention moments are compared ( $p < 0.05$ ). However, there is a clear trend in the behavior of the variables, very similar between the two groups.

Regarding the scale of the evaluation simulation, it is possible to see that the average values between the 2 groups are very similar.

## 5 Discussion

Regarding the EEG, there is an undoubted greater activation of the right DLpfc and, consequently, an increase in empathy through feelings considered negative, such as sadness, related to the withdrawal/approach mechanism, but also with feelings such as compassion and concern (Alimardani, Hermans, & Tinga, 2020), due to clear tendency to decrease the LC, from the pre-intervention moment to the moment during the intervention.

The ECG showed undoubted statistical evidence to affirm differences in the interaction between the 2 factors, only between groups and only between intervention times. We believe that this is due to the fact that the Autonomic Nervous System (ANS) is more easily activated, because it is closely linked to the withdrawal/approach system, which is constantly on the alert in our daily lives for the usual fight-or-flight responses.

The subjective analysis through the questionnaires proved an increase in the total score of the Attitudes and Social Distance dimensions. On the other hand, the Empathy dimension score was lower than the pre-intervention one, which may show that opinions towards people with schizophrenia worsened in a very similar way between the 2 groups. However, this dimension contains very different issues, that is, it is scored in the same way, if the person feels, for example, compassionate or scared towards a person with schizophrenia.

## 6 Conclusion

The two immersive tools were shown to be able to increase the empathy of individuals, mainly by altering prefrontal brain activity and, consequently, increasing the activation of the right DLpfc, as well as the heart rate through the activation of the ANS. The results obtained in the questionnaires also support this idea that this type of immersive tool is extremely useful in decreasing stigma and increasing empathy towards individuals with schizophrenia. In the future, given the relevance from a scientific and educational point of view, and considering the scarce number of works in this area, this study assumes special importance in the field of mental health literacy and stigma, so it would be important to establish standards and rules for using this type of technology.

## References

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