Expert Systems with Applications 42 (2015) 1699–1709

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Assessing brain activations associated with emotional regulation during virtual reality mood induction procedures

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ARTICLE INFO

Article history:
Available online 13 October 2014

Keywords:
Emotional regulation strategies
EEG
Emotiv EPOC
Virtual reality
Sadness
sLORETA

ABSTRACT

Emotional regulation strategies are used by people to influence their emotional responses to external or internal emotional stimuli. The aim of this study is to evaluate the brain activations that are associated with the application of two different emotional regulation strategies (cognitive reappraisal and expressive suppression) during virtual reality mood induction procedures. We used Emotiv EPOC to measure the brain electrical activity of participants while sadness is induced using a virtual reality environment. We monitored 24 participants, who were distributed among three experimental groups: a control group, a cognitive reappraisal group and an expressive suppression group. In the control group, we found significant activations in several right frontal regions that are related to the induction of negative emotions'. We also found significant activations in the limbic, occipital, and parietal regions in the emotional regulation groups. These regions are related to the application of emotional regulation strategies. The results are consistent with those shown in the literature, which were obtained through clinical neuroimaging systems.

1. Introduction

Emotional Regulation (ER) is a surging field of great interest for health sciences in general and for psychology and education in particular. There are several reasons for this, but one of the most important ones is the central role that emotions play in day-to-day living. In the words of Chambers, Gullone, and Allen (2009), ER can be generally defined as "the process of modulating one or more aspects of an emotional experience or response". This process has an impact on the intensity, duration, and expression of emotions (Gross & Thompson, 2007). ER is therefore considered to be an important factor influencing virtually all aspects of life, including our physical and mental health, maintenance of social relationships, and adaptation to new daily situations. This reinforces ER as a perfect candidate in prevention measures for psychological problems. Numerous scientific studies indicate that a lack of adequate ER is highly linked to the occurrence of numerous mental and physical health problems, including borderline personality disorders, depression (Oschner & Gross, 2007), anxiety disorders, social interaction or adaption problems, addictions, violent behavior, and other disruptive behaviors (Davidson, Putnam, & Larson, 2000; Gross, 2002).

As Gross & Thompson, 2007 defined in their "modal model" of emotion, the generation of emotions is a special sequential process (situation-attention-appraisal-response) that occurs over time. According to this "modal model", many of the psychopathological traits are due to deficiencies in one or more stages of these emotion-generative processes. In other words, a psychopathological trait may be due to not knowing how to change or select a situation, which could lead to a strong positive or negative emotion. It may also be due to not being able to focus attention from emotionally harmful activities to other less harmful activities. Finally, deficiencies or defects in the processes of reevaluation of emotional situations or modulation of emotional responses to more socially accepted ones are possible causes of psychopathological traits (Werner & Gross, 2010). Therefore, adaptive ER is the selection and implementation of emotional regulation strategies (ERS) that are adapted to the different stages of this emotion-generative process, so that an emotional experience can be processed as a healthy emotional experience (Mennin & Farach, 2007). These ERS could

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http://dx.doi.org/10.1016/j.eswa.2014.10.006
0957-4174/

also provoke simultaneous changes in cognitive and physiological processes (Chambers et al. 2009). Thus, the association between emotional regulation and personal adjustment, social competence, and cognitive function suggests that the development of ERS has significant personal consequences.

ERS enable people to influence the emotions they have, when they have them, how they experience them, and how they express them. ERS can be automatic or controlled and conscious or unconscious. ERS should be differentiated based on when they have their first impact on the emotion-generation process. ERS are able of being involved at one or more stages of this process. According to the model of emotion regulation presented by Gross and John (2003), ERS can either be antecedent-focused or response-focused. Antecedent-focused strategies refer to the manipulation of the stages previous to the creation of an emotion, which involves the selection and modification of the situation, the control of attention deployment, and the cognitive reappraisal of the situation by seeking to modify the emotional response before it manifests itself. In contrast, response-focused strategies refer to the manipulation of the emotional response once it has been generated (Chambers et al. 2009). Both the physical and psychological implications will be different depending on the strategy used.

Despite the fact that there are diverse ERS, in this study we focus on one antecedent-focused strategy (Cognitive Reappraisal) and one response-focused strategy, (Expressive Suppression). Cognitive Reappraisal (CR) is a cognitive-linguistic strategy that changes the trajectory of the emotional response by assigning a non-emotional meaning to a situation. On the other hand, the Expressive Suppression (ES) is a strategy that is directed towards inhibiting behaviors that are associated with emotional responding (e.g., controlling facial expression or gestural response due to an emotion (Goldin, McRae, Ramel, & Gross, 2008)). Numerous studies have identified the efficacy of CR strategies in modulating and decreasing the impact of intense negative emotions without generating high psychological and physiological responses (Chambers et al., 2009). In contrast, the excessive use of ES strategies is linked to the appearance of emotional disorders, such as depression (Gross & John, 2003).

Currently, there are tools based on new technologies that are starting to be applied to train ER. For example, Playmancer (Moussa & Magnenat-Thalmann, 2009) is a European Project that developed a system that was capable of multimodal emotional recognition. It combined a serious game with virtual reality for ER training for the purpose of treating psychological and behavioral disorders. Another project is REPLAY (Ibañez, Playfoot, Fabregat, Costa, & Torres, 2010), which evaluated ways of improving the emotional involvement and sense of presence of the players in a virtual reality environment and training them in ER strategies through the proper selection of content and use of exocentric avatar-based interfaces and technologies, such as low-cost tracking.

Another way of training ER strategies is through the use of new interactive technologies that allow having influence on certain aspects of the ER training process. This influence can be achieved through virtual reality (VR). VR is a technology that allows us to create environments where we can interact with any object in real time and that has been widely used for training and learning purposes. The devices and techniques for navigation and interaction through virtual experiences have improved greatly, thus providing a more natural and motivating learning experience. Moreover, VR provides benefits such as a high capability for immersion and persuasion. All of these features allow us to use VR in studies of emotional evaluation and intervention. This is evident in previous studies that have demonstrated the usefulness of VR in psychological intervention for various psychological disorders such as claustrophobia (Botella et al., 1998), fear of flying (Baños et al., 2002; Botella, Osma, & García-Palacios 2004) or stress (Baños et al., 2011).

In order to assess emotional regulation, we must have tools that allow us to evaluate and assess the ERS that subjects apply in the context of emotional experiences. The traditional methods that are used include subjective questionnaires, which ask the patients about how they experience and manage their emotions. The Emotion Regulation Checklist (Shields & Cicchetti, 1997) and The Emotion Regulation Questionnaire (Gross & John, 2003) are good examples of ER questionnaires. Although these questionnaires have proven to be very useful, they have limitations that make them not very suitable for certain groups that are especially reluctant to be assessed. Moreover, when these questionnaires are used in combination with virtual environments, it may only be possible to use them before or after the experience, but never during the virtual exposure without interrupting it. The use of other kinds of techniques, such as physiological measures, can help to overcome these limitations and complement the information obtained with the questionnaires. Gross (1998b) analyzed the influence of the application of ERS on heart rate during a stressful interview. The students that applied an ERS showed a greater heart rate than the students that did not apply an ERS. Campbell-Sills, Barlow, Brown, and Hofmann (2006) compared the physiological effects of two ERS (suppression and acceptance) in individuals with emotional disorders. This experiment consisted in a negative emotional induction using a film clip while the subjects applied one of the two strategies. It was observed that the acceptance group showed less negative emotion than the suppression groups in the recovery period after the film. Moreover, there was an increase in the heart rate of the suppression group, and a decrease in the heart rate of the acceptance group.

Other tools that can be used to supplement the information supplied by traditional methods are brain activity measures. Increasingly, affective studies are using brain activity measures to improve understanding of the underlying mechanisms of affective states. Brain activity can be assessed by means of different neuroimaging techniques, such as functional magnetic resonance imaging (fMRI) or Positron Emission Tomography (PET). Several neural structures that intervene in ER processes have been identified using fMRI (Phillips, Ladouceur, & Drevets, 2008). The majority of these structures were localized in the limbic and frontal regions. The frontal region is reciprocally connected with other subcortical limbic regions, which have an influence on the different steps of the ER process (Stein et al., 2007). The prefrontal cortex (PFC), cingulate cortex, and amygdala have been shown to have influence on the responses to emotional stimuli (Johnstone, van Reekum, Kalin, & Davidson, 2007; Oschner & Gross, 2007; Wager et al., 2008).

More specifically, the neural structures involved in emotional processing form two systems (the ventral emotion system and the dorsal emotion system) that have a role in the decrease of negative emotions (Ertl, Hildebrandt, Ourina, Leicht, & Mulert, 2013). These structures form a complex network that is responsible for processing responses to emotional events (Ochsner & Gross, 2005). In turn, they involve the ventromedial prefrontal cortex, the dorsolateral prefrontal cortex, the orbitofrontal cortex, amygdala, insula, hippocampus, and cingulate cortex (Davidson, 2000; Ertl et al., 2013; Ochsner & Gross, 2005; Phillips et al., 2008; Suveg, Southam-Gerow, Goodman, & Kendall, 2007). These neural networks play an important role during voluntary or involuntary ER processes as well as in the support to brain regions that are involved in cognitive processes (Marsh et al., 2006; Phillips et al., 2008; Rubia et al., 2000).

In spite of the fact that neuroimaging tools such as fMRI have many advantages (including their high spatial resolution and their ability to detect sub-cortical areas) these techniques do not offer a direct measurement of neural activity (Ertl et al., 2013) and their use combined with navigation in VR imposes many restrictions. A complementary tool to fMRI that has been used in many studies