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DEPARTMENT OF CLINICAL PSYCHOLOGY AND PSYCHOTHERAPY

Ph.D. THESIS SUMMARY

MULTILEVEL ANALYSES OF THE MECHANISM OF VIRTUAL REALITY INTERVENTION IN EMOTIONAL DISORDERS

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(3) All the Tables and Figures are numbered within the corresponding chapter or subchapter of the thesis.

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Keywords: virtual reality, psychotherapy, affective disorders, anxiety, presence, efficacy, hypnotic suggestions, rational/irrational beliefs, frontal alpha asymmetry

CHAPTER I. THEORETICAL BACKGROUND

1.1. Introduction and research problem

Virtual reality (VR) is a computer generated three dimensional world, which can be experienced through the use of specific interaction devices. The information is presented on multiple sensory channels, the most important ones being the visual and the auditory channels. An important characteristic of the virtual reality is the possibility of the user to interact with the virtual world.

Psychotherapy consists of both a set of psychological procedures applied to individuals with emotional, behavioral and somatic pathology, as well as more general strategies aimed at personal development and optimization of the patients (David, 2006).

A high number of studies reported that psychotherapy is effective, showing better results than no treatment (Kopta et al., 1999). The evidence-based interventions movement has shown that the cognitive behavior therapy (CBT) is one of the best validated treatments for anxiety disorders (Butler, Chapman, Forman, & Beck, 2006).

The efforts to improve the efficacy of CBT led to the incorporation of new therapeutic strategies aimed at dealing with the shortcomings, like the existence of a segment of non-responsive patients (David et al., 2008). Among these new therapeutic strategies, we can mention the animal assisted therapy, the mindfulness-based interventions and also the virtual-reality psychotherapy, a form of computer-based psychotherapy.

Our focus is the virtual-reality psychotherapy, which is seen here as a tool used inside an already established psychotherapeutic framework.

There is a growing body of evidence that virtual reality is an effective tool in psychotherapy. Virtual reality exposure therapy (VRET) is a new tool for conducting exposure therapy with the help of a computer-generated virtual environment, allowing for the systematic exposure to the feared stimuli within a contextually relevant setting (Parsons & Rizzo, 2008).

From the very beginning of the research in the field of VR and its applications, *presence* was considered an important factor related to the use of virtual reality in psychotherapy (Rizzo et al., 1998; Slater et al., 1993). Presence has been defined as “an interpretation of the artificial environment as if it were real” (Lee, 2004).

Presence is considered by many authors as a potential mechanism by which virtual reality psychotherapy operates (Rothbaum et al, 1995; Regenbrecht, Schubert & Friedman, 1998; Wiederhold & Wiederhold, 2005; Parsons & Rizzo, 2008). However, some authors have recently reported that presence does not always predict the treatment result (Krijn et al., 2004; Price & Anderson, 2007). In the context of these new findings, presence is still described as a construct which is necessary but not sufficient for successful virtual reality exposure therapy (Price & Anderson, 2007).

One can notice that any research on the efficacy or mechanism of change of VR psychotherapy should take into account the presence experienced by the subjects. Even with a number of presence assessment instruments being available worldwide, there is still no presence questionnaires adapted for the Romanian population.

Because presence is such an important construct in the field of VR, we investigated the possibility to enhance it. Currently there are many theories of presence, showing that there is no agreement among the researchers with regard to a unified model of presence. Since there may be still unknown factors affecting presence, we decided to investigate the effect of hypnotic

suggestions as a presence enhancing variable. It has been previously suggested that the hypnotic suggestions could be used to increase the sense of presence in the virtual world (Askay, Patterson & Sharar, 2009).

Beside the subjective reports, virtual reality psychotherapy mechanisms and effects should be analyzed within a multilevel approach. According to David et al. (1998) there are four levels of analysis: cognitive, behavioral, psychophysiological/biological and affective/subjective.

Rational/ irrational beliefs have long been described as the proximal causes of affective factors, such as functional/ dysfunctional emotions (Ellis, 1958; Ellis, 1994). With the development of cognitive psychology, the rational and irrational beliefs, as cognitions, started to be analyzed from a multilevel perspective: computational, algorithmic-representational, and implementational (David, 2003). Until now, there have been relatively few studies of rational/ irrational beliefs at the implementational level (David, Lynn & Ellis, 2010). Using his clinical experience, Ellis (1994) hypothesized the existence of biological bases for the irrationality. When taking into consideration that psychotherapy's effects can be distinguishable in the brain (Linden, 2006), it becomes clear that investigating the irrational beliefs at the implementational level is an interesting and promising line of research.

1.2. Relevance of the research

The current thesis aims to perform a multilevel analysis of the mechanism of the virtual reality intervention in emotional disorders, by addressing issues as presence in virtual reality, and, respectively, cognitive and implementational level analysis of emotions. An efficacy analysis of the virtual reality interventions in anxiety disorders is also performed. The thesis focuses on: 1) an investigation of CBT enhancement through the use of VR, with a special focus on anxiety disorders, 2) presence in virtual reality, as a key concept for VR applications in clinical psychology, and 3) an implementational level analysis of rational/ irrational beliefs and functional/ dysfunctional emotions, in the context of a multilevel approach to VR therapy.

CHAPTER II. RESEARCH AIMS AND OVERALL METHODOLOGY

Even if previous studies have shown good results for the virtual reality interventions, they are still not widely used. Part of this situation can be explained by the still not fully convincing results from the effectiveness studies on the virtual reality interventions. Our quantitative review aimed at providing effectiveness data for the virtual reality interventions in anxiety disorders.

Another explanation for the low usage figures for the virtual reality interventions is that we may have not exploited their whole potential yet. In fact, there are little things known about the mechanisms of change involved in virtual reality interventions (Meyerbröker & Emmelkamp, 2010). Our study was focused on providing implementational level data (i.e. frontal EEG asymmetry) regarding the rational/ irrational beliefs and functional/ dysfunctional emotions.

From the very beginning, presence was considered an important factor related to the use of virtual reality in psychotherapy (Rizzo et al., 1998; Slater et al., 1993) and today is still regarded at least as a necessary but not sufficient condition for successful virtual reality exposure therapy (Price & Anderson, 2007). Even with a number of presence assessment instruments being available worldwide, there is still no presence questionnaire adapted for the Romanian population.

Because presence is so important in VR research, we investigated the possibility to enhance it. Since there may be still unknown factors affecting presence, we decided to investigate the effect of hypnotic suggestions as a presence enhancing variable.

CHAPTER III. ORIGINAL RESEARCH

Study 1. Virtual reality exposure therapy in anxiety disorders: a quantitative meta-analysis[1]

Introduction

The anxiety disorders have a high prevalence, being a very important area for mental health research. The evidence-based interventions movement has shown that cognitive behavior therapy (CBT) is one of the best validated treatments for anxiety disorders (Butler, Chapman, Forman, & Beck, 2006).

Virtual reality exposure therapy (VRET) is a new tool for conducting exposure therapy with the help of a computer-generated virtual environment, allowing for the systematic exposure to the feared stimuli within a contextually relevant setting (Parsons & Rizzo, 2008).

Until now, for the anxiety disorders, there has been no meta-analysis in which the treatments combining a virtual reality exposure component with classical evidence-based interventions (e.g. cognitive-behavioral therapy and virtual reality, or behavioral therapy and virtual reality) were directly compared with the classical evidence-based interventions (in which no virtual reality component was used).

Overview of the present research

The current review will focus on how effective the virtual reality exposure enhanced evidence-based interventions are compared to the classical evidence-based interventions.

Virtual Reality Exposure Therapy (VRET) is defined as treatments that include a virtual reality component, either in the behavioral framework (i.e., behavioral therapy + VR exposure) or in the cognitive-behavioral framework (i.e., cognitive-behavioral therapy + VR exposure).

The present meta-analysis tries to provide answers to the following questions: 1) what is the efficacy of VRET compared to wait-list?; 2) what is the efficacy of VRET compared to classical evidence-based interventions?; 3) what is the impact of VRET on the real life, or in other words to what extent do the results of the treatment generalize to real-life situations for the clients?; 4) what are the long term effects of VRET?; 5) is there a dose-response relationship for VRET?; 6) is there a difference in the dropout rate between the virtual reality exposure and the in vivo exposure?

Methods

We selected randomized clinical trials of virtual reality exposure therapy in anxiety disorders. We searched the following databases: PsycINFO, PubMed , ISI Web of Science and Academic Search Premier.

On the basis of exclusion and inclusion criteria, in the meta-analysis we included 21 articles reporting 23 studies, with a total sample size of 608 participants.

We collected data regarding the following variables: disorder, treatment condition, comparison condition and number of participants per condition. The dependant variables were classified as follows: primary outcomes, and real life impact outcomes.

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[1] This study was accepted for publication.

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Authors contribution: David Opriş – design of the study, data interpretation and analysis, writing the manuscript; Sebastian Pintea – data interpretation and analysis; Azucena García-Palacios – data interpretation and analysis; Cristina Botella – design of the study, data interpretation and analysis; Ştefan Szamosközi – data interpretation; Daniel David – design of the study, data interpretation.

The comparison conditions to which VRET was compared were categorized as follows: Classical evidence-based interventions and Wait-list.

We calculated Cohen's d effect sizes, according to published procedures (Hunter & Schmidt, 2004). To avoid the bias induced by the differences in the sample sizes of the studies, we chose to calculate D (the average weighted effect size) instead of d, and variance of D (VAR D) instead of SD of d (Hunter & Schmidt, 2004).

Results

I. VRET vs. wait-list

There were eight studies concerning the comparison of VRET to wait-list control at post-treatment, on the primary outcomes. The results show a large and statistically significant overall effect size (D = 1.12; VAR D = .34, 95% CI [.71–1.52], p<.05), a large and statistically significant effect size on social phobia (two studies; D = 1.01; VAR D = .05, 95% CI [.69–1.33], p<.05) and a medium and statistically significant effect size for fear of flying (two studies; D = .53; VAR D = .007, 95% CI [.41–.64], p<.05).

II. VRET vs. classical evidence-based interventions

At post treatment

There were 15 studies regarding the comparison at post treatment between VRET and the classical evidence-based treatments at the level of primary outcomes. The results show no overall effect on the primary outcomes for VRET compared to the classical evidence-based treatments (D = .16, VAR D = .16, 95% CI [-.03–.36], p>.05). When the analysis was repeated for each anxiety disorder, the results were similar for panic disorder / agoraphobia, social phobia, arachnophobia and fear of flying.

There were eight studies regarding the comparison at post treatment between VRET and the classical evidence-based treatments at the behavioral level. The overall effect size of D = -.03 (VAR D = .07, 95% CI [-.22–.14], p>.05) revealed no effect for VRET relative to the classical evidence-based treatments. The results were the same in the case of fear of flying and arachnophobia. In the case of panic disorder with or without agoraphobia, measuring the clinical improvement, we obtained a small but statistically significant effect size, favoring the classical evidence-based treatments over the VRET interventions.

At follow-up

Regarding the comparison at follow-up between VRET and the classical evidence-based treatments at the level of primary outcomes, there were seven studies for the 3-6 months follow-up and three studies for the one year and beyond follow-up. For the 3-6 months follow-up the overall primary outcome effect size of D = -.02 (VAR D = .18, 95% CI [-.33–.29], p>.05) revealed no effect for VRET relative to the classical evidence-based treatments. For the one year and beyond follow-up the overall primary outcome effect size of D = -.11 (VAR D = .01, 95% CI [-.26–.03], p>.05) revealed no effect for VRET relative to the classical evidence-based treatments. When analyses were taken down at the disorder level all the results were the same: fear of flying at 3-6 months follow-up, fear of flying at the 1 year or more follow-up, panic disorder /agoraphobia at 3 months - 1 year follow-up and arachnophobia at 3-6 months follow-up.

There were four studies regarding the comparison at the 3-6 months follow-up between VRET and the classical evidence-based treatments at the behavioral level. At the behavioral level the overall effect size of D = .24 (VAR D = .09, 95% CI [-.05–.53], p>.05) revealed no

statistically significant effect for VRET relative to the classical evidence-based treatments. The same result was obtained in the case of panic disorder, measuring the clinical improvement. Three studies are on fear of flying and in their case there was a small, but statistically significant effect size, favoring the VRET interventions.

In order to test if there is a dose-response relationship for VRET we have tested whether there is a linear relationship between the number of sessions and the effect-size obtained in each study, using the procedure suggested by Hedges and Olkin (1985). Thus, we performed a weighted linear regression. The analysis revealed an unstandardized regression coefficient B=1.40, a standardized coefficient Beta=.26 with a Z=23.48 significant at $p<.01$. In conclusion we can confirm the hypothesis that the number of sessions moderates the effect-size obtained in the studies.

We performed the analysis regarding the difference in the dropout rate at post-treatment between the virtual reality exposure and the in vivo exposure. The overall dropout rate showed no difference between the virtual reality exposure and the in vivo exposure, $\chi 2$ (1,N=355)=.33, $p>.05$.

Discussion and Conclusion

Our results show that, in the case of anxiety disorders, (1) VRET does far better than the waitlist control; (2) the post-treatment results show similar efficacy between the behavioral and cognitive-behavioral interventions incorporating a virtual reality exposure component and the classical evidence-based interventions, with no virtual reality exposure component; (3) VRET has a powerful real life impact, similar to that of the classical evidence-based treatments; (4) VRET has a good stability of results in time, similar to that of the classical evidence-based treatments; (5) there is a dose-response relationship for VRET; and (6) there is no difference in the dropout rate between the virtual reality exposure and the in vivo exposure.

These results are arguments for the usefulness of VRET in clinical psychology and in the psychological treatments field and for a wider application of VRET in the clinical practice. Emmelkamp (2005) presented a number of advantages that virtual reality exposure has over the traditional exposure: the exposure can be performed inside the therapist's office, a convenient and safe environment in itself; the therapist has better control over the content and the pace of the exposure; the exposure can be repeated as much as needed; the exposure can be customized, to a certain degree, for a particular patient; in the case of fear of flying the virtual reality exposure it is also very cost-effective. Virtual reality exposure can be even more useful for PTSD treatment. Also, VR exposure could help to increase the likelihood of a patient to be willing to start and complete an exposure treatment.

Also, we think it is necessary to compare virtual reality exposure therapy versus other kinds of Internet and Computer Technologies based treatments, such as computer-aided psychotherapy and Internet-based treatments. Given the big differences in the cost and availability of these treatments, we believe this is a good moment to determine who can benefit better from which kind of treatment.

There are some limitations of the present study. First, the number of studies and subjects is relatively small. Similarly, the results cannot be generalized to the whole spectrum of anxiety disorders, given the limited availability of studies for certain anxiety disorders.

Study 2. Adaptation of the Presence and Reality Judgment Questionnaire

Introduction

From the very beginning, *presence* was considered an important factor related to the use of virtual reality in psychotherapy (Rizzo et al., 1998; Slater et al., 1993). Some authors defined presence as "a subjective experience of being in one place or environment, even when one is situated in another" (Witmer and Singer, 1998), while others considered presence as "an interpretation of the artificial environment as if it were real" (Lee, 2004). Different research groups argue for the need of a multifactorial model of presence (Schubert et al., 2001; Lessiter et al., 2001; Baños et al., 2005; Witmer and Singer, 1998). Most of the researchers agree that presence is a "complex and likely multidimensional construct" (Baños et al., 2008).

Recently, several authors have started to consider *presence* as a mechanism by which virtual reality psychotherapy operates (Rothbaum et al, 1995; Regenbrecht, Schubert & Friedman, 1998; Wiederhold & Wiederhold, 2005; Parsons & Rizzo, 2008). There are a number of studies that clearly support the connection between presence and the level of anxiety experienced within a virtual environment (Regenbrecht et al., 1998; Schuemie et al., 2000; Renaud et al., 2002; Robillard et al., 2003; Bouchard et al., 2008; Juan et al., 2009).

On the other hand, there are some authors who presented data that appear to contradict the current hypothesized relationship between presence and treatment response. These two studies "found no significant relations between presence and response to VRE treatment for specific phobias" (Price et al., 2011). However, even in the context of these new findings, presence is still described as a construct that is necessary but not sufficient for successful virtual reality exposure therapy (Price & Anderson, 2007).

The present research focuses on the adaptation of a presence questionnaire, Presence and Reality Judgment Questionnaire (Baños et al., 2000; Salvador Almela, 2007), to the Romanian language.

Method

The participants (N=228) were Psychology undergraduate students, which completed the instruments in exchange for course credits. Their age ranged from 19 to 44 years (M=22.04, SD=4.47), with 31 male and 197 female participants. A subgroup of subjects was used in the validity studies (age range from 19 to 44, M=21.71, SD=4.13, 21 male and 102 female).

The present study employed a correlational design. The subjects filled in the informed consent, a short demographic survey (i.e., age, gender) and completed the Immersive Tendencies Questionnaire (Witmer & Singer, 1998). They were then individually exposed to a virtual environment (SnowWorld 3, Hoffman et al., 2001). The exposure lasted five minutes, and the subjects were instructed how to visually explore and interact with the environment. After the exposure session, the subjects had to complete three more questionnaires: Presence and Reality Judgment Questionnaire – PRJQ (Baños et al., 2000), Presence Questionnaire – PQ (Witmer and Singer, 1998) and Simulator Sickness Questionnaire – SSQ (Kennedy, Lane, Berbaum, & Lilienthal, 1993).

Results

Factor Analyses

We performed an exploratory factorial analysis, but we were not able to replicate the five-factor structure that was supposed to emerge. We decided to validate a short form of the Presence and Reality Judgment Questionnaire. This short form has 16 items, those that emerged as a pattern during the initial factorial analyses. These items are grouped into 4 factors, each factor includes 4 items: Factor 1 – Emotional Involvement, Factor 2 – Reality Judgment and Presence, Factor 3 – Satisfaction with the Experience, Factor 4 – Influence of Formal Variables in Reality Judgment and Sense of Presence.

We tested the Romanian Short Version of the Presence and Reality Judgment Questionnaire by running a factorial analysis again, this time without a fix number of factors. As anticipated, the items were grouped into the 4 expected factors, based on the number of factors having Eigenvalues bigger than one. The four factors accounted for the 71.37% of the total variance. All the items showed high loadings (over .7) on one factor, with only one exception (item 19), which had a lower loading of .45.

Reliability analysis

Internal consistencies were examined with the help of alpha Cronbach for the PRJQ-RSV total score, as well as for the four factors. All scores showed a good internal consistency: total score $\alpha = .88$, Factor 1 $\alpha = .91$, Factor 2 $\alpha = .86$, Factor 3 $\alpha = .81$ and Factor 4 $\alpha = .75$.

Validity analyses

Concerning the validity analyses, we correlated the total score and the subscales of PRJQ-RSV with the Presence Questionnaire (PQ), with the Immersive Tendencies Questionnaire (ITQ) and with the Simulator Sickness Questionnaire (SSQ). We were expecting a high correlation between the scores of the two presence measuring instruments. Based on the previous studies, we were also expecting a medium and negative correlation between PRJQ-RSV and SSQ and, respectively, a positive and small-to-medium correlation between PRJQ-RSV and ITQ.

There is a high and positive correlation between the two presence questionnaires total scores, as expected. The correlation between the total scores of PRJQ-RSV and ITQ is positive and medium-low, similar to the one found in the literature between PQ and ITQ. Regarding the correlations between PRJQ and SSQ, our data failed to reveal the expected relationship, but at least the direction of the correlation is congruent with the earlier results (Witmer & Singer, 1998).

Discussion and Conclusion

Presence and Reality Judgment Questionnaire – Romanian Short Version (PRJQ-RSV) has been shown to have good psychometric properties, evidenced by the factorial analyses, the reliability and the validity analyses. This version has 16 items, four items for each factor: Factor 1 – Emotional Involvement, Factor 2 – Reality Judgment and Presence, Factor 3 – Satisfaction with the Experience, Factor 4 – Influence of Formal Variables in Reality Judgment and Sense of Presence.

An important limitation of our study was the use of general population, rather than clinical or subclinical population, as this bias in subject selection may have not evidenced some reactions specific to the clinical subgroups. Another limitation of the study is the use of only two types of virtual environments, both of them lacking some possibilities of interaction (i.e. the subjects could not move by themselves), which may have led to distorted responses at certain items of the questionnaire. Further studies are required, involving more types of virtual environment, as well as clinical and subclinical populations.

Study 3. Hypnotic suggestions effect on sense of presence in virtual reality[2]

Introduction

Presence in VR has been defined as an interpretation of the artificial environment as if it were real (Lee, 2004). VR presence was considered a multi-component concept, related also to the subjective evaluation of the realness of the environment and its content (Lessiter et al.,2001). Banos et al. (2000, 2005) proposed a complex model of five factors.

Most of the scientific literature identifies presence as a critical concept related to the efficacy of the virtual reality interventions (Rizzo, Wiederhold & Buckwalter, 1998; Wiederhold & Wiederhold, 2005). Presence is generally regarded as "a critical construct both for the experience of anxiety within a virtual environment and for a successful response to the virtual reality exposure" (Price et al., 2011).

Hypnosis is a very effective tool for pain management (Montgomery, DuHamel & Redd, 2000). Recently it has been shown that hypnosis can be successfully applied in virtual reality too (Askay, Patterson & Sharar, 2009). It has also been shown that increasing the level of presence in a virtual world is correlated with an increase in the efficacy of the intervention in the case of pain control (Hoffman et al., 2004). Presence "is believed to be the key factor in making immersive virtual reality more effective for pain control than traditional methods of distraction" (Askay, Patterson & Sharar, 2009).

Overview of the present research

The objective of this study is to investigate the impact of hypnotic suggestions on VR presence. More specifically, we are interested whether the level of presence in a virtual environment will increase if we administer presence enhancing suggestions in the same time. Our hypothesis is that these presence enhancing suggestions (while the subject is exposed to the virtual environment) will lead to an increase in the level of reported presence in the virtual environment.

Method

The participants were students of Babes-Bolyai University, Faculty of Psychology and Education Sciences (N=60, age m= 21.98 , sd= 2.71, all females). Based on the scores on Harvard Group Scale of Hypnotic Susceptibility, Form A (Shor & Orne, 1962) we selected these participants from a larger group as follows: 30 students had a high level of hipnotizability (score between 8-12) and 30 students had a low level of hypnotizability (score between 0-4).

We measured the presence with the help of a 36 items version of Presence and Reality Judgement Questionnaire. The hynotizability of the participants was evaluated with the Romanian version of the Harvard Group Scale of Hypnotic Susceptibility, Form A (David, Montgomery & Holdevici, 2003).

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[2] This paper was published.

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We used an experimental design, with the subjects allocated into two experimental groups based on a stratified randomization procedure. We had two experimental groups of 30 subjects, and in each group half of them had a high level of hypnotizability and the other half had a low level of hypnotizability.

The independent variable was the use of hypnotic suggestions, while the dependant variable was the level of presence.

Both groups were exposed to a virtual reality environment (SnowWorld3) while in the same time a painful stimulus was presented to them with the help of a pain inducing device that applied constant pressure on the index finger ("Forgione-Barber Strain Gauge"-like Pain Stimulator). The difference between the experimental and the control group was that in the case of the experimental group we used the hypnotic induction and suggestions, while in the case of the control group we did not use the hypnotic induction and suggestions. At the end of the procedure, all the subjects filled in the presence questionnaire.

A standard trance induction was performed with Stanford Hypnotic Susceptibility Scale, Form C (SHSS: C; Weitzenhoffer și Hilgard, 1962) and the script that uses the suggestion of an anaesthetic glove was adapted from Yapko (2003).

Results

In order to calculate the differences between the experimental and the control group we used the t test for independent samples. To estimate the effect size we computed Cohen's d (Cohen, 1977). The results of the t test show that there are statistically significant differences between the two experimental groups in the case of the "Reality judgment and presence" subscale, $t(59)=2.178$, $p< 0.05$, with a medium effect size Cohen's $d= 0.57$. Therefore the hypnotic suggestions influenced the level of VR presence, measured on the component of reality judgement and presence.

Also, a tendency toward a statistically significant result was found in the case of the „Emotional involvement" subscale, $t(59)=1.918$, $p=0.06$.

Discussion and conclusion

Our hypothesis, namely that presence enhancing suggestions (while the subject is in the virtual environment) will lead to an increase in the level of reported VR presence, is supported by the experimental data.

Our most important result is the difference between the two groups on the "Reality judgment and presence" subscale, which is statistically significant and also has a medium effect size. Previous studies showed that posthypnotic suggestions increased the distraction effect of virtual reality from the experimental provoked pain (Patterson et al., 2006). The results of the present study indicate that hypnotic suggestions can amplify the illusion of presence in virtual reality, this having practical and methodological implications for future research.

Our results provide preliminary support for the possibility of using the hypnotic suggestions specifically to increase the level of presence one experiences in a virtual environment. This could be an important way to raise the effectiveness of the virtual reality interventions.

However, we should be aware of some limitations of this study. The suggestions were directed both at increasing the presence and reduce the pain, and in this way the pain reduction suggestions may have shifted attention away from the virtual environment and to the

participant’s hand, leading to a reduction in presence. Another limitation is that the presence was assessed by a self report measure at the end of the virtual reality exposure session, and the subjects who received the presence enhancing suggestions may have responded in a desirable way to the presence questionnaire, reporting more presence at the end. Another limit of the present study is that we used the hypnotic induction only with the group that received the hypnotic suggestions. It is possible that the hypnotic induction alone to have had some effects on the presence.

Study 4. The relationships of rational/irrational beliefs and functional/dysfunctional emotions with the frontal alpha power asymmetry

Introduction

Cognitive Behavioral Therapy (CBT) is one of the most effective forms of psychotherapy today (Butler, Chapman, Forman, & Beck, 2006). Rational and Emotional Behavioral Therapy (REBT) is one of the main forms of psychotherapy under the CBT umbrella, being the first one to introduce the concepts of rational beliefs and irrational beliefs (Ellis, 1958). Both the rational and the irrational beliefs are evaluative cognitions, a difference between them being in terms of flexibility vs. rigidity (Ellis & DiGiuseppe, 1993). According to the ABC model (Ellis, 1962; Beck, 1976), when a negative situation occurs, people have two possibilities to react. Thus, when people employ rational cognitions, they will employ adaptive behaviors and will experience functional emotions, whereas when they employ irrational cognitions, they will perform maladaptive behaviors and will experience dysfunctional emotions (Ellis, 1994). With the development of cognitive psychology, the rational and irrational beliefs, as cognitions, started to be analyzed from a multilevel perspective: computational, algorithmic-representational, and implementational (David, 2003). At computational level, the rational/irrational cognitions were described as having a pivotal role in the generation of emotions, being understood as *hot cognitions* in a modified version of Lazarus' (1991) appraisal theory of emotion (David, Lynn & Ellis, 2010). Until now there have been relatively few studies of rational/ irrational beliefs at the implementational level (David, Lynn & Ellis, 2010). Taking into account that the effects of psychotherapies can be distinguishable in the brain (Linden, 2006), it becomes clear that the investigation of the irrational beliefs at the implementational level is an interesting and promising line of research.

The frontal asymmetry is a measure of the relative activity of the right and left hemispheres (Coan & Allen, 2004). The frontal asymmetry can be measured by more instruments, but the most usually employed one in the research of the relationship between emotion and frontal asymmetry is electro-encephalogram (EEG; Harmon-Jones et al., 2010).

In the recent years, the relationship between the frontal hemispheric asymmetry and emotions has been of special interest for researchers (Cacioppo, 2004). The first studies supported a valence oriented model. Based on the studies associating depression with relatively greater right frontal EEG activity (e.g., Jacobs & Snyder, 1996), it was supposed that the negative emotions are related with greater right than left frontal EEG activity. Other studies have related trait positive affect with relatively greater left frontal activity, and trait negative affect with relatively greater right frontal activity (Tomarken et al., 1992). However, the theory suggesting a valence related association of emotions with the frontal EEG asymmetry was challenged by a number of experimental results (e.g. Amodio et al., 2008; Coan & Allen, 2003). Thus, one study found out that, at resting state, trait approach motivation was associated with relatively greater left frontal activity, while trait withdraw motivation was associated with relatively greater right frontal activity (Sutton & Davidson, 1997). Another study found an association between trait approach and greater left frontal activity (Harmon-Jones & Allen, 1997). The above mentioned results supported a *motivational direction* oriented association with the frontal EEG asymmetry, rather than a *valence* oriented association (Harmon-Jones et al., 2010).

However, the distinctions between rational and irrational beliefs and, respectively, between functional and dysfunctional emotions, has not been taken into consideration in this line of research. Based on the fact that these distinctions are supported by affective research in cognitive sciences (i.e. modified version of appraisal theory of Lazarus; Ellis, David & Lynn, 2010) and by a strong line of clinical practice (REBT; Ellis, 1994), one could infer that they might play a role in the relationship between emotions and frontal EEG asymmetry.

The present study aims to investigate the relationship between the rational/ irrational beliefs and the frontal alpha power asymmetry. We used a quasi-experimental design, hypothesizing that: 1) Irrational cognitions are positively correlated with greater relative right frontal hemisphere activity, and 2) Rational cognitions are positively correlated with greater relative left frontal hemisphere activity. We also assessed, as a secondary analysis, the relationships between the functional/ dysfunctional emotions and the frontal asymmetry.

Method

The participants (N=31) were age ranged from 19 to 35 years (M=22.70 , SD=4.54), with six male and 25 female participants. All the participants were college students. Participants were not diagnosed with any psychiatric disorder and were not taking any medication that may affect brain activity.

The present study employed a correlational design. Upon arrival, the subjects filled in the informed consent, a short demographic survey (i.e., age, gender), the Edinburgh Handedness Inventory (Oldfield, 1971), the Profile of Affective Distress scale (PDA; Opriș & Macavei, 2007), and the Attitudes and Believes Scale (ABS II; DiGiuseppe et al., 1988). After the completion of the questionnaires, the participants were introduced in the laboratory room, where the EEG recordings were performed. Continuous EEG signal was recorded for two minutes, while the subjects were seated with their eyes closed, relaxed but awake.

The psychophysiological data collection was done in a sound and light attenuated room, with a constant temperature. The subjects were sat on a chair and the electrodes were fitted, according to the 10-20 International Electrode System (Davidson, Jackson & Larson, 2000). The signal was measured from F3 and F4 locations, both referenced online to an electrode placed on the nasion (see Figure 1). Grounding was provided by an electrode placed on the left ear.

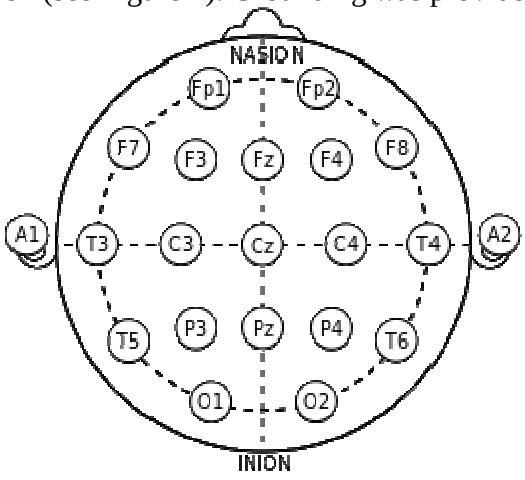

Figure 1. The placement of the electrodes on a 10-20 International Electrode System

The impedances were generally kept below 10kΩ, and never exceeded 20kΩ. The impedance was measured with a UFI (Morro Bay, CA) impedance meter. After the placement of the electrodes, the subject was instructed to close his/her eyes and remain relaxed for the next two minutes, a period of time in which the EEG activity was recorded (Coan, Allen & Harmon-Jones, 2001). This experimental setup was chosen because the alpha activity is highest during periods of time in which subjects are sitting with their eyes shut, awake but relaxed (Davidson, Jackson & Larson, 2000). The EEG activity was continuously recorded with the help of two Biopac (Biopac Systems, Inc., Goleta, CA) EEG100C amplifiers (Gain 10,000; High Pass 0.1 Hz; Low Pass 35 Hz), connected to a Biopac MP150 system. An AcqKnowledge 4.1 software, running on a Windows XP computer, was used to record the 1 kHz digitized signal. An online filter built-in with the Biopac system was used to remove online the 50Hz artifacts.

The most commonly used index of frontal EEG asymmetry is a difference score, computed "by subtracting the natural log of left hemisphere alpha power from the natural log of right hemisphere alpha power (ln[right alpha] – ln[left alpha])" (Coan & Allen, 2004). The unidimensional scale that results represents the relative activity of the hemispheres, with higher scores (i.e. positive values) meaning relatively higher activity of the left frontal hemisphere and lower scores (i.e. negative values) meaning relatively higher activity of the right frontal hemisphere (Coan & Allen, 2004).

To compute the asymmetry index, the data from F3 and F4 electrode locations were separately processed. The EEG frequency bands were derived for the two minutes period, then for the Alpha band the mean power was extracted for each one second interval. This new values were natural log transformed. The values for the left hemisphere (F3) were then subtracted from the ones for the right hemisphere (F4), and a final averaged value was computed.

Results

ABS II scale (DiGiuseppe et al., 1988) is structured on three factors: modalities of evaluative cognitions, domains of content and evaluative cognitive processes.

Analyzing the results of the correlations between the frontal alpha power asymmetry and the modalities of the evaluative cognitions, we can see that there is a statistically significant, medium (Cohen, 1992) and positive correlation between the relative greater left frontal activity and the rational cognitions ($r=.38$, $p<.05$, $N=31$). In case of the irrational cognitions and the total score of irrationality, there are no statistically significant correlation at a $p<.05$. However, a retrospective statistical power analysis indicates that the current medium to small correlation between frontal asymmetry and the ABS II total score ($r=-.25$, $p=.17$, $N=31$) would have become statistically significant for $N\geq70$ subjects, at a $p<.05$ significance level. It may be possible that the lack of statistically significant correlation is due to a rather modest statistical power of the study, rather than due to a relationship which does not exists. The correlations between the ABS Total Score, ABS IR and ABS R are in the direction and at the expected levels.

In case of the domains of content, none of the ABS II scales is significantly correlated with the frontal asymmetry. Again, as in the case of the modalities of evaluative cognitions, ABS Achievement would have become statistically significant for $N\geq40$ and ABS Approval would have become statistically significant for $N\geq60$.

Regarding the modalities of evaluative cognitions, three situations have been distinguished. First, ABS DEM is statistically significant, inversely correlated with the frontal asymmetry ($r=.39$, $p<.05$, $N=31$). In the second situation, we have the ABS AWF and ABS LFT, both showing an inverse, small to moderate, but statistically not significant correlation with the

frontal asymmetry. These correlations would have become significant for N≥60 subjects for ABS AWF, and for N≥80 subjects for ABS LFT. In the third situation, we have ABS SD/OG, which shows no correlation with the frontal asymmetry.

As secondary analyses, we investigated the relationships between functional/ dysfunctional emotions and the frontal asymmetry. In the case of functional and dysfunctional emotions, no statistically significant correlations with the frontal asymmetry were found. However, we detected some encouraging trends in the data. PDA FN would have become statistically significant at $p<.05$, with a low to medium, inverse correlation with the alpha power asymmetry for N≥60, while the same is true for PDA N for N≥70 subjects. Even if the correlation level is small and not statistically significant, the correlation for PDA P is direct, and in the opposite direction compared to the negative emotions. The correlations between the PDA subscales are large and statistically significant, similar with those obtained in previous studies.

Discussion and Conclusion

Our results show a statistically significant, medium sized, positive correlation between the rationality subscale of ABS II and the frontal EEG alpha power asymmetry. These results are consistent with our hypothesis that the rational beliefs are associated with a relatively greater left frontal activity. To our knowledge, these are among the first experimental data regarding the implementational level analysis of the rational/ irrational beliefs theory of Albert Ellis (1994). Two previous models have been used to explain the association between frontal EEG asymmetry and emotions: the *valence model* (Tomarken et al., 1992) the *motivational direction model* (Sutton & Davidson, 1997). The inclusion of new variables, namely the rational/ irrational beliefs and their subsequent functional/ dysfunctional emotions, may enhance our understanding of the relationship between emotions and the frontal asymmetry.

In the case of the irrational beliefs, our results show no statistically significant correlations with the frontal EEG asymmetry. ABS II has two scores, which are supposed to measure irrational beliefs: ABS IR is a score that is directly measuring irrationality, with all its items being phrased in an irrational manner. The frontal EEG asymmetry shows no correlation at all with this subscale. There is also a total score of the ABS, in which the irrationally phrased items are directly scored, and the rational items are inversely scored. In the case of the ABS Total Score, the small-to medium correlation with the relatively greater right frontal activity would have become statistically significant at $p<.05$ for N≥70. However, in this case it seems that the relationship may be due to the rationally phrased, but inversely scored items, rather than to the irrationally phrased items. A possible explanation for the existence of the relationship with the frontal asymmetry in the case of the rational beliefs and for the absence of the relationship in the case of irrational beliefs is that, in the case of the irrational beliefs, other subcortical areas (i.e. amygdala) may also play an important role, beyond the prefrontal cortical structures (David, Lynn & Ellis, 2010).

We also investigated the relation between irrationality and the frontal asymmetry, when taking into consideration the cognitive processes or the domains of content.

In terms of cognitive processes, the relatively greater right frontal activation shows a statistically significant medium correlation with the demandingness. The small to medium correlations may become statistically significant in case of an added statistical power in case of awfulizing and low frustration tolerance, and there is no correlation at all between the frontal asymmetry and the over-generalization/ self-downing. A hypothesis which may explain these

results is that the different processes rely on different cortical structures, and in the case of self-downing a more important role may be played by subcortical structures (i.e. amygdala).

In the case of different domains of content, there are no statistically significant correlations between frontal asymmetry and ABS II subscales. However, the correlation between the relatively greater right frontal activation may become statistically significant and small-to-medium in case of an added statistical power in case of achievement and approval, but there is no correlation with the comfort. Again, this result may be due to the different involvement of the subcortical structures in the cases of these three domains of content, suggesting that in the case of comfort, the subcortical structures may have the biggest involvement.

Neither the level of functional emotions, nor the level of dysfunctional emotions had a statistically significant association with the frontal alpha power asymmetry. However, in both cases, an increase in statistical power would have resulted in statistically significant at $p<.05$, small to medium correlations between the functional and the dysfunctional emotions and, respectively, the relatively greater right frontal activity. In the context of a difference found in this study between the rational and irrational beliefs' association with the frontal asymmetry, a possible explanation could be the measurement of the emotions in the absence of an emotion-inducing stimulus, which is supposed to be a necessary condition to induce a functional or dysfunctional emotions.

There are some limitations of the present study. First of all, it is important to note that all the subjects were college Psychology students, and it is possible that their responses at ABS II and PDA were biased by their previous knowledge on this type of psychological measurements. Also, we are aware that, due to the fact that our participants were all students, the results cannot be generalized to the whole population. Another limit of this study is the rather small number of subjects. Even though no causal relations can be extracted from this study, there are other studies which could be performed to establish a causal relationship. Further studies are needed to elucidate the relationship between the state/trait frontal asymmetry and, respectively, the rational/ irrational beliefs and the functional/ dysfunctional emotions.

CHAPTER IV. GENERAL CONCLUSIONS AND DISCUSSION

The purpose of Study 1 was to assess the efficacy of the VRET interventions in anxiety disorders. We are not trying to show the contribution of the virtual reality exposure *per se*, instead we are interested in how well the interventions incorporating a virtual exposure component did compared to the classical evidence-based interventions used in anxiety disorders. As a result, in the following discussion VRET means either behavioral therapy augmented by virtual reality exposure, or cognitive-behavioral therapy augmented by virtual reality exposure.

Our results show that, in the case of anxiety disorders, (1) VRET does far better than the waitlist control; (2) the post-treatment results show similar efficacy between the behavioral and cognitive-behavioral interventions incorporating a virtual reality exposure component and the classical evidence-based interventions, with no virtual reality exposure component; (3) VRET has a powerful real life impact, similar to that of the classical evidence-based treatments; (4) VRET has a good stability of results in time, similar to that of the classical evidence-based treatments; (5) there is a dose-response relationship for VRET; and (6) there is no difference in the dropout rate between the virtual reality exposure and the in vivo exposure.

These results are arguments for the usefulness of VRET in clinical psychology and in the psychological treatments field and for a wider application of VRET in the clinical practice. Emmelkamp (2005) presented a number of advantages that virtual reality exposure has over the traditional exposure: the exposure can be performed inside the therapist's office, a convenient and safe environment in itself; the therapist has better control over the content and the pace of the exposure; the exposure can be repeated as much as needed; the exposure can be customized, to a certain degree, for a particular patient; in the case of fear of flying the virtual reality exposure it is also very cost-effective. Virtual reality exposure can be even more useful for PTSD treatment. Also, VR exposure could help to increase the likelihood of a patient to be willing to start and complete an exposure treatment. On the other hand, we think it is necessary to compare virtual reality exposure therapy versus other kinds of Internet and Computer Technologies based treatments, such as computer-aided psychotherapy and Internet-based treatments. Given the big differences in the cost and availability of these treatments, we believe this is a good moment to determine who can benefit better from which kind of treatment.

There are some limitations of the present study. First, the number of studies and subjects is relatively small. Similarly, the results cannot be generalized to the whole spectrum of anxiety disorders, given the limited availability of studies for certain anxiety disorders.

In Study 4, we conducted studies focused on providing implementational level data (i.e. frontal EEG asymmetry) regarding the rational/ irrational beliefs and functional/ dysfunctional emotions.

Our results show a statistically significant, medium sized, positive correlation between the rationality subscale of ABS II and the frontal EEG alpha power asymmetry. These results are consistent with our hypothesis that the rational beliefs are associated with a relatively greater left frontal activity. To our knowledge, these are among the first experimental data regarding the implementational level analysis of the rational/ irrational beliefs theory of Albert Ellis (1994). Two previous models have been used to explain the association between frontal EEG asymmetry and emotions: the *valence model* (Tomarken et al., 1992) the *motivational direction model* (Sutton & Davidson, 1997). The inclusion of new variables, namely the rational/ irrational beliefs and their subsequent functional/ dysfunctional emotions, may enhance our understanding of the relationship between emotions and the frontal asymmetry.

Concerning the methodological/ practical advances, Study 2 focused on the adaptation of a presence questionnaire for the Romanian population.

Presence and Reality Judgment Questionnaire – Romanian Short Version (PRJQ-RSV) has been shown to have good psychometric properties, evidenced by the factorial analyses, the reliability and the validity analyses. This version has 16 items, four items for each factor: Factor 1 – Emotional Involvement, Factor 2 – Reality Judgment and Presence, Factor 3 – Satisfaction with the Experience, Factor 4 – Influence of Formal Variables in Reality Judgment and Sense of Presence.

An important limitation of our study was the use of general population, rather than clinical or subclinical population, as this bias in subject selection may have not evidenced some reactions specific to the clinical subgroups. Another limitation of the study is the use of only two types of virtual environments, both of them lacking some possibilities of interaction, which may have led to distorted responses at certain items of the questionnaire. Further studies are required, involving more types of virtual environment, as well as clinical and subclinical populations.

In Study 3, we investigated the effect of hypnotic suggestions as a presence enhancing variable. Our hypothesis was that the presence enhancing suggestions (while the subject is in the virtual environment) will lead to an increase in the level of reported VR presence.

Our most important result is the difference between the two groups on the "Reality judgment and presence" subscale, which is statistically significant and also has a medium effect size. Previous studies showed that posthypnotic suggestions increased the distraction effect of virtual reality from the experimental provoked pain (Patterson et al., 2006). The results of the present study indicate that hypnotic suggestions can amplify the illusion of presence in virtual reality, this having practical and methodological implications for future research.

Our results provide preliminary support for the possibility of using the hypnotic suggestions specifically to increase the level of presence one experiences in a virtual environment. This could be an important way to raise the effectiveness of the virtual reality interventions.

However, we should be aware of some limitations of this study, related to the suggestions. The suggestions were directed both at increasing the presence and reduce the pain, and in this way the pain reduction suggestions may have shifted attention away from the virtual environment and to the participant's hand, leading to a reduction in presence. Another limitation is that the presence was assessed by a self report measure at the end of the virtual reality exposure session, and the subjects who received the presence enhancing suggestions may have responded in a desirable way to the presence questionnaire, reporting more presence at the end. Another limit of the present study is that we used the hypnotic induction only with the group that received the hypnotic suggestions. It is possible that the hypnotic induction alone to have had some effects on the presence.

In summary, this thesis reports a multilevel analysis of the mechanism of the virtual reality intervention in emotional disorders, by addressing issues as presence in virtual reality, and, respectively, cognitive and implementational level analysis of emotions. An effectiveness analysis of the virtual reality interventions in anxiety disorders is also performed. Our results support the usefulness of VR psychotherapy in anxiety disorders, while bringing a preliminary confirmation of the relationship between rational beliefs and the left frontal hemisphere activity.

It also validates a presence assessment instrument for the Romanian language and supports the effect of hypnotic suggestions as a presence enhancing variable.

Limitations and future directions

In the case of Study 1, the main limitations are a relatively small number of subjects/ studies and also a limited availability of studies for certain anxiety disorders. Future randomized control trial on the efficacy of virtual reality in anxiety disorders should be conducted on most of the anxiety disorders, and they should include more subjects.

In the case of Study 2, the main limitations are related to the use of general population and to the small number of virtual environments, lacking some possibilities of interaction. Future studies should use also clinical and subclinical participants, as well as a more diverse range of virtual environments.

In the case of Study 3, the limitations are related to the formulation of the suggestions and to the lack of a group which where only hypnotized, but without further using the suggestions. Future studies should address these limits, by more carefully designed suggestions and by including a group to which the hypnotic induction will be performed but no suggestions will be given.

In the case of Study 4, the limitations are related to the relatively small number of subjects, to the use of general population, and to the use of an experimental design which allows only correlational analysis. Future studies should include more participants and should use general as well as subclinical and clinical population. Even though no causal relations can be extracted from this study, there are other studies which could be performed to establish a causal relationship. A possibility would be to try to modify the frontal asymmetry (e.g. by neuro-feedback training) and see the effects of this modification on the rational/ irrational beliefs and functional/ dysfunctional emotions. Another line of studies should also try to associate the state dependant frontal asymmetry with the rational/ irrational beliefs and the functional/ dysfunctional emotions. Further studies are needed to elucidate the relationship between the state/trait frontal asymmetry and, respectively, the rational/ irrational beliefs and the functional/ dysfunctional emotions.

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