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Publisher: Routledge

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Psychotherapy Research

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tps20>

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Published online: 28 Nov 2013.

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To cite this article: Luisa Zaunmüller, Wolfgang Lutz & Timothy J. Strauman (2014) Affective impact and electrocortical correlates of a psychotherapeutic microintervention: An ERP study of cognitive restructuring, *Psychotherapy Research*, 24:5, 550-564, DOI: [10.1080/10503307.2013.847986](https://doi.org/10.1080/10503307.2013.847986)

To link to this article: <http://dx.doi.org/10.1080/10503307.2013.847986>

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EMPIRICAL PAPER

Affective impact and electrocortical correlates of a psychotherapeutic microintervention: An ERP study of cognitive restructuring

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(Received 31 March 2013; revised 30 August 2013; accepted 16 September 2013)

Abstract

Objective: Psychotherapy for depression emphasizes techniques that can help individuals regulate their moods. The present study investigated the affective impact and electrocortical correlates of cognitive restructuring, delivered as a 90-minute psychotherapeutic microintervention in a dysphoric sample. **Method:** Participants ($N = 92$) who reported either low or high levels of dysphoric symptoms were randomly assigned to the restructuring microintervention, a control intervention or a no-intervention condition. We obtained recordings of event-related potentials (ERPs) as well as mood self-ratings during an experimental session immediately after the psychotherapeutic microintervention and the control intervention in which a set of negatively valenced pictures (IAPS) was presented with different instructions. **Results:** Whereas the restructuring intervention group and the control intervention group reported both increases in positive and decreases in negative affect from pre- to post-intervention, the three groups differed significantly on ERP measures. **Conclusions:** Findings provide support for current models of mechanisms of action in cognitive therapies.

Keywords: cognitive restructuring; microintervention; depression; neuroscience; EEG

The effectiveness of psychotherapeutic interventions are well established for a broad range of psychological disorders. In the last two decades a large number of studies have produced evidence, including randomized control trials as well as routine care studies (e.g., Elkin et al., 1989; Lambert 2013; Lutz, 2002; Wampold, 2001), demonstrating that psychotherapy is efficacious in reducing distress. For instance, in the treatment of depression, effect sizes are comparable to or even exceed effect sizes for pharmacotherapy (DeRubeis, Siegle, & Hollon, 2008; Hollon & Ponniah, 2010). However, much is still unclear about the mechanisms underlying particular components of psychotherapy, such as cognitive restructuring (Kazdin, 2009). Cognitive restructuring is one important technique in psychotherapy in general and one of the core techniques of cognitive behavioral therapies (CBT), including identification of maladaptive thinking that

accompanies and precedes the experience of upsetting moods, questioning the validity of those beliefs, and finally challenging or modifying the maladaptive thoughts (which, in turn, is hypothesized to reduce acute distress). Knowing more about the mechanisms of change underlying specific components of psychotherapy is important both for enhancing the overall efficacy of treatment and for matching specific interventions to the needs of individual patients (DeRubeis et al., 2008).

Microintervention Studies

Treatment-focused research designs generally assess the impact of psychological treatments as a whole (i.e., as a “package”), but such designs often cannot distinguish the impact of particular components on the outcome of treatment (Lutz, 2002; Lutz, Stulz, & Kock, 2009). In the present study, we used an

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alternative design for investigating specific therapeutic components based on the implementation of a therapeutic *microintervention* that targets smaller units of cause and effect in a therapeutic setting (Strauman et al., 2012). A microintervention can be characterized as a discrete, time-limited application of a single, specified psychotherapeutic component or technique, which in this study was a 90-minute cognitive restructuring session. Microinterventions can be delivered and studied within controlled experimental designs, enabling the researcher to draw conclusions about whether and how specific psychotherapeutic techniques contribute to the efficacy of a treatment. To the extent that a microintervention study can balance rigorous experimental design and internal validity with applicability to the broader literature of psychological treatments, the data from such studies might provide a conceptual and empirical bridge between efficacy and process/mechanism research.

Microintervention studies allow for the use of a broader range of dependent measures that might be less feasible to incorporate into efficacy or effectiveness studies. Perspectives from multiple research disciplines can be brought to bear on the important question of how specific techniques, such as cognitive restructuring, work (Carrig, Kolden, & Strauman, 2009). In particular, the application of neuroscience research methods can open new perspectives for the study of mechanisms of change that mediate the complex processes of psychological treatments (Roffman, Marci, Glick, Dougherty, & Rauch, 2005). By identifying aspects of the working brain that can be altered by psychotherapeutic interventions, either immediately or cumulatively, valuable new information about how specific therapeutic components work might be available (Grosjean, 2005). Nonetheless, in order to take full advantage of neuroscience techniques within psychotherapy research, investigators must familiarize themselves with relevant technologies and pose hypotheses that are both well suited for experimental designs and yet faithful to the therapist/patient interaction that is an important part of therapy (Frewen, Dozois, & Lanius, 2008).

Cognitive Restructuring and Emotion Regulation

Emotion regulation researchers have proposed that different kinds of regulatory strategies can be implemented at different points during the process of emotion generation (Gross & Thompson, 2007). Cognitive restructuring or cognitive reappraisal is classified as an antecedent-focused strategy, a category of strategies which modulate emotional response tendencies before the full emotional

response is generated, in contrast to response-focused strategies, which modulate the responses when they have been generated.

A number of psychological disorders, such as anxiety and mood disorders, are associated with ineffective or even counterproductive attempts of emotion regulation. These disorders often involve use of maladaptive cognitive or behavioral strategies, such as rumination, worry, distraction, thought suppression or substance use (Campbell-Sills & Barlow, 2007). Those strategies might help to suppress or dampen unpleasant moods in the short term, but in the long term they are associated with costs and can even intensify distress. Cognitive restructuring, in contrast, has been found to show more enduring effects (e.g., Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011), to be negatively correlated with distress, and to be associated with psychological and physical well-being (e.g., Garnefski & Kraaij, 2006; Gross & John, 2003).

Cognitive behavioral treatment approaches focus on different aspects of disordered emotion regulation (Campbell-Sills & Barlow, 2007). Cognitive treatment strategies, for instance, primarily focus on cognitive restructuring of maladaptive negative appraisals and thereby address the emotional significance of an event. Patients are encouraged to identify negative appraisals, to test the validity of such beliefs and appraisals, and to establish more valid and adaptive patterns of thinking. Mindfulness and acceptance-focused treatment protocols, on the other hand, target emotions once they have been activated. These approaches are intended to reduce maladaptive emotional avoidance tendencies, such as rumination, distraction and thought suppression, which often maintain psychopathology (e.g., Goldin & Gross, 2010). Individuals are encouraged to change attentional deployment and to focus on and learn to tolerate their subjective and somatic experiences. Finally, behaviorally oriented approaches address the modification of emotional action tendencies, such as avoidance behavior. All these different components of cognitive behavioral treatments have the same ultimate goal, i.e., to reduce incidence and intensity of disordered emotions and to improve psychosocial functioning. However, there are few well-controlled experimental studies actually testing the mechanisms of action for individual components of CBT.

The Neural Correlates of Cognitive Restructuring

In the present study, we used EEG recordings as well as mood self-ratings to test hypotheses regarding the acute impact of a cognitive restructuring microintervention. EEG is particularly feasible for

investigating treatment mechanisms of action, as the method is non-invasive, cost-effective, and provides excellent temporal resolution to detect neuronal changes. However, relatively few studies of psychotherapy to date have used EEG (e.g., Gutberlet & Miltner, 1999; Leutgeb, Schäfer, & Schienle, 2009). For example, we were unable to find a single treatment study focusing on the psychophysiological impact of cognitive restructuring. However, a number of studies have been investigating cognitive emotion regulation strategies in healthy adults, from which hypotheses relevant to treatment mechanism of action might be derived (for overviews, see Gross, 2007; Ochsner & Gross, 2005, 2008).

Recent work on the neurobiological basis of cognitive restructuring as an emotion regulation strategy, based on functional imaging studies, highlights the importance of several functionally connected networks that can be observed in healthy individuals performing cognitive reframing tasks. The coactivation of these networks during cognitive reframing is suggestive of an interaction between prefrontal and limbic regions. Cognitive restructuring of negative emotion-inducing stimuli activates the dorsal anterior cingulate cortex (ACC) and the prefrontal cortex (PFC), both of which are associated with cognitive control processes and support the selection and application of restructuring strategies. Activations in these cognitive control regions are associated with a decrease of activity in emotional processing regions such as the amygdala or insula and a reduction in the intensity of negative affect. In electrocortical studies, cognitive emotion regulation strategies used by healthy adults have been found to be particularly associated with changes in the late positive potential (LPP) (for a review see Hajcak, MacNamara, & Olvet, 2010). The LPP is a centro-parietally maximal positive slow modulation ERP, starting about 300 ms after stimulus onset, which in a number of previous studies has been related to the emotional intensity or motivational significance of stimuli (e.g., Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Schupp et al., 2000). In the study of emotion regulation, LPP amplitude has been found to be attenuated in centro-parietal regions when participants were instructed to decrease their feelings in response to unpleasant stimuli, compared to passively viewing these stimuli (e.g., Moser, Hajcak, Bukay, & Simons, 2006; Moser, Krompinger, Dietz, & Simons, 2009). Decreased centro-parietal LPP amplitude has been found to be positively correlated with reductions in emotional intensity ratings, suggesting that reduced centro-parietal LPP represents an index of diminished or suppressed negative affect (Hajcak & Nieuwenhuis, 2006). However, studies considering the topographical distribution of the LPP

also have found increased LPP amplitudes when participants were instructed to decrease their feelings in response to unpleasant stimuli, but in frontal regions (e.g., Hajcak & Nieuwenhuis, 2006; Langeslag & Strien, 2010). Frontal positivity during decreasing emotion regulation instructions has been associated with down-regulation of brain areas involved in the generation of emotional responses, mediated by prefrontal brain areas (Langeslag & Strien, 2010). Finally, cognitive reappraisal has been recently found to be associated with reduced frontal alpha-band power, which is indicative of PFC activity and might reflect cognitive regulation processes (Parvaz, MacNamara, Goldstein & Hajcak, 2012).

These findings from studies of emotion regulation in healthy adults can be integrated with current models about the neural mechanisms underlying cognitive therapy (e.g., DeRubeis et al., 2008). DeRubeis and colleagues proposed that cognitive therapy for depression, including cognitive restructuring as one core strategy, strengthens prefrontal regulatory brain mechanisms, which interrupt or dampen limbic activation associated with intense negative affect. Depressed individuals frequently manifest an increase in activation of the amygdala (e.g., Bench, Friston, Brown, Frackowiak, & Dolan, 1993; Siegle, Thompson, Carter, Steinhauer, & Thase, 2007), as well as decreased activation in the prefrontal cortex (e.g., Siegle, Steinhauer, Thase, Stenger, & Carter, 2002; Siegle et al., 2007). According to this model, successful cognitive therapy should yield decreased amygdala activity and increased PFC activity as the individual becomes better able to regulate negative affect.

The Present Study

The present study aimed to investigate the impact and electrocortical correlates of cognitive restructuring, delivered as a 90-minute microintervention, and particularly to determine whether any intervention-specific effects were observed on the LPP. Participants who reported either high or low levels of dysphoric symptoms were randomly assigned to a cognitive restructuring microintervention or to one of two comparison conditions. The specific effects of the restructuring condition were examined using recordings of event-related potentials as well as self-reported mood change. In the EEG paradigm, participants viewed unpleasant pictures, with the instruction to either reframe the picture content or to simply attend to it, a paradigm that has been employed in a number of previous studies (e.g., Hajcak & Nieuwenhuis, 2006; Ochsner, Bunge, Gross, & Gabrieli, 2002; Phan et al., 2005).

Our first research question was whether the restructuring microintervention and the control

intervention would have a differential impact on mood change. Following the existing literature, we hypothesized that, relative to the comparison conditions, participants in the cognitive restructuring intervention group would manifest an *increase* in *frontal LPP* amplitude in response to the “reframe” instruction, as the microintervention was expected to lead to a strengthening of prefrontal regulatory brain mechanisms (which might or might not also be detected by a measure of self-reported mood change). Moreover, we anticipated a *decrease* in *centro-parietal LPP* amplitude in response to the “reframe” instruction for that group, as the top-down regulatory mechanisms should lead to a reduction in perceived negative affect, which previously has been associated with decreased centro-parietal LPP. We had no specific predictions regarding how the level of dysphoric symptoms might influence the expected LPP effects.

Participants

Participants were recruited from a university community in the southwest of Germany using an announcement that was sent via email to all university members. The announcement directed potential participants to an online screening tool including the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977; German version: ADS-L; Hautzinger & Bailer, 1993). A total number of 715 individuals completed the initial online screening (30.6% male, 69.4% female), with an overall mean age of 27 years ($SD = 10.7$). The initial sample had a mean score of 16.7 ($SD = 9.8$) on the CES-D, which is significantly higher than the mean of the reference sample ($M = 14.3$, $SD = 9.7$, $t_{df=714} = 6.3$; Hautzinger & Bailer, 1993). To make sure that we would have enough participants in our sample with substantial levels of dysphoria as well as a group of participants with low dysphoria scores, two groups of participants from the screening sample were invited to take part in the study: (i) dysphoric participants with scores above 23 ($N = 145$), the standard cut-off score for depression, and (ii) individuals who scored below 15 on the screening ($N = 376$), that is at or below the normative sample mean for this instrument. A total of 92 eligible individuals (73 female) agreed to participate in the study.

In order to ensure that participants' levels of dysphoric symptoms were stable, we obtained a second CES-D assessment immediately before the start of the intervention. We used the average of the CES-D scores of the screening assessment (which was obtained approximately 6 weeks prior to the main investigation) and the baseline assessment to divide the sample into a dysphoric and a non-dysphoric

subgroup. In order to do that, we averaged the initial sample ($M = 16.7$) as well as the reference sample ($M = 14.3$) and used the mean of 15.5 as cut-off score to divide the sample into a dysphoric and a non-dysphoric subgroup. This procedure classified 45 participants into the dysphoric group and 47 into the non-dysphoric control group. Only right-handed individuals were included, as cortical activity is frequently observed to differ in left-handed individuals (e.g., Savage & Thomas, 1993). Participants were randomly assigned to either the cognitive restructuring intervention (RI: $N = 30$), a control intervention (CI: $N = 34$) or a no-intervention condition (NI: $N = 28$), with approximately equal numbers of high and low dysphoric individuals within each of the groups. All groups were comparable with respect to age ($F(2,88) = .617$, $p = .542$) and gender ($\chi^2(2) = 1.26$, $p = .533$) with an overall mean age of 23.5 (range: 19–54). Table I presents the characteristics of the participants for each of the three intervention conditions.

Prior to the study, all participants gave written informed consent after explanation of the experimental protocol. The study was approved by the local research ethics committee. All participants received 20 Euros as compensation for their time. EEG data from one subject within the dysphoric group and assigned to the no-intervention condition could not be analyzed due to technical problems, hence data analyses for the EEG variables were conducted for 91 subjects. All other analyses were conducted including all 92 subjects.

Interventions

Subjects were randomly assigned to the restructuring intervention, the control intervention or to the no-intervention condition, with approximately the same

Table I. Sample characteristics by intervention condition

Variable	RI ($n = 30$)	CI ($n = 34$)	NI ($n = 28$)
Age (years; $M \pm SD$)	23.6 (3.5)	23.9 (5.9)	22.8 (2.4)
Gender			
Female	24	25	24
Male	6	9	4
Dysphoric status			
Dysphoric (CES-D ≥ 15.5)	14	16	15
Non-dysphoric (CES-D < 15.5)	16	18	13
Previous psychological treatment experience			
With experience	7	13	6
With no experience	23	21	22

Note. RI = restructuring intervention, CI = control intervention, NI = no-intervention. CES-D, Center for Epidemiological Studies Depression Scale (Radloff, 1977); German version: ADS-L (Hautzinger & Bailer, 1993).

proportion of dysphoric individuals across groups. Both interventions were delivered by therapy trainees following a brief intervention manual.¹ Two doctoral candidates in clinical psychology with two years experience delivering manualized treatments were trained with both protocols. Both therapists delivered the same number of each of the interventions, with randomization across therapists. Therapists were blind with regard to participants' level of dysphoric symptoms.

The restructuring intervention (RI) group received a manualized one-session intervention that presented cognitive restructuring as a stand-alone microintervention technique. The microintervention was based primarily on specific techniques from the cognitive therapy protocol by A. T. Beck (Beck, 1995; Beck, Rush, Shaw, & Emery, 1979). The central features of the intervention were (i) to introduce the participants to the idea that distorted cognitions can contribute to negative moods and (ii) to provide specific strategies to identify and modify dysfunctional thoughts. Using examples drawn from the lives of each participant, dysfunctional cognitions were identified and participants were assisted in exploring more adaptive ways of thinking about the example events. In the latter part of the session, cognitive restructuring skills were reinforced and practiced by applying them to two film clips. The film clips were 10-minute excerpts from the movies "Schindler's List" (Spielberg, 1993) and "Forrest Gump" (Zemeckis, 1994), both showing episodes identified in pilot testing as reliably inducing negative mood states. Both episodes also comprised positive aspects (e.g., friendship, solidarity, love, hope, willingness to help). Participants were encouraged to re-examine their initial perspective associated with negative feelings, and to focus on alternative interpretations, including also positive aspects.

After watching the film clips, participants were instructed to write down their reframing thoughts and then the participant and experimenter would discuss how reframing what was happening in the film could actually prevent the induction of a negative mood. The entire session lasted approximately 90 minutes.

The control intervention (CI) group received a manualized intervention that was intended as to control for nonspecific factors associated with outcome (e.g., a collaborative relationship, attention from a knowledgeable professional). CI focused on a different set of skills that were clearly distinguishable from cognitive restructuring. In order to represent the nonspecific effect of psychological treatment, the control intervention was designed to be as interesting and challenging as the cognitive restructuring condition. The topics discussed in the CI condition focused on dealing with different teaching methods

and learning aspects within the university courses students normally get. Other than the different content, the CI was constructed to be as equivalent to the RI as possible. Using examples drawn from the lives of each participant, aspects of previous class experiences that impede learning were identified and participants were assisted in composing more adaptive strategies to improve learning effects (e.g., learning by teaching others). In the second part of the session, two film clips were shown. The two film clips in the CI group were 10-minute excerpts of a documentary about teaching methods and learning aspects (Fehse, 2007), showing two different teaching situations. Participants were instructed to analyze the film clips with regard to the teaching and learning strategies. After watching the film clips, participants were instructed to write down which helpful strategies they identified and discussed those aspects with the experimenter. The CI session also lasted approximately 90 minutes.

Following the interventions, participants in the RI and CI groups rated a modified version of a credibility/expectancy questionnaire adapted to serve as an adherence measure for both interventions (e.g., Devilly & Borcovec, 2000). A six-item rating scale was used to assess the adherence to the procedures on a 7-point Likert scale between "not at all" and "very much" (1. I could easily follow the words of the trainer, 2. The instructions seemed logical to me, 3. The presented contents were interesting to me, 4. The presented contents were new to me, 5. I was inspired to think about the presented ideas, 6. Now I can see past events from a new perspective). The average scores of those six items for the RI group ($M = 5.89$, $SD = .61$) and the CI group ($M = 5.64$, $SD = .54$) did not differ significantly ($t(62) = -1.72$, $p > .05$). All six items had scores on average above 4 for both conditions and there was no significant difference between the two interventions in any of the items. These results indicate that both interventions appeared to be credible from the perspective of the participants and that the therapy trainees were adhering appropriately to the intervention procedures.

The no-intervention (NI) group was included as a second control condition against which to compare the impact of the RI. As such, no adherence measure was administered to these participants.

Mood Ratings

Prior to the start of the intervention, a baseline assessment of each participant's affective state was conducted using the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988), which was repeated subsequent to the intervention but prior to the EEG data collection.

EEG Paradigm

For the RI and CI participants, the EEG data collection was conducted after a 15-minute break subsequent to the post-intervention mood assessment. During the 15-minute break, participants were encouraged to use the toilet facilities or to drink something. For the NI condition, the EEG data collection occurred immediately after completion of the initial mood assessment.

The stimulus set for the EEG session consisted of 40 unpleasant and highly arousing pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008).² The mean normative valence and arousal values for the pictures were 2.62 ($SD = 0.5$) and 5.67 ($SD = 0.62$), respectively, measured on a 9-point scale (1 = most unpleasant/least arousing, 9 = most pleasant/most arousing). The task was administered via E-Prime software (Psychology Software Tools) on a personal computer. The pictures were displayed in color and covered the entirety of the 19-inch monitor. The viewing distance between the participants and the monitor was standardized to approximately 1 meter.

The EEG task design was adapted from Hajcak and Nieuwenhuis (2006). Each trial started with the presentation of the instruction word “view” in the center of a black screen for 1000 ms, which was followed by the presentation of an unpleasant picture for 1000 ms. Subsequently, the instruction either to “attend” or to “reframe” was presented for 4500 ms, in individually randomized order for half of the trials each. Immediately following this second instruction, a blank screen appeared for 500 ms, after which the same unpleasant picture was presented again for 2000 ms. The “view” instruction with the first presentation of each picture was intended to give the participants time to perceive the scene and to generate an initial emotional response, which they were then instructed to regulate or not to regulate. On “reframe” trials, participants were encouraged to take a different perspective in which they generated a less negative interpretation of the picture content (e.g., seeing a group of injured people after an attack but focusing on the fact that they survived). On “attend” trials, the instruction was to only attend to and be aware of the shown picture but not to alter any of the feelings it elicited. As we were interested in the active reframing processes, we focused the data analyses on EEG samples obtained during the second part of each trial (i.e., in response to the “reframe” and “attend” instructions). After the second presentation of each unpleasant picture, the participants were asked to rate the intensity of their emotional response (“affect check”) to the second presentation of the unpleasant picture on a 7-point scale (1 = “weak” to

7 = “strong”). An additional 7-point scale was presented on which participants rated the extent to which they followed the instruction to either “reframe” or to “attend” (“implementation check”). At the end of each trial, the instruction word “relax” appeared in the center of the screen for 4000 ms, indicating that participants should relax until the next trial began.

The session started with a brief explanation of the study, followed by detailed instructions regarding how to respond to the different instruction words. All instructions were presented on the computer screen. Next, the participants received a block of four practice trials, using unpleasant pictures that were not part of the experimental stimulus set. The experimental block consisted of 40 trials, 20 with the instruction to “reframe” and 20 with the instruction to “attend” in individually randomized order. Affect and implementation ratings for each picture were entered via the numeric keypad at the right side of the computer keyboard. The instruction words were presented as white characters on a black background in the center of the screen. The entire EEG session took approximately 25 minutes. Figure 1 illustrates the experimental design and the time course of each stimulus presentation.

EEG Recording

EEG was recorded from 32 electrode sites according to the 10–20 electrode reference system (Jasper, 1958), including the mastoids, using the Easy-Cap electrode system (Falk Minow Services, Munich). All sites were referenced to vertex (Cz). A bipolar horizontal electrooculogram (EOG) was recorded from the epicanthus of each eye, and a bipolar vertical EOG was recorded from supra- and infra-orbital positions of the left eye. The EEG and EOG signals were recorded with Ag/AgCl electrodes. Prior to electrode placement, the electrode sites on the participant’s scalp and face were cleaned with alcohol and gently abraded. All impedances of the EEG electrodes were below 5 k Ω . EEG and EOG were amplified using a 32-channel digital amplifier (input impedance 10 M Ω ; BrainAmp, Brain Products, Munich, Germany). The pass-band was set from 0.05 to 35 Hz; the signals were digitalized at 200 Hz and stored directly to hard disk for subsequent analysis.

EEG data were pre-processed and analyzed using the Brain Vision Analyzer (Brain Products, Munich, Germany). First, the EEG was re-referenced to the linked mastoids and the data were filtered using a 12-Hz digital low pass filter. Next, the data were segmented into epochs of 3400 ms starting 400 ms before the onset of the second presentation of each picture and ending 3000 ms after picture onset.

Figure 1. Experimental design and time course for events on each trial of the EEG paradigm. Unpleasant pictures from the IAPS were presented. The first presentation of each picture was preceded by the instruction to “view,” as a signal that a new picture was about to appear. The second presentation was preceded by the instructions to “reframe” the picture content or to simply “attend” to it. Participants then provided a rating of the intensity of their emotional response as well as a rating of the success in following the final instruction. Finally, participants had a moment to relax before the onset of the next trial.

Artifacts due to eye movements were corrected via the algorithm developed by Gratton, Coles, and Donchin (1983). Trials with non-physiological artifacts were excluded from analysis via semiautomatic artifact rejection. An average of 18.54 ($SD = 1.97$) artifact-free epochs for the “reframe” condition and 18.33 ($SD = 1.98$) artifact-free epochs for the “attend” condition were available for analysis. After artifact correction, a baseline correction was performed using the first 400 ms as baseline reference. Epochs were averaged separately for the “reframe” and “attend” conditions.

Analyses

Analyses comparing the affective states measured via PANAS at baseline and after the RI and CI were conducted using repeated measures analysis of variance (ANOVA). The PANAS scores were analyzed separately for the positive affect (PA) and negative affect (NA) with *intervention condition* (RI, CI) and *level of dysphoric symptoms* (dysphoric, non-dysphoric) as between-subject factors and *time of measurement* (pre-intervention, post-intervention) as a within-subject factor. Because pre- and post-intervention PANAS data were only available for the RI and CI groups, the sample for these analyses consisted of 64 subjects.

Analyses of the “affect check” (intensity rating of emotional response) and “implementation check” (degree of following the instruction to either

“reframe” or to “attend”) data were also conducted using repeated measures ANOVA, with *intervention condition* (RI, CI, NI) and *level of dysphoric symptoms* (dysphoric, non-dysphoric) as between-subject factors and *instruction* (“reframe,” “attend”) as a within-subject factor.

For determination of the LPP, average amplitudes for the time window of 500–1500 ms post-stimulus were extracted. We analyzed data from nine electrodes that represent a standard selection of sites for topographical analyses: F3, Fz, F4, C3, Cz, C4, P3, Pz, and P4 (Luck, 2005; see also e.g., Miltner et al., 2005; Schienle, Schäfer, & Naumann, 2008). Mean amplitude values of the LPP then were submitted to a repeated measures ANOVA using *intervention condition* (RI, CI, NI) and *level of dysphoric symptoms* (dysphoric, non-dysphoric) as between-subject factors and three within-subject factors: *instruction* (“reframe,” “attend”), *caudality* (frontal, central, parietal) and *hemisphere* (left, mid, right).

All statistical analyses were conducted using SPSS 15 for Microsoft Windows. A p -value threshold of less than .05 was specified as the criterion for determining statistical significance. For violations of the sphericity assumption within the EEG self-report data, Greenhouse–Geisser corrections were applied. Post-hoc comparisons were conducted to clarify the nature of any statistically significant interaction effects via Dunn’s multiple comparison test (Dunn, 1961).

Results

Mood Ratings (PANAS)

ANOVA results for NA and PA revealed significant main effects for *level of dysphoric symptoms*, with dysphoric participants showing overall higher negative affect ($M_{\text{dys}} = 13.35$, $M_{\text{non-dys}} = 11.30$) and lower positive affect ($M_{\text{dys}} = 29.65$, $M_{\text{non-dys}} = 32.78$) compared to non-dysphoric participants (PA: $F(1,60) = 5.40$, $p = .023$, $\eta^2 = .08$; NA: $F(1,60) = 10.29$, $p = .002$, $\eta^2 = .15$). Significant main effects were also found for *time of measurement* (PA: $F(1,60) = 27.56$, $p < .001$, $\eta^2 = .32$; NA: $F(1,60) = 9.11$, $p = .004$, $\eta^2 = .13$). A general increase in positive affect ($M_{\text{pre}} = 29.30$, $M_{\text{post}} = 33.14$) and decrease in negative affect ($M_{\text{pre}} = 12.94$, $M_{\text{post}} = 11.70$) was observed from pre- to post-measurement for both intervention groups. There was no significant difference between the two intervention groups (PA: $F(1,60) = 1.45$, $p = .233$, $\eta^2 = .02$; NA: $F(1,60) = 0.08$, $p = .785$, $\eta^2 = .00$), and no other statistically significant main or interaction effects were found.

LPP Amplitude

ANOVA results revealed significant main effects for *caudality* ($F(2,170) = 11.77$, $p < .001$, $\eta^2 = .12$) and *hemisphere* ($F(2,170) = 4.45$, $p = .013$, $\eta^2 = .05$) as well as a significant *caudality* $\times$ *hemisphere* interaction ($F(4,340) = 12.92$, $p < .001$, $\eta^2 = .13$). For the frontal region, left-sided electrodes and those located along the midline showed significantly larger LPP amplitudes compared to electrodes over the right hemisphere (both $p < .01$). In contrast, in the central region a significant difference was found between right-sided electrodes and electrodes located along the midline, with larger amplitudes in the right hemisphere ($p < .01$). For the parietal region, no significant hemisphere differences were found. Overall, LPP amplitudes were largest in the parietal region (all $p < .01$).

Moreover, a significant main effect for *instruction* was observed ($F(1, 85) = 6.84$, $p = .011$, $\eta^2 = .07$) as well as a significant *caudality* $\times$ *instruction* interaction ($F(2, 170) = 6.68$, $p = .006$, $\eta^2 = .07$) and a *caudality* $\times$ *instruction* $\times$ *intervention condition* $\times$ *level of dysphoric symptoms* interaction, which after the Greenhouse–Geisser correction marginally crossed the significance level ($F(4, 170) = 2.49$, $p = .07$, $\eta^2 = .06$). However, post-hoc tests revealed significant pairwise comparisons. In the RI group, dysphoric participants showed larger LPP amplitudes for the “reframe” compared to the “attend” instruction at frontal and central sites (both $p < .01$) but not at parietal sites. A significantly smaller effect was found for dysphoric participants within the CI group, but only at frontal

electrode sites ($p < .05$). Comparing amplitude values for the “reframe” instruction between the dysphoric participants within the two intervention groups revealed significantly larger amplitudes in frontal and central regions for the RI condition (both $p < .05$).

In contrast, in the NI condition, dysphoric participants showed larger amplitudes for the “reframe” compared to the “attend” instruction at central ($p < .05$) and parietal ($p < .01$) sites but not at frontal sites. Comparison of dysphoric participants within the NI condition with those in the CI and RI conditions revealed significantly smaller amplitudes for the “reframe” instruction in central ($p < .05$) and parietal ($p < .01$) regions for the CI group as well as larger amplitudes in the frontal region and smaller amplitudes in the parietal region for the RI group (both $p < .01$; see also Figure 2).

Comparing the LPP amplitude values following the “reframe” instruction for the dysphoric vs. non-dysphoric participants within the RI condition showed larger amplitudes for the dysphoric compared to the non-dysphoric participants for the frontal ($p < .05$) but not for the central or parietal electrode sites. For the non-dysphoric participants across the RI, CI and NI conditions, no significant differences between the two instruction conditions were found. Figure 2 illustrates the mean voltages for each condition, Figure 3 shows the ERP waveforms, and Figure 4 shows the voltage scalp topographies for the instruction condition effects. Mean LPP amplitude values at frontal, central and parietal electrode sites for the three intervention conditions are presented in Table II. No other statistically significant interactions or main effects were observed.

In summary, intervention-specific effects were found only for dysphoric participants and were particularly apparent at frontal regions. Within the RI condition, the most noteworthy finding consisted of enhanced LPP amplitude at frontal and central electrode sites for the “reframe” compared to the “attend” instruction in response to unpleasant pictures. The CI group showed a significantly smaller frontal LPP effect, whereas, in contrast, the NI group showed maximal amplitude differences at central and parietal regions.

To examine whether enhanced frontal LPP amplitude values for the “reframe” instruction were associated with self-reported mood change subsequently to the RI, correlation analyses were conducted with mean LPP amplitude values for the frontal electrode sites (F3, Fz, F4) and the PA and NA scales of the PANAS, respectively. However, no significant correlations were found (all $ps > .1$).

Figure 2. Mean LPP amplitude by intervention condition (restructuring intervention (RI), control intervention (CI), no-intervention (NI)), level of dysphoric symptoms (dysphoric, non-dysphoric), caudality (frontal, central, parietal) and instruction ("reframe", "attend"). Error bars represent ± 1 standard deviation. Only statistically significant pairwise comparisons for the two instruction conditions ("attend", "reframe") are displayed. Asterisks indicate $p < .05$ (*) and $p < .01$ (**). Other statistically significant comparisons are described in the text.

Self-Ratings During the EEG Task

ANOVA results for the "affect check" during the EEG task revealed a significant main effect for instruction ($F(1,84) = 9.62$, $p = .003$, $\eta^2 = .10$). The intensity of negative emotional responses to the unpleasant pictures was higher following the instruction to "attend" compared to the instruction to "reframe".

The ANOVA concerning the "implementation check" of the reframing instruction revealed a significant main effect for instruction ($F(1,84) = 196.74$, $p < .001$, $\eta^2 = .70$), indicating that participants were generally better at following the instruction to "attend" than following the instruction to "reframe". No other main or interaction effects were statistically significant.

Discussion

The aim of the present study was to investigate the affective impact and electrocortical correlates of cognitive restructuring, delivered as a 90-minute microintervention. Event-related potentials (ERPs) during an experimental session immediately after the restructuring intervention, a control intervention, and a no-intervention condition as well as mood self-ratings were assessed. In the experimental session, a set of negatively valenced pictures (IAPS) was presented with the instruction to either reframe the picture or to simply attend to it. With respect to mood self-ratings (PANAS), dysphoric participants showed overall higher negative affect and lower

positive affect compared to non-dysphoric participants and a general increase in positive affect and decrease in negative affect was observed from pre- to post-measurement for both active intervention groups. There was no significant difference in self-rated affect between the two intervention groups. However, intervention-specific effects were observed for the LPP, particularly at frontal regions but only for dysphoric participants. Specifically, the RI condition was associated with enhanced LPP amplitudes for the "reframe" compared to the "attend" instruction in response to unpleasant pictures at frontal and central electrode sites. The CI condition showed a significantly smaller frontal LPP effect, whereas, in contrast, the no-intervention condition showed maximal amplitude differences at central and parietal regions.

Our finding that both intervention groups showed a similar change on the self-report measures, but a different pattern of LPP responses represents evidence for a differential effect of the cognitive restructuring microintervention. It is not unusual for treatment studies to fail to find modality-specific effects using self-report measures alone (e.g., Elkin, Falconner, Martinovich, & Mahoney, 2006). Our results point to a potential assessment effect in such studies which might be controlled in future studies by including electrophysiological measures investigating cognitive processes and not relying solely on self-report instruments to measure treatment-induced change.

For frontal LPP, dysphoric participants within the RI condition showed larger mean LPP amplitudes

Figure 3. Grand average waveforms at three frontal, three central and three parietal electrode sites for the "reframe" compared to the "attend" instruction, separately for dysphoric and non-dysphoric subjects of (A) the restructuring intervention condition (RI), (B) the control intervention condition (CI), and (C) the no-intervention condition (NI).

for the "reframe" compared to the "attend" instruction. This observation is in line with our hypotheses regarding potential neural correlates of the restructuring technique. These results also are consistent with previous findings of increased frontal LPP amplitude when participants were instructed to decrease their feelings in response to unpleasant stimuli (Hajcak & Nieuwenhuis, 2006; Langeslag &

Strien, 2010). Such a pattern of EEG change has previously been interpreted as reflecting prefrontal down-regulation of brain areas involved in the generation of emotional responses to affectively salient stimuli (Langeslag & Strien, 2010). Thus, our finding of enhanced frontal LPP amplitude for the "reframe" compared to the "attend" condition among dysphoric participants who received the

Figure 4. Voltage scalp topographies of the instruction effects ("reframe" minus "attend") between 500 and 1500 ms after stimulus onset, separately for dysphoric and non-dysphoric subjects in the restructuring intervention condition (RI), the control intervention condition (CI) and no-intervention condition (NI). Note: For a coloured version please see the online edition.

restructuring microintervention, might reflect an intervention-specific strengthening and intensified utilization of prefrontal regulatory brain mechanisms that could serve to dampen emotional arousal. This line of interpretation is consistent with current theorizing about the neural substrates of emotion regulation, and particularly with the perspective that cognitive restructuring of negative affect is mediated by the PFC and related paralimbic structures such as the ACC which have inhibitory effects on emotional processing (Gross, 2007; Ochsner & Gross, 2005, 2008). Moreover, DeRubeis and colleagues' model of the neural mechanisms underlying cognitive therapy for depression, which features cognitive restructuring as one core strategy, proposes a strengthening of prefrontal regulatory brain mechanisms that is associated with a dampening of activation linked to intense negative affect (DeRubeis et al., 2008). However, as these models are essentially deduced from fMRI findings, they cannot be directly tested using ERP data. As such, our conclusions will need to be examined in future studies, ideally with simultaneous recording of fMRI and EEG. Nonetheless, the present findings are highly congruent with the aforementioned fMRI-based models for the impact of cognitive restructuring on affect

Table II. Mean LPP amplitude at frontal, central and parietal electrode sites for the three intervention conditions

Variable	RI $M \pm SD$	CI $M \pm SD$	NI $M \pm SD$
Mean frontal LPP			
Attend	1.10 (4.5)	1.04 (4.1)	1.88 (4.2)
Reframe	3.04 (4.9)	2.40 (3.8)	2.32 (4.0)
Mean central LPP			
Attend	1.92 (3.6)	1.64 (4.0)	2.53 (3.9)
Reframe	2.65 (3.8)	2.25 (3.2)	3.30 (3.2)
Mean parietal LPP			
Attend	3.30 (4.2)	3.80 (3.9)	3.89 (3.9)
Reframe	3.29 (3.7)	2.97 (3.3)	4.49 (3.0)

Note. RI = restructuring intervention, CI = control intervention, NI = no-intervention. Mean frontal = mean of F3, Fz and F4 electrode. Mean central = mean of C3, Cz and C4 electrode. Mean parietal = mean of P3, Pz and P4 electrode.

regulation. It is important to note, however, that in the present study, frontal LPP amplitude and self-reported mood change were uncorrelated.

For dysphoric participants within the CI group, we also observed an increase in frontal LPP for the "reframe" compared to the "attend" instruction, even though amplitudes for the "reframe" instruction were significantly larger for the RI condition versus the CI condition. In contrast, no significant frontal LPP effects were found for the dysphoric participants within the NI condition. The interpretation for increased frontal positivity that we offered regarding the cognitive restructuring instruction does not fit well with the frontal positivity findings for the CI group, who of course were not trained in cognitive restructuring prior to the testing. One alternative interpretation would be that both active interventions were cognitively demanding for the participants. Hence, increased frontal LPP amplitudes might have been influenced in part by the amount of effort involved in the two interventions, potentially resulting in relatively decreased cognitive resources. However, the fact that the frontal positivity findings were significantly larger for the RI condition indicates, that effort or resource utilization alone is not likely to be a sufficient explanation of our findings.

For centro-parietal LPP amplitude, the expected decrease in the RI group under the "reframe" condition, indicating a reduction in perceived negative affect, was not confirmed. For both active intervention groups, comparisons between centro-parietal LPP for the "reframe" and the "attend" instruction revealed no significant effects. One possible explanation for this lack of effect involves the study design itself. A 90-minute microintervention is obviously not equivalent to a full course of therapy. Even though the RI may have yielded a strengthening and intensified utilization of prefrontal regulatory brain mechanisms in dysphoric participants, it is possible that its effects on emotional arousal level

after a single 90-minute session were too small to be detected in centro-parietal LPP signals. It would be interesting to determine whether repetitive practice in cognitive restructuring, e.g., with multiple training sessions or additional extensive homework between sessions, would lead to the expected decrease in centro-parietal LPP. Moreover, further training in cognitive restructuring might also have effects on the frontal LPP. Previous research has found that increased efficiency in inhibitory processes is accompanied by a decrease in frontal positivity, which might reflect a decrease in cortical resource consumption (Lewis, Lamm, Segalowitz, Stieben, & Zelazo, 2006). Of course, these possibilities would need to be tested in subsequent studies and we offer them here merely as suggestions for future research.

It remains unclear why no effects on LPP were found for the non-dysphoric participants, although it should be noted that affect regulation within emotionally healthy individuals was not our primary focus. Previous studies have reported centro-parietal as well as frontal LPP modulations for cognitive emotion regulation strategies in response to unpleasant stimuli among healthy adults (e.g., Hajcak & Nieuwenhuis, 2006; Langeslag & Strien, 2010; Moser et al., 2006, 2009). However, the lack of replication might be due to differences in experimental design. Hajcak and Nieuwenhuis (2006), for instance, used an elaborated introduction to the concept of reappraisal before their experimental session began. All participants were encouraged to generate reinterpretations for several examples until the experimenter determined that the participants were successfully reappraising negative pictures. Then participants ran through an additional practice block of 10 trials until the experimental block started. In our design, the introduction was more standardized and limited, with all instructions presented on the computer screen. Participants received a block of four practice trials before the experimental block started. Thus, participants in the two control conditions of the present study might have been on a different level of practice, compared to participants in the Hajcak & Nieuwenhuis study.

Consistent with previous findings (e.g., Hajcak & Nieuwenhuis, 2006; Phan et al., 2005), self-ratings during the picture viewing task indicated that across all participants the “reframe” instruction reduced the perceived emotional intensity of unpleasant stimuli compared to the instruction to “attend,” even though participants evaluated their implementation of the cognitive restructuring instruction as generally less successful than their implementation of the “attend” instruction. The latter finding is not surprising, as following the instruction to only attend is obviously

less challenging than following the instruction to try to take a different, less negative perspective.

Several limitations of the present study should be noted. First, it is reasonable to ask whether a 90-minute microintervention is an adequate proxy for the process depressed patients undergo during cognitive restructuring in CBT. Certainly one important distinction between a microintervention and a full course of therapy is the lack of repetitive practice across multiple sessions and outside the therapy setting. However, the cognitive restructuring microintervention in this study was not intended to be seen as a substitute for a multi-session therapy, but rather simply as a means to activate the mental and neural processes associated with a specific therapeutic technique. The results indicate that even such a time-limited cognitive microintervention had specific and reliably detectable effects on ERP. It would be interesting, however, to compare the present findings with a similar assessment of repetitive practice in cognitive restructuring, e.g., using multiple training sessions and additional extensive homework between sessions. Also, a more elaborated rating procedure based on videotapes of the interventions could be developed to assess adherence to the microintervention protocols and to test the credibility of interventions.

The second limitation concerns our sample, which consisted of individuals selected via an internet-based screening using the CES-D. As such, our participants represent an analog sample and replication within a sample of individuals seeking treatment for depression will be important. Future studies therefore should also incorporate structured diagnostic tools to confirm the clinical significance of the dysphoric individuals' symptoms. Those tools additionally allow investigators to control for comorbidity and to determine whether our findings are best interpreted as reflecting characteristics of a diagnostic entity or a chronic affective state.

Third, with regard to the ERP experimental design, we focused only on the cognitive reframing of unpleasant pictures. It might be useful for future studies to compare LPP characteristics for multiple emotion regulation strategies as well as different picture types and valences. Rumination or suppression, for instance, both regulation strategies that are known to be maladaptive (Campbell-Sills & Barlow, 2007), also involve cognitive resource allocation. It would be interesting to determine how these alternative regulation strategies would affect the LPP. The additional use of positive and/or neutral pictures could help to clarify whether the LPP effects are specific to the processing of negatively valenced and/or highly arousing stimuli. It would be also interesting if our findings could be replicated with more

self-relevant or individually tailored stimulus sets, which would further increase the resemblance of the experimental task to the kinds of affect regulation scenarios for which CBT techniques are intended.

An important aspect for future studies might also be the choice of control instruction. Based on previous studies, we selected the passive instruction to simply “attend” (e.g., Hajcak & Nieuwenhuis, 2006). However, it is possible to construe instructing participants to “attend” to a shown picture but not to alter any of the feelings as very similar to the basic notion of mindfulness and acceptance approaches. However, it should be noted that our participants had no formal training in mindfulness or acceptance strategies. Moreover, these strategies are known to be effective in the long term (as patients for example learn that they are strong enough to cope with emotions and that their negative predictions are unfounded; e.g., Goldin & Gross, 2010) but not to reduce perceived negative affect in the immediate short term. Therefore, it is hardly surprising that self-ratings for the “attend” instruction revealed higher levels of perceived negative affect compared to the “reframe” instruction.

It also should be noted that the number of trials in our ERP-design was limited, and therefore the signal/noise ratio for the EEG data may not have been optimal. However, as our study included dysphoric participants, we also needed to ensure that the overall participant burden was not unreasonable. Our recommendation for future studies would be to increase the number of trials and to split them into blocks, with a short break between blocks to help participants maintain the necessary level of attention and concentration.

Finally, because of resource limitations, only post-intervention EEG measurement was implemented in the study. Future studies assessing mechanisms of change related to microinterventions should include a baseline EEG assessment to facilitate direct conclusions regarding change over time.

In conclusion, the results of the present study provide support for the hypothesis that a single session of a cognitive restructuring microintervention activates mental processes associated with stimulus reinterpretation and affect regulation. We were able to demonstrate, that the restructuring microintervention, compared to two other conditions, had specific effects, particularly for dysphoric participants, which were reliably detected on ERP measure. Should these findings be replicated, this line of research may provide ways to test specific components within CBTs. The observation that intervention-specific effects were more clearly delineated within the electrocortical data points to the additional utility of neuroscience methods for generating data regarding

specific factors and mechanisms of change. More research is needed to clarify the discrepancy between psychophysiological and self-report measures.

Funding

This work was supported by grants from the Humboldt Foundation (Trans-Coop Program).

Notes

1. For the detailed intervention protocols, please contact the authors.
2. Unpleasant and highly arousing IAPS pictures: 1300, 1930, 2053, 2120, 2141, 2703, 2710, 2799, 2800, 2900, 3160, 3220, 6200, 6212, 6244, 6312, 6315, 8230, 8485, 9050, 9160, 9220, 9250, 9254, 9405, 9415, 9421, 9424, 9432, 9520, 9560, 9561, 9592, 9620, 9622, 9903, 9911, 9921, 9925, 9926.

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