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Emotion Regulation

Functional neuroimaging studies of cognitive reappraisal

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Emotion Regulation: Functional neuroimaging studies of cognitive reappraisal

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I hereby certify that all material in this final year project which is not my own work has been identified and that no work is included for which a degree has already been conferred on me.

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Abstract

The importance of investigating Emotion Regulation (ER) may be self-evident, given that emotions have a substantial impact on our daily lives. ER encompasses set of processes that people go through in order to cultivate their feelings that arise at the moment and produce some response. Brain-imaging studies of ER have broadly focused on examining cognitive strategies, such as reappraisal, in order to understand underlying variables that contribute to the development of this particular process of emotions. The main focus in this paper was to summarize some of the observation done by functional Magnetic Resonance Imaging (fMRI) on neural processes underlying cognitive reappraisal. Furthermore, the paper will discuss some of these experiments that have been made through the last 15 years in the field where indications have been somewhat confusing when it comes to certain aspects of presented data, especially in comparison with other studies. Finally, a brief overview and some of the significant contributions, such as a process model of ER, to the field of ER have been presented and discussed. Cognitive reappraisal has been shown to effectively down-regulate subjective emotional experience. Even though many studies have been performed in measuring brain-activity when engaging in cognitive reappraisal, a unified and accepted agreement has yet not been found. In broader terms, brain-responses when engaging in cognitive reappraisal seem to operate in a particular manner where different parts of prefrontal and parietal cortex execute control over subcortical regions, such as amygdala.

Keywords: emotion, regulation, cognition, fMRI, cognitive reappraisal, PFC

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Introduction

Emotion regulation (ER) is essential in everyday life. The need to investigate how and why some people are good at regulating their emotions, while others are not good at it, has gained more attention in the last years. Some people seem to be in control over their emotions and how they respond to them while others appear to be just about emotionally unrestricted. ER research is exploring differences in the ways we try to operate in order to control or respond to our emotions, as well as how and why these emotional processes exist in the first place. Researchers are also interested in looking into possibilities if there are "better" ways one can regulate the emotion and if these methods (techniques) can be learned by anyone. Emotions are by their character (valence) positive or negative (can be neutral as well); both of which can be down-regulated (decreased), up-regulated (increased) or merely maintained (Thompson, 1994) in order for an individual to produce the response that is required. Major progress has occurred in understanding the functions of ER, followed by increased interest in finding the ways in which one can apply the current knowledge (Gross, 2014). In the last decades there have been an expanding number of publications written on the subject, which is indicating the growing relevance for the field of ER (Gross, 2013). It shows that the longstanding interest for the subject is developing extremely fast, although the most increase is noted in the last decade, with more than 10 000 published articles in the last year alone.

At the end of 1980s ER was indicated to be a distinct construct from emotion, emerging as such in the developmental literature (Campos, Campos, & Barrett, 1989). Around the same time, Thompson (1994) noted the need in finding a precise definition of ER due to its impact and possible contribution to the field of emotion research. The implication for the importance was followed by Gross (1998), who is known as one of the pioneers in the field of ER, reviewing up-to-date knowledge in the area. His publication also emphasized the need to separate the concept of ER from other related, but yet different, terms. Gross (1998) proposed that *ER* can be described as *an individual's ability to control the emotions one goes through, while undergoing them, as well as how the individual experiences and express these emotions*. Subsequently, he stated that ER is hard to be defined if not considering the diversity of these processes. ER can operate on a conscious or unconscious level, as processes can be automatic or controlled, and they may have their effects on one or more aspects in the emotion generation. Almost twenty years later, there is still an ongoing debate about what can

be classified as ER and what does not fall within this structure; as well as its consequences on human functioning.

Better understanding of ER contributes to better development of treatments for people who have problems with self-regulation in general. Psychological coaching may benefit in teaching these strategies to their clients, considering that emotions are a large part of the well-being. Many interventions in positive psychology have been focused mainly on dealing with emotions, ER research builds upon these teachings. Understanding of how the ER works is critical if we are ever to win over the emotional war that is going on within ourselves from time to time. Application of neuroscientific findings on our clients can lead to better understanding underlying mechanisms of the process, which will in turn promote lasting happiness and joy in us as well as in others.

This paper aims to provide an integrative review of the theoretical and empirical developments in rapidly growing field of ER. The main focus of this project was to sum up some of the data collected in the neural circuits of one of the most studied ER strategies called cognitive reappraisal. Some of the already developed therapy forms of ER and empirical findings, as well as background and the main contributions to the field, will be presented. Note that appraisals are equivalent to evaluations in this paper, meaning that these two terms will be mostly treated as synonyms. For ease of reading, at the beginning of each paragraph there is a short presentation that explains the main points of it. At the end of the paper, there would be a discussion regarding major findings in the field of ER. Some of the main points will be addressed as well as the future of this area.

Emotion

In this section, principal theories of emotion, which are in the interest of better understanding some of the current misunderstandings in the field of ER, are addressed. Moreover, the cognition and its theoretical connections to the emotion are considered. Below is following a background of emotion and cognition that is of great importance considering the name of the phenomena of interest and the relatedness to the fundament of area of ER.

Even though, there has been a lot of research done on the study of emotions, a distinct unitary definition on the phenomenon has yet not been found (Dixon, 2012; Scherer, 2005). There are discrepancies about what exactly the term means and how (and if) it can be

measured. It is important to underscore that some features of emotions are commonly recognized thought the literature. There is general agreement that an emotional state shares some common features. Mainly, most people agree that the emotion is triggered by some external or internal stimuli. Followed by emotional response, which comes from our appraisals (evaluations) of one or more stimuli (that gives the situation personal meaning and significance). Finally, the effect of emotion results in physical changes (both by increasing and decreasing bodily signs) and can leads to behavioral changes.

Emotion can be differentiated from a number of similar, but yet distinct, constructs within the field of neuroscience; such as feeling, mood and affect (Gross & Thompson, 2007). *Feelings* are in everyday life often referred to synonymously as emotions. In ER field, feelings are defined as subjective exemplifications of emotions, or one's personal experiences of the affective process. Emotions can also be distinguished from moods. While emotions are relatively brief outcomes to potentially significant events in the external or internal environment, *mood* refers to the affective state with a lower intensity, but higher duration than emotions, and it does not have an explicit object of influence. *Affect* is mostly seen as a broadly including term, used to describe a state of experiencing emotions, feelings, and moods. Although, by some of the researchers, the term "affect" is commonly used as equivalent to the term "emotion".

Theories of Emotion

Many theories of emotions have been proposed during the years, and a lot of research has been done on many of them. Cognitive psychologists like Lazarus have suggested that it is not the emotion by itself that is important, but how people (cognitively) appraise particular situation and deal with it (Lazarus, 1999). According to Lazarus, cognitive appraisals are individual evaluations related to the impact that given situation will have on one's wellbeing. According to his theory, there are different forms of cognitive appraisal: primary, secondary and possibility for reappraisal (Lazarus, 1991). *Primary appraisal* refers to individual's first impression of the stimuli from situation that can be considered positive, negative, or irrelevant to personal wellbeing. *Secondary appraisal* takes place when an individual takes into account resources that are at hand that can benefit one in dealing with the situation. *Reappraisal* may occur when the individual monitors stimuli and resources from the primary and secondary appraisals and modifies them if it is required. Lazarus (1991)

suggested that emotions are products of person's cognitive appraisal, also stating that emotions can be produced both consciously and unconsciously.

According to neurological research, emotions serve as a guide to evaluate how relevant situations are, and are not necessarily a conscious process. It is argued that the appraisal can take place before one's conscious awareness, resulting in outcomes of the evaluation that are made conscious (LeDoux, 1995). A research by psychologists LeDoux (2000) has revealed that when the thalamus receives the inputs from the environment, it can send messages along two independent biological pathways of emotions: the high road and the low road. The former is *a long pathway* that passes via the cortex and the hippocampus before it results in an emotional response; while the latter is *a short pathway* that goes from the sensory thalamus directly to nearby amygdala, thereby activating the stress response system. Accordingly, the low road enables the amygdala to receive direct input from the senses and generates emotional reactions before the cerebral cortex has had time to interpret what is causing this particular reaction.

According to LeDoux (2000), the advantage of having both direct and indirect pathway to the amygdala and the stress response system is the flexibility in one's response. In the case of emergency, the fast and direct pathway which is important when faced with the life and death situation, because it saves time. On the other hand, the long and indirect pathway allows for a more systematic evaluation of the situation, which can help to avoid inappropriate responses to situations. He also proposed that people can have two simultaneous, but different, emotional reactions to the same situation, a conscious one (as a result of cortical activity) and an unconscious one (as caused by the amygdala). Conclusively, LeDoux at this point distinguishes between cognitive and emotional processes according to their biological significances, where emotions are produced before cognition process takes place, as a result of these two different pathways in the brain.

The Emotion-Cognition Relationship

Cognition such as thoughts, memories, and evaluations are involved in virtually every aspect of the emotions. Cognitive processes can evoke an emotional response as well as influence how we express our emotions and act on them. Each event can be viewed in many different ways; one's emotional reaction depends on how one appraises the significance of the event. The central idea of the present cognitive theories of emotion is that it depends on the

way in which one interprets or explains the occurrence in the absence of any emotional arousal. Accordingly, to which degree one can objectively (non-emotionally) process some event without involving the emotional aspect that goes with it seems to be for the most relevance.

The classical debate in emotion theory considering whether emotion proceeds or follows cognition is known as Zajonc-Lazarus debate. The debate began in the 1980s with an indication that subjects could respond emotionally to some stimuli, and act accordingly, even though subjects could not (consciously) recognize them as familiar (Zajonc, 1980). With that foundation, Zajonc (1980) reasoned that an emotion occurs before and independently of cognition. He claimed that emotional responses are too quick for cognition, leading to the conclusion that emotion thus must come before cognition and not follow it. The fundamental argument here is that there has been no cognitive processing of the stimulus although subjects seem to have an emotional response to the familiar items. His claims were encountered with strong disagreement by Lazarus (1982) who argued, according to his research, that emotions could not occur without a cognitive appraisal. He stated that although there was not (conscious) recognition of items does not mean that it has not been cognitively processed. Thus, not being able to declare that one remembers something does not mean that it has not happened or that one has not experienced it.

Almost two decades later both Lazarus (1999) and Zajonc (2000) seemed to hold the same view. Lazarus (1999) points out that primacy of emotion and cognition may be less important, in comparison to the fact that emotion cannot occur without cognition. Although, he states in the same editorial that the emotion occurs when something meaningful to the person happens in the environment, how one appraises event will produce emotion. Considering the work done by LeDoux (2000), it is evident that emotion and cognition are interdependent. Despite the fact that there are different neural systems specialized for emotional processing as well as for cognition, they do seem to influence each other on basic levels of existence. In a recent review it has been demonstrated that emotion and cognition are processes that cooperate in the brain in order for both of them to properly function (Ray, & Zald, 2012). The discussion seems to continue, mostly because there is evidence for the both sides of the story but also because it affects many aspects of a broader spectrum. Origins of the debate may be outdated, but they are still relevant, especially considering that debate may have started simply because of the definitional issues (Lazarus, 1999). Implication of

difficulties in measuring variables such as emotion and cognition can contribute in further stimulating the debate if variables have not been defined in details in future research.

Emotion Regulation

A presentation to the ER field will follow where the general knowledge in the field about ER is described. Significant contributions to the field such as categorization of different strategies that can be used in regulating one's emotion are discussed. Although many of these strategies seem to process on our conscience level (e.g. we are aware of them) the field of ER has not neglected the more basic of automatic and unconscious strategies. Also, a few therapy forms have been developed, as to promote beneficial longstanding ER, will be shortly presented at the end of the paragraph.

The concept of ER is as confusing as emotion, mostly because of the misperception that follows with the term of emotion itself. Most commonly ER refers to processes by which emotion itself is regulated (Gross, 2014), although it can also refer to processes by which we regulate our emotions in order to regulate emotions in others (Gross & Thompson, 2007). The former is considered intrinsic (comes from within the person) ER, while the latter is extrinsic process (comes from outside the person).

Given that many theories of emotion emphasize that all emotions include subjective experience and evaluation, expressive behavior and physiological response, ER (as emotional processes) may not differ by its definition. Still, there are disagreements in such that if emotional generation and regulation can be seen as distinct processes. As discussed by Gross and Barrett (2011) core assumption in the basic emotion perspective (e.g., LeDoux, 1998) is the existence of biological distinction between emotion generation and regulation in a way, these operate on the neural level. According to this perspective, ER is a process that maintains increases or decreases particular emotions from being expressed once they have been elicited, specifically by the cortical influence on the subcortical systems. On the other hand, according to appraisal emotion perspective (e.g. Lazarus,1991) cognition and emotion are thought to affect each other in order to provide emotional respond. Emotion is generated and regulated by some combination of overlapping brain circuits and are thus hard to be separated as specific processes (Gross & Barrett, 2011). Furthermore, they can be both conscious and subconscious processes and may or may not impact each other in order to produce some response.

Traditionally, it was assumed that ER strategies aim at promoting comfort and preventing pain; mostly considering that thought the development humans aim at adapting strategies that aspire in increasing pleasure and decreasing pain and thus nurture one's growth. Findings suggest that emotions are regulated with aspect to both how they subjectively make someone feel as well as what they help people to achieve (Gross, 2014). In a recent work the distinction between different personal objectives and underlying motives while ones is regulating own emotions have led Koole (2009) to believe that functions are oriented towards the individuals beliefs about the outcome. According to him, the ER functions are oriented towards three different outcomes, specifically need, goal and person. The *need-oriented ER* is determined by the individual's needs to experience hedonic satisfaction, mostly by lowering the effect of negative emotions and amplifying the effect of positive emotions. The *goal-oriented ER* is defined by one particular purpose in mind, containing individual's beliefs about the efficacy of particular emotional states in the future or by an enduring goal, task, or norm that may change the relevance of emotional information. The *person-oriented ER* is determined by the individual's overall functioning, its self-aspects, and may include one or both of already mentioned functions.

What is not ER?

Distinguishing between ER and other forms of emotion processing seems to be the biggest issue in distinguishing definition of ER from other concepts. As proposed by Gross and Thompson (2007) one can make segregation between concept of ER from coping, mood regulation, and psychological defenses. *Coping* can be distinguished from ER as such it focuses mainly on decreasing negative emotions as well as it unfolds under longer time. As already mentioned, mood lasts typically in longer periods than emotions do, as well as moods often do not involve behavioral or physiological pattern. Moreover, *mood regulation* focuses on the longer term states of the subjective part of the emotion, while ER also covers behavioral and physiological responses. ER can also be differentiated from *psychological defenses* that refer to regulation of aggressive or sexual impulses only. Psychological defenses are also automatic and unconscious, whereas ER can be both actively conscious and unconscious. Aside from already mentioned constructs, ER can also be separated from *emotional sensitivity*. While the latter decides the onset of emotional response, ER decides the offset of an emotional response (Koole, 2009). Furthermore, the concepts follow different developmental paths and are functionally different during one's life.

The Process Model of ER

ER strategies refer to the specific methods (tactics) people use in the purpose of processing and regulating their emotions (Gross & Thompson, 2007). If any activity that impacts an individual can generate emotional respond and thus has the potential in being regulated, and then one can assume that diversity of ER strategies is substantial. In order to classify these strategies the most effective approach to the problem would be one that combines top-down (theoretical) and bottom-up (empirical) approaches, as proposed by Koole (2009). The researcher's explanation is that it would be an efficient interaction since theoretical approaches to classification of strategies would be empirically tested to feet into categories. Although, as mentioned in the review, a combined approach of theoretical and empirical findings has yet to be used to the classification of ER. It is noted that it seems that the idea of automatic versus controlled emotional processes is accepted and evaluated in the field. This distinction can be useful in the classification of the ER, although no precise classification of such has been proposed.

The diversity of definitions of emotion has led many theories to combine different aspects of emotions into one singular emotion model, as opposite of uniting existing theories of emotions. Consequently, Gross (1998) proposed a modal model of emotions that combine features of emotions emphasized in many different theories of emotion. It resulted in a situation-attention-appraisal-response operation of emotion generation (see Figure 1). According to this model, the emotions arise in the context of the situation relevant to the person that is cognitively processed by giving the attention (to the stimuli relevant to the individual). By appraising the event (or the stimuli relevant to the individual), will result in the most likely respond given the situation and personal cognitive evaluation of it.

The process model of ER was built upon the proposed modal model of emotion (Gross, 1998). This outlined process model of ER, as seen in figure 1, was found very useful by the author himself in his work as well as his colleagues (Gross, 2014). It advocates five main points by which individuals can regulate their emotions through different strategies, where each of them may have an impact on emotion generation: situation selection, situation modification, attention deployment, cognitive change and response modulation (Gross, 1998).

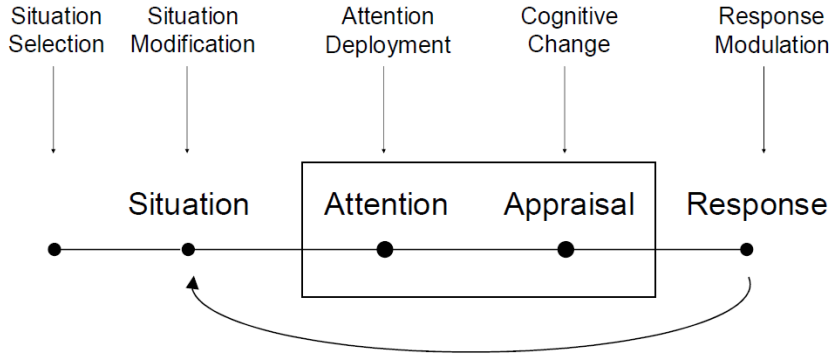

Figure 1. The process model of emotion regulation. Adapted from Gross and Thompson (2007).

The model begins with considering a personally relevant situation in the event, or stimuli that are often external, but it can be internal as well. It refers to the time-period before an emotion occurs; that is a potential situation that can give rise to or trigger an emotional response. The first group of strategies here is called *situation selection*, which refers to taking actions that will make it more or less likely that one will end up in a situation that can give rise to desired or undesired emotions. This strategy can involve taking actions. Such as, choosing to spend time with a friend that you think is fun when you have had a bad day or that you are avoiding going to a party where you do not feel comfortable with the host or the people who are invited. The second one is *situation modification*, which refers to directly modifying a situation so as to change its emotional impact. For example, if you do not feel comfortable in your apartment or if you find it boring to spend time there, you can renovate it to make yourself feel better. Investment in the strategy primarily means changing something in the surroundings (external) in order to feel better. Situation selection and modification are barely mentioned in the research context and according to Gross (2014) explanation can be that these strategies are not easy to study in an experimental context.

The second part of the process model of ER refers to the ways one can regulate one's emotion when they already have occurred (Gross, 1998). This component includes two groups of different emotional strategies which are referred to as attention deployment and cognitive change. *Attention deployment* refers to focusing one's attention towards or away from given situation, in order to influence one's emotion. One of the most common tactics in this category is called distraction; which can include both internal and external components.

Examples of this direction include both watching a funny movie when you are sad as well as thinking about good memories when you are feeling down. Trying to change the emotional impact of given situation by recalling memories or by altering thoughts has shown to have an impact on the emotional responses to the situation (Shurick et al., 2012).

Cognitive change refers to altering the way one evaluates the given situation in order to modify its emotional impact; the ways people adjust how they think about what is happening to them in any given situation. The ways one goes about in think about (appraising) the event is what gives rise to our emotions. Hence, by changing the way one values (appraises) some situation will change the way we emotionally experience it. The most studied strategy in this category is called cognitive reappraisal. A wide range of tactics can be used as a cognitive reappraisal, such as, for example, one can objectify the particular situation as to distance oneself away from an emotionally eliciting situation. Distancing can mean that you are looking at the bigger picture as to get a better perspective on what is happening in the moment. It involves cognitively changing emotional impact, by decreasing or increasing emotional experience, at any given situation in order to respond appropriately to the event. This strategy and its empirical contributions in understanding how it operates are the focus of this paper, and as such will be discussed in more details later on.

The last main point focuses on how one changes the response to the already occurred emotion. Thus, *response modulation* refers to how we change an ongoing emotional expression. The most studied strategy here is expressive suppression, in which one can decrease or increase an emotional response, and by its extension behavior, to any given situation. A good example here would be trying to laugh and look happy when you are feeling down. The last years, expressive suppression has been extensively studied in many meta-analyses where strategy's effectively, and functioning was reviewed (Gross, 2014).

This process model of ER also points out that the whole process is circular; responses in the end can give rise to an entirely new situation and subsequent emotions that will undergo the same process, which will then be regulated. The first four main categories in the process model of ER can be considered as *antecedent-focused ER strategies* as they occur before cognition and emotional responses take place (Gross, 1998). While, the last category is considered to be *a response-focused ER strategy*; as it occurs after responses are generated. The model provides a conceptual framework useful for understanding various forms of ER.

ER Strategies

The goal of ER is not to decrease inappropriate emotions and replace them with better-suited ones, but rather to impact emotions so one can produce a functionally beneficial behavior (Koole, 2009). Thus, the prime function of strategies is not to produce other emotions within the person experiencing some event, but to produce a different outcome (or emotional result) of these endured emotions. ER consists of behavioral, cognitive, attentional, physiological, or emotional strategies that aim at reducing, maintaining, or changing emotional experience or its expression or both (Ochsner & Gross, 2005). Individuals engage in a specific ER strategies in an attempt to modify the degree or their emotional experience or the responses caused by emotions (Gross, 1998). The former is known as antecedent-focused strategies, which an individual may use to regulate emotions before they arise, while the latter is considered response-focused strategies, which an individual may use once an emotion has begun to unfold. Purpose of different strategies is to wholly or partially alter the nature of emotional experiences and its subsequent responses. ER goals include intrinsically (from the inside of a person) and extrinsically (by the influence of others) decreasing as well as increasing both positive and negative emotions, depending on what is needed in the context (Gross & Thompson, 2007).

Furthermore, when it comes to the development of abilities to regulate emotions it is noted that both intrinsic and extrinsic features can contribute to the progress of ER (Fox & Calkins, 2003). The *intrinsic factors* are described as one's own emotional and cognitive processes (e.g. mental representations, experiences, internal processes) that are responsible for the course of the ER. Correspondently, the *extrinsic factors* are considered the environmental contributions to the emotional processes (e.g. culture, people, objects, surroundings) one is raised in as well as the one living at the moment.

There is a growing recognition of the importance of antecedent-focused strategy, referred to as cognitive reappraisal, as an adaptive ER strategy. Data from many studies indicate that when frequently used this strategy is beneficial for person's well-being and optimal functioning. More specifically, it has been shown that individuals who report using more frequently reappraisal in everyday life experience less negative and more positive emotions, in addition to having fewer symptoms of depression (Gross & John, 2003). In the brain imaging studies, it has been well studied throughout the last 15 years and has shown effectively to diminish subjective experience of negative stimuli.

Automatic ER

It has also been recognized in the field that many strategies that individuals use in order to regulate their emotions can be both a conscious or voluntary, and unconscious or automatic process. It has been indicated that the habitual use of reappraisal may produce better neural functioning, and can accordingly be beneficial for the people who use it more often (Drabant, McRae, Manuck, Hariri, & Gross, 2009). Although most of the experimental manipulations have been done on voluntary ER strategies, studies have investigated automatic processes as well. One study even showed that one can be unconsciously primed to regulate emotions in accordance to the primer (Mauss, Cook, Cheng, & Gross, 2007).

One study investigated automatic (spontaneous) ER (by providing no instructions about how to respond to emotional films) found that participants reported regulating their emotions more to the negative than to the positive movie (Volokhov & Demaree, 2010). They also tested respiratory sinus arrhythmia in participants while viewing the movie. It was found that individuals with high baseline respiratory sinus arrhythmia spontaneously regulated their emotions more than those with low baseline respiratory sinus arrhythmia when viewing a film that purpose is to produce primary negative emotions. High baseline respiratory arrhythmia can be signed to a more relaxed state, considering it is a measure of parasympathetic nervous system activity. When deducting the findings conclusion can be made that more relaxed individuals are better at regulating their negative emotions.

Long-term Effects of ER

The most of the experiments done in neuroscience have used observational methods to study ER, usually by instructing participants to engage in a particular ER strategy in response to an emotion-eliciting stimulus and then observing the effects on participants' subsequent emotions, cognitions, or physiological responding while measuring their brain activity. These studies can primary show the short-term effects of ER strategies; they do not test for long-term effects of engaging in a particular strategy.

A great deal of up-to-date known research has been demonstrated by comparing and contrasting the behavior consequences of engaging in each of these strategies. Some of them have shown beneficial effects of engaging in cognitive reappraisal. As for example reappraisal has been shown to have long-lasting effects on one’s tendency to have an

emotional response to presented stimuli (Ahn et al., 2013). Furthermore, the people who use reappraisal more frequently are better at processing negative feedback as well. Subsequent cognitive performance of people who reported that they used reappraisal more regularly was better and faster than of those who use it less often (Raftery & Bizer, 2009). The same study also compared the level of suppression use but did not find any connection between negative feedback and cognitive task that followed.

To my knowledge, the most of studies done on various processes of ER strategies have usually focused only on one or two ER strategies at a time. In addition to that, they are highly heterogeneous in their designs and results, making it difficult to compare findings among the same strategies as well as between different ones. Nerveless, extensive reviews and meta-analyses of experimental manipulations across ER strategies have been done in the last decade.

Emotions are a big part of our lives, signaling us about our needs, wants and desires. Research has shown that our ability to deal with our emotions is imperative for adaptive functioning (Gross, 2014). As it is already discussed, many different strategies (and various forms of it) can be used in order to voluntary or automatically regulate one's emotions. These strategies can also be thought and are regarded as they are the basis of cognitive therapy (Frewen, Dozois, & Lanius, 2010). Because many of mental disorders include some impairments in emotional processing (Johnstone & Walter, 2014) it is crucial developing techniques that can promote adaptive ER. Keeping in mind that improving individuals functioning is the primary goal of every therapy, many different interventions have been designed in order to treat emotional dysregulation.

Emotions have been studied for many decades. It is known that when facing stressful events one needs to learn how to respond to a given situation in order to perform to its best abilities. Many books have been written on the subject of ER and its implementation in therapy. Some of them aim at educating clinicians in implementing different strategies in order to teach people on how effectively to regulate their emotions. One of the recent books written on the subject is *Emotion regulation in psychotherapy: A practitioner's guide* written by researchers in the field of ER therapy (Leahy, Tirch, & Napolitano, 2012). This book includes many different ways one can help clients to learn to regulate their emotions. The techniques are presented in a step by step manner as for easier implementation and understanding. The primary focus is interventions implemented in cognitive behavioral

therapy as those are the basis of the authors' treatment form. Some of them that have been described are, for example, Emotional Scheme Therapy, Mindfulness, Acceptance and Commitment Therapy, Cognitive Restricting and related ER strategies. According to authors, presented ER interventions (tactics) can be used in many different settings and can be found useful when dealing with clients that have impairments in their ER abilities.

Cognitive-behavioral therapy is globally accepted as an effective treatment for various types of psychological problems. This model is based upon the re-evaluation of the emotions, or cognitive reappraisal as by its definition, and as such it is an essential teaching for adaptive ER. Cognitive-behavioral techniques for ER have been a fundamental teaching in this treatment form for many decades. This therapy form has been shown to be a promising tool in normalizing both emotion generation and regulation.

Dialectical behavior therapy is a form of therapy originally developed to treat people with severe mental difficulties and suicide tendencies, but has extended into treating borderline personality disorder and drug addiction (Linehan et al., 1999). It is mindfulness-based behavior treatment, primary by teaching people to focus on the present. Dialectical behavior therapy can be used in a variety of psychological treatments including treatment for emotional deficits (Neacsius, Bohus, & Linehan, 2014). It is somewhat extensive and phonology therapy form that can be thought both individually and in group, it requires a lot of devotion and commitment from both the giver and taker, with promising results for improvement (Turner, 2000).

Emotion Regulation Therapy (ERT) has been recently developed as a treatment for Generalized Anxiety Disorder. ERT is relatively new treatment and was first brought to the attention only decade ago (Mennin, 2004). It combines components of cognitive behavioral therapy, dialectical behavior therapy, mindfulness-based training, and experiential emotion-focused treatments. According to Mennin and Fresco (2014) it consists of 16 weekly sessions designed to help individuals acquire skills needed for adaptive emotional response; it is built upon Gross' process model of ER and finding in the field of ER. The presented are three main milestones in therapy are in order targeting motivation, regulation and contextual learning, and training in awareness and regulation of emotions that are later on practiced. Although this treatment form is still in its development, preliminary results in testing ERT have shown somewhat confounding results (Mennin & Fresco, 2014).

Cognitive restructuring is the most broadly used clinical form of reappraisal. It is by definition almost identical to the concept of reappraisal focused on in this paper. The techniques include such that, one can choose to distance themselves from their emotion and look more holistically at the emotional situation or chose to get more involved and reinterpret its emotional impact as to change the subsequent response. Techniques used here can involve anything from defining emotions, imagining different outcome scenarios, looking at the pros and cons of emotional responding, etc. (Leahy et al., 2012). To my knowledge, it has been tested mainly in combination with another form of therapy and results have been mixed.

In one of the earlier study it was found that cognitive restructuring can be an effective instrument, as much as exposure, in the treatment of panic disorder with agoraphobia (Bouchard et al., 1996). Foa and colleagues (2005) found that when comparing prolonged exposure alone as a therapy form and in combination with cognitive restructuring both seem to be more efficient forms of dealing with people diagnosed with posttraumatic stress disorder than the control condition (the waiting list). The similar effects on posttraumatic stress disorder-patients have been indicated in prior researches (Power et al., 2002). The presented are just some of the earlier examples of the effectiveness of cognitive restructuring.

The Neural Basis of Cognitive Reappraisal

This paragraph summarizes neural correlates of ER (i.e. cognitive reappraisal) and related concepts are presented. In order to address all of the already mentioned challenges in previous sections as they relate to ER, a closely related term such as emotional generation will be given. Findings on the cortico-subcortical connections when engaging in regulation process are addressed. The main focus here is to present functional neuroimaging studies done on cognitive reappraisal. A table that summarize articles of interest is presented with the detailed explanation of how and what is measured in them. Age and gender differences, as well as inherited characteristics that may favor adaptive regulation, are discussed from the few studies that have been found.

A recent review of functional imaging studies of ER proposed a model of the cognitive control of emotion (MCCE), which was built upon the existing knowledge in the field (Ochsner, Silvers, & Buhle, 2012). A multilevel approach was used in building a model of ER. Firstly, describing the phenomena in terms of relationships among three levels of

analysis, including experience and behavior, psychological processes, and neural systems. And secondly, it is built through the measurement or experimental manipulation. The MCCE uses classification of strategies and processes as proposed by Gross in the process model of ER, as the groundwork.

According to a review, the neural systems involved in using cognitive strategies, such as reappraisal, that was used as a paradigm case, considering that the most research is done on the strategy, are sorted in three categories of systems (Ochsner et al., 2012). The first category includes systems that are thought to regulate emotion: dorsomedial prefrontal cortex (dmPFC), dorsolateral prefrontal cortex (dlPFC), inferior parietal cortex (iPC), dorsal anterior cingulate cortex (dACC), posterior prefrontal cortex (pPFC) and ventrolateral prefrontal cortex (vlPFC). Second category consists of systems involved in generating those emotional responses, such as ventral striatum (VS), insula and amygdala. Third are systems with an undefined or intermediary role in reappraisal, and include following: ventromedial prefrontal cortex (vmPFC), medial orbitofrontal cortex (mOFC), temporal polar cortex (TPC), temporoparietal junction (TPJ), superior temporal gyrus (STG) and middle temporal gyrus (MTG). Brain mapping studies have trough the last decades yield somewhat inconsistent results when it comes to areas involved in ER. Although, when it comes to cognitive reappraisal, the most of researchers seem to be in accord with each other at one fact, that is that the prefrontal cortex (PFC) is regulating areas that are responsible for generating an emotional response.

Methods of studying the brain

The most well studied ER strategy is cognitive reappraisal. It has been shown to alter subjective emotional experience effectively in desired direction (Kim & Hamann, 2007). So by the means of reappraisal one can successfully diminish or enhance the emotional experience to the event. Cognitive reappraisal is conscious, effortful, voluntary and intrinsic ER, defined as cognitively reinterpreting the meaning of affective stimuli in ways that change their emotional impact according to the Gross' model of ER. The strategy involves a cognitive change of a given stimulus and belongs to the antecedent-focused strategies according to the process model of ER. There are two main types of cognitive reappraisal *reinterpretation* and *distancing*. The former is a situation-focused strategy and involves re-thinking the meaning of the actions and events represented in an image; while, the latter is a

self-focused strategy that includes viewing an image from the objective perspective, i.e. as a distant observer (for review see Ochsner et al., 2004).

By the use of functional magnetic resonance imaging (fMRI), in the last decades more that 50 of individual studies have identified a distributed network of brain regions underlying voluntary ER in response to affective images, film clips or some case more specific stimuli. Most of these studies examined patterns of brain activation while participants decreased (down-regulated) emotional responses through reappraisal of the (positive, negative or both) eliciting stimuli. A few of the studies considered increasing (up-regulating) emotional affect as well (e.g. Domes et al., 2010; Ichikawa et al., 2011; Leiberg, Eippert, Veit, & Anders, 2012; Schulze et al., 2011).

Participants in these studies were trained on the experimental procedure in a separate session a number of days before scanning in which an experimenter guided the participants through the different instructions presented during the tasks. A manipulation check was conducted afterwards as to test if the participants regulated their emotion according to the specified instructions. These were contrasted with the control conditions participants, where they were typically given instructions either to “attend” (“watch”) or “maintain” their emotions. The former is succeeded by instructing participants to pay attention and respond naturally to given stimuli while the latter is accomplished by asking participants to view given stimulus without trying to alter the affective reaction. These studies indicate that the cognitive reappraisal engages various executive function processes involved in cognitive control.

Table 1 was primarily created to make it easier to get an overall picture of how cognitive reappraisal is studied in the field of ER and the characteristics of the participants. All of the articles presented here have focused on measuring cognitive reappraisal in healthy participants by the fMRI. The choice of presented columns is done by the following as psychological coaching is most interested in knowing how brains of healthy participants work, all of them presented results of ER in healthy participants. Given the fact that coaching psychology focuses on treating every individual as a unique person they should, therefore, be coached by their abilities, more general this gave rise to consideration of columns such as age and gender, as shown in the table.

Furthermore, it is well known that there are differences in emotional responding between these groups (gender and age) and some of the studies have addressed this question.

Positive psychology, which is closely related to psychological coaching, deals with reactions and experience of the entire emotional spectrum. Considering positive psychology, different stimuli presented in studies have been labeled by its appropriate valence and type as reported in these studies. Some of the studies considered neutral stimuli as well (Kanske et al., 2011; Lang et al., 2012; Walter et al., 2009), although this table marks only elicitation of positive and negative stimuli. These generated emotions can be raised, lowered or maintained, and various observations have focused on different techniques. Important to note is that these are not all of the observations made in the field of ER, they are more a few selected ones that can guide in the direction that the field is taking at the moment. Presented stimuli have been mostly images or movie-clips of complex scenes in these fMRI studies on ER so far. All of the studies using photos have selected these from the International Affective Picture Set (Lang, Greenwald, Bradley, & Hamm, 1993).

Self-test was usually administered in these experiments after a trial. Participants were also asked to indicate the degree of success at following the instructions on a 5-point Likert-scale (e.g. Kim and Hamann, 2007), or to rate their current affect on a 5-point (e.g. Denny, Ochsner, Weber, & Wager, 2012; Lang et al., 2012) or 8-point (e.g. Staudinger et al., 2009) or 9-point scale (e.g. Mak et al, 2009).

The main focus have been from the beginning on brain imaging studies, so the primary criteria when selecting these studies was that researchers examined brain activity by cognitive reappraisal through fMRI (later selected were only studies involving healthy individuals). The particular tactic that was studied in different experiments is interpreted trough Grosses definitions of cognitive reappraisal. Two main conditions of interests are presented; a work that have been inspired by similar interpretation in meta-analysis done by Ochsner and colleagues (2012). Some of the studies however did not specify the instructions they gave (Krendl, Kensinger, & Ambady, 2012)

The last column presents contrast looked at in the specific fMRI study in order to establish specific neural circuits involved in the regulation of emotions. Namely, which brain areas are more active (as indicated by increased blood flow) and which are attenuated (indicated by decreased blood flow) in the course of the process. Some of the studies compared healthy individuals to BPD patients (e.g. Lang et al., 2012; Schulze et al., 2011), and MDD-patients (e.g. Erk et al., 2010), but here are presented only contrasts relative for healthy individuals as it was main focus, as previously mentioned.

Table 1
fMRI studies of cognitive reappraisal

Study	Sample Details	Stimulus valence	Stimulus type	Goal of ER	Tactic	Contrasts
Beauregard et al. (2001)	10 mHA (23,5)	P	Erotic videos	Dec	Dist	Dec > attend
Denny et al. (2012)	36 HA 23m/13f (22,0)	N	Image	Dec	Reint	Dec > look
Domes et al. (2010)	33 HA 16m /17f (25,6m/24,6f)	N	Photos	Both	Both	M: Dec >maintain F: Dec > maintain M: Inc > maintain F: Inc > maintain
Erk et al. (2010)	17 HA 9m /8f (43,9) 17 MDD 9m/8f (43,5)	N	Photos	Dec	Dist	Regulation > no regulation HA regulation > MDD regulation
Grecucci et al. (2013)	21 HA 11m/10f (23,5)		Photo	Both	Reint	Inc > look Dec > look Dec > Inc
Hayes et al. (2010)	25 HA 14m/11f (21,6)	N	Photos	Dec	Reint	Reappraise > view Suppress > view
Harenski and Hamann (2006)	10 fHA 10 fHA (rage 18-29)	N	Photos	Dec	Both	Dec moral > odd–even baseline Dec non-moral > odd–even baseline Dec moral > watch moral Decr non-moral > watch non-moral
Ichikawa et al. (2011)	17 HA 9m/8f (24,2)	N	Task errors	Both	Reint	Dec > baseline Inc > baseline
Kanske et al. (2011)	30 HA 13m/17f (21,8)	P + N	Photos	Dec	Both	Reappraise > view Reappraise/distract > view
Kim and Hamann (2007)	10 fHA (rage 20,7)	P + N	Photos	Both	Reint	Dec P > watch P Dec N > watch N Inc P > watch P Inc N > watch N Inc P > Dec P Inc N > dec N
Kim et al. (2013)	49 HA 27m/22f (23,61)	N	Photos	Dec	Both	Dec > Look Dec > Maintain
Kober et al. (2010)	21 HA 12m/ 9f, (26,8)	P	Photos	Dec	Reint	Dec > baseline
Koenigsberg et al. (2010)	16 HA 7m/ 9f	N	Photos	Dec	Dist	Dec > look

	(31,8)					
Krendl et al. (2012)	20 HA 10m/10f (21,6)	N	Photos	Dec	X (not explained)	Dec > attend Dec > dec stigma
Kross et al. (2009)	24 HA 9m/15f (20,8)	N	Memories	Dec	Reint	Dec > attend
Lang et al. (2012)	15 fHA (24,7) 14 fBPD (27,2) 15 fNon-PTSD (29,3)	N	Scripts	Both	Dist	Inc > maintain Dec > maintain HA > BPD HA > non-PTSD
Leiberg et al. (2012)	24 fHA (24,1)	N	Photos	Both	Dist	Dec > view Inc > view
Mak et al. (2009)	12 f HA (24)	P + N	Photos	Dec	X (Own choice)	Dec N > view N Dec P > view P
McRae et al.(2008)	25 HA 12 m/13f (20,6)	N	Photos	Dec	Reint	M: Dec > look F: Dec > look
McRae et al. (2010)	18 fHA (24,4)	N	Photos	Dec	Reint	Dec > look Distract > look
McRae, Gross, et al. (2012)	38 HA 17m/21f (10-22) A: 12 HC (rage10-13) B: 10 HC (rage 14-17) C: 16 HC (rage18-23)	N	Photos	Dec	Reint	Dec > look A:Dec > B:Dec > C:Dec
McRae, Misra, et al. (2012)	26 fHA (24,9)	N	Photos of faces	Dec	Reint	Dec > look
Modinos et al. (2010)	18 HA 11m/7 f (21,1)	N	Photos	Dec	Reint	Dec > attend
Ochsner et al. (2002)	15 fHA (21,9)	N	Photos	Dec	Reint	Dec > attend
Ochsner et al. (2004)	24 fHA (20,6)	N	Photos	Both	Both	Inc > look Dec > look Reint > Dist
Ochsner et al. (2009)	20 fHA (20,3)	N	Photos	Inc	Both	Inc > look
Opitz et al. (2012)	31 HA A: 8m/8f (19,3) B: 8m/9f (59,9)	N	Photos	Both	Reint	Dec > look A: Dec > B: Dec Inc > look A: Inc > B: inc
Phan et al. (2005)	14 HA 6m/8f (27,6)	N	Photos	Dec	Reint	Dec > maintain
Pitskel et al. (2011)	15 HA 9m/ 6f,	N	Photos	Both	Reint	Dec > look Inc > look

	(13,0)					
Schulze et al. (2011)	15 f HA (24,5) 15 BPD (27,6)	N	Photos	Both	Both	Dec > maintain Inc > maintain HA inc >BPD inc HA dec >BPD dec
Sripada et al. (2013)	49 HA 26m/23f (23,6).	N	Photos	Dec	Both	Dec > maintain
Staudinger et al. (2009)	16 HA 8m/8f (23,1)	P	Anticipation and receipt of reward	Dec	Dist	Dec > permit
Staudinger et al. (2011)	24 HA 11m/13f (25,1)	P	Anticipation of reward	Dec	Dist	Dec > permit
Urry et al. (2006)	17 HA 8m/9f (62,9)	N	Photos	Both	Reint	Dec > maintain Inc > maintain
Urry et al.(2009)	26 HA 11m/15f (64,8)	N	Photos	Both	Reint	Dec > maintain Inc > maintain
van Reekum et al. (2007)	29 HA 11m/18f (rage 61–65)	N	Photos	Both	Reint	Dec > maintain Inc > maintain
Vrticka et al. (2011)	19 f HA (24,82)	P + N	Photos	Dec	Reint	Dec P > dec N Dec N > dec P Nonsocial dec > social dec Social > non-social Reappraise > Suppress
Wager et al., (2008)	30 HA 12m/18f (22,3)	N	Photos	Dec	Reint	Dec > look
Walter et al. (2009)	18 fHA (24,0)	N	Photos	Dec	Dist	Dec N > no-regulation neutral Dec N > no-regulation N Dec neutral > no-regulation neutral Dec neutral > no-regulation N
Winecoff et al. (2011)	42 HA A: 20 HC (69) B: 22 HC (23,1)	P + N	Photos	Dec	Dist	A: Dec P > experience P A: Dec N > experience N B: Dec P > experience P B: Dec N > experience N

Note. HA= healthy adults; m = male; f = female; HC= healthy controls that are part of bigger group (HA), here A, B and C presents their smaller groups; P = positive; N= negative; P + N = positive & negative; Inc = increase; Dec = decrease ; Both = increase & decrease; Reint= reinterpret ; Dist = distance Both= combination; X = unclear which tactic is used.

One of the first to study the neural correlations involved in ER of negative evoking photos were Ochsner and his colleagues (2002). The reappraisal paradigm for observing ER was built upon their work and replicated in many of the following experiments.

As earlier stated all of these studies investigated the brain activation while instructing the subjects to voluntary regulate their emotions by the means of cognitive reappraisal. Although, what participants are doing in these brain imaging studies while being instructed to regulate their emotions in a precise manner is hard to know, or control. Especially, if considered that emotions can be regulated unconsciously and automatically, as well as extrinsically.

Van Reekum and colleagues (2007) examined brain patterns of reappraisal in 29 healthy adults (61–65 years) while their gaze fixations were recorded. The findings indicate that, when instructed to decrease their emotions participants spent less time looking at the presented picture, as compared with an increase and maintain conditions. In addition, both the increase and the decrease conditions had more considerable number of fixations made per second fixating the photos, as well as larger distance between participants' fixations. The results also imply that overt attention was controlled differently depending on the goal of the ER, meaning that when decreasing their emotions participants gaze fixations was related to a large part of the variation in areas of PFC.

One recent study found that voluntary ER produces powerful alterations in functional connections in the brain involving visual, attention, frontoparietal, and default networks (Sripada et al., 2013). Consequent to their data, it was concluded that these findings add a new aspect to the brain mechanisms underlying ER by suggesting a potentially important role for changes in and between large-scale networks in the brain. This study, as well as many others that will be discussed in the rest of the paper, is described in more details in Table 1.

Generation and Regulation of Emotions

The distinction between processes of regulation and generation of emotions have been early on suggested and distinguished in theory (Gross & Thompson, 2007; Rottenberg & Gross, 2003) even though its connectivity is well acknowledged and not in any way denied. Differencing between these two processes remains the source of debate, mostly because of its connectivity (Campos, Frankel, & Camras, 2004), in addition to the neural correlates were it is an overlap across different brain regions and its connectivity between these two processes.

In the brain imaging studies generation of emotions is considered to be the initial response, or more natural response, to targets; occurring when people attend to some stimuli without the effortful regulation of these. On the other hand, ER is considered to involve cognitive control over emotions elicited, i.e. voluntary attempts at regulating own emotions. As already specified by reviews and meta-analyses (Buhle et al., 2013; Kalisch, 2009; Kohn et al., 2014; Ochsner et al., 2012; Viviani, 2013), many of the brain imaging studies have indicated that several cortical and subcortical regions are involved in emotion generation. Some of these brain-areas seem to play key roles in both of the processes.

The Cortico-Subcortical Connections

The existence of the connections between cortical (PFC) and subcortical brain areas have, to my knowledge, not be argued. The main disagreement seems to be as to how areas such as amygdala are regulated by the PFC; or more precisely, parts of it. Two major hypotheses have been born from this discrepancy. The initial is proposing the meditative role of PFC and subcortical networks on successful emotional responding while the other is maintaining that the reappraisal success is directly related to cortical activity. Both the mediation and the direct hypotheses, as they have been named respectively, give an explanation on how deeply reappraisal influences the emotional appraisal process (Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008).

The mediation hypothesis holds that PFC activity mediates emotional responding by impacting the subcortical systems, which in turn impact regions involved in the representation of emotional states, such as amygdala (Beauregard, Levesque, & Bourgouin, 2001; Kim & Hamann, 2007; Ochsner et al., 2004; Phan et al., 2005; Urry et al., 2006; Wager et al., 2008; van Reekum et al., 2007). Alternatively, *the direct pathway hypothesis* suggests that the successful ER is directly related to cortical activity and minimally impacts evolutionarily older subcortical systems (Barrett, Mesquita, Ochsner, & Gross, 2007). In the recent years, there has been more research supporting the mediation hypothesis. Furthermore, it has resulted in the propositions for different pathways by which subcortical systems can be modulated by cognitive control of PFC.

To test the meditation theory Urry and colleagues (2006) examined the vmPFC links to amygdala by fMRI in older adults (mean age 62,9). Simultaneously, they looked at participants pupil diameters (that was recorded as a measure of the cognitive resource

distribution), while participants were being scanned, and their brain activity recorded; the production of cortisol levels during the one-week post-scan was also selected. Primary, findings suggest that both the right and the left vmPFC, or more specifically the anterodorsal medial frontal gyrus, can exercise a top-down inhibitory effect on the left amygdala. Moreover, the participants who displayed higher vmPFC and lower amygdala activation when decreasing their emotion, compared with the control condition, indicate more normative declines in cortisol levels over the course of the day. In addition to these findings, the regression analyses suggest that decrees in left amygdala activation distinctively explains 27% of the variance while decrease in vmPFC explains 20% of the variance in rise of cortisol. Also, the more activation in the superior and the inferior frontal gyrus and less activation in the amygdala when increasing their emotion as compared to the control condition led to larger pupil diameters in participants. Later on, more studies have supported the meditative role of vmPFC (Kanske, Heissler, Schönfelder, Bongers, & Wessa, 2011; Pitskel, Bolling, Kaiser, Crowley, & Pelphrey, 2011).

On the other hand, in order to investigate the mediation hypothesis about brain pathway-behavior relationships Wager and colleagues (2008) found the evidence supporting the vlPFC as a mediator. In this experiment, they recruited 30 healthy individuals (with median age of 22.3) that were instructed to reinterpret negative photos by decreasing its negative impact, alternatively by barely looking at the photos (control condition), after which all participants rated their experienced negative affect. They specifically designed their analysis as to test the hypothesis by its relationships among multiple variables. The Mapping of various brain regions that satisfy the formal criteria for mediators and application of clustering methods to examine how multiple mediating regions are organized into networks was done (as reviewed in Wager et al., 2008). The primer region of interest in the study was vlPFC and its relationship to the nucleus accumbens (NAcc) and VS. Their findings suggest that the brain regions implicated in reappraisal are structured into at least two independent cortical-subcortical networks one through the NAcc/VS and one through amygdala. The activation produced by cognitive reappraisal (as compared to the control condition) that was found in vlPFC was positively associated with the activity in both amygdala and NAcc/VS, where increases in the NAcc/VS pathway and decreases in the amygdala pathway led to reappraisal success (measured by reduction in reported negative emotion).

In the favor of the meditation hypothesis, similar findings as previously reported were obtained in a study examining similarities and differences between positive and negative down- and up-regulation of emotions. It was found that reappraisal processes are mediated by PFC which in turn regulated areas involved in emotional states (Kim & Hamann, 2007). In this research, it was shown that regulating negative emotion engaged similar activations in dmPFC, left lateral PFC (lPFC), anterior cingulate, and left OFC while increasing and decreasing positive emotions activated dmPFC and the left OFC. Up-regulation of negative and positive emotion employed commonly the left lPFC, dmPFC, the left lateral OFC, the left medial OFC (referred to as left-lateralized prefrontal regions). Whereas, down-regulating emotion activated the right lPFC, dmPFC, the medial PFC, and bilateral lateral OFC (referred to as bilateral prefrontal regions).

In the same study, the activity in the bilateral amygdala increased during the positive up-regulation, while activity in right amygdala was lower during positive down-regulation as compared to the control condition (Kim & Hamann, 2007). Additionally, the activity in the bilateral VS was greater when positive emotion was up-regulated in comparison to the control and the decrease condition; and thus was suggested that the VM is a modulatory target for the up-regulation of the positive emotions. Similar to these findings both up-regulation and down-regulation of negative emotion was associated with increased activity in the PFC and the anterior cingulate, which modulated up- or down-activity in amygdala according to its regulatory goal as previously reported (e.g. Ochsner et al., 2004). Furthermore, the down- and up-regulation of negative stimuli demonstrated similar activations in the PFC, with the addition of insula being modulated when decreasing negative emotions (Kim & Hamann, 2007).

Comparing Cognitive Reappraisal with Distraction

In one study done by McRae and colleagues (2010) cognitive reappraisal (in this case reinterpretation) was compared to distraction, while participants were instructed to keep the presented six-letter word in mind (working memory task). Their analyses show that both forms of ER were successful in reducing negative affect compared to the control condition. Furthermore, the reappraisal led to a greater reduction in self-reported negative affect than distraction in these conditions; activations in regions correlated with decreases included left lPFC, dmPFC, and in caudate all the way to the VS. Although, the results also show that a

greater down-regulation of amygdala activity was noticed in distraction relative to the reappraisal condition.

On the other hand, distraction may prove to be an efficient intervention if used as a short-term strategy for reducing an emotional response. In a comparable study comparing cognitive reappraisal to distraction, as one already mentioned, similar finding were acquired (Kanske et al., 2011). In this study, distraction was induced by an arithmetic problem that was to be solved and then decided upon the correctness of a presented answer. Common effects of both of these strategies included a decreased activation in the amygdala and the vmPFC/sgACC, and increased activation in the dmPFC and dlPFC, as well as in the precuneus and the iPC as compared to control the condition. Reappraisal-specific regions (more activation as compared to distraction) included enhanced OFC, distraction-specific activation was found in dACC/dmPFC, the parietal cortex, and the insula. Another work has demonstrated that in can depend on the given situation how successful one of these two strategies is, as well as which one should be applied (Sheppes & Gross, 2011).

Although, the strategy used to regulate emotion generation may be less important as previously assumed. McRae, Misra and associates (2012) proposed that a top-down and a bottom-up emotion generation should be treated as such and regulated by the appropriate ER strategy; as it was previously indicated in another study (Ochsner et al., 2009). Mainly, according to the findings, top-down reappraisal is more efficient than bottom-up reappraisal (e.g. top-down generated emotions are more successfully down-regulated by reappraisal than bottom-up emotions) and using reappraisal to decrease bottom-up generated emotions may even be counterproductive.

Age Differences

Given the fact that cognitive abilities decline with age, the question about age deficiencies in ER was evident. Although most of the brain-imaging studies examined younger age groups, some of the studies did include older participants (e.g. Winecoff, 2011), but few studies compared younger and older groups directly. For example, one study used a novel gaze-directed reappraisal paradigm that holds attentional deployment constant, as to isolate the effects of cognitive reappraisal, while instructing participants both to increase and decrease their emotional impact by reinterpretation (Opitz et al., 2012).

The subjects were able to use cognitive reappraisal in order to increase but not decrease negative emotion when attentional deployment was held constant. Compared with younger adults (ages 18–22), older adults (ages 55–65) had greater difficulty decreasing the intensity of negative emotion while engaging in cognitive reappraisal. Even so they were much better at increasing their negative emotions as compared to the younger group. Opitz and associates (2012) stated that these findings were related to significant age-related reductions in the activation of two regions of PFC: left ventrolateral (where activation predicted greater reappraisal success when goal was to increase negative emotion) and dorsal medial PFC (where activation predicted lower reappraisal success with the goal to increase negative emotion).

The same year (McRae, Gross, et al., 2012) building on their previous research (e.g. McRae, 2008), authors presented analysis showing that ER is impacted by development (for more information see Table 1). Comparing three different age groups they have shown that activity shifts in different brain regions in accordance to participants' age. In this study, adults seem to have better ability to regulate their emotions cognitively as compared to the younger participants.

Gender Differences

Previous work has indicated the existence of sex-differences in emotional processing. Two studies directly observed these differences in their participants while instructing them to reappraise their emotional impact. In one study, they instructed participants to decrease negative emotions (McRae et al., 2008) while another study also looked at the up-regulation of negative emotions (Domes et al., 2010). The results are somewhat conflicting, although both studies show the distinct differences in ER processing between the genders.

On one hand, the first study reported that while decreasing their emotions women showed more activation in VS, ACC, SFG and IFG, than in men who illustrated more decrease in amygdala (McRae et al., 2008). While the other reported less activation in women (compared to men) in the OFC, ACC and dlPFC while they decreased their emotions (Domes et al., 2010). Also, in the second study en showed increased activation in many areas (e.g. SFG, IFG, fusiform gyrus) in addition to increasing of activation in the amygdala while attempting to increase their emotions in comparison to women. Moreover, increased

activation in amygdala, PFC and temporal cortex was found in women in the initial viewing phase but not in men (i.e. emotion generation).

The Contributions to Alteration of ER

The capacity of the ER strategy used in a particular situation, and by its extension the neural functioning at the time of emotion generation may change depending on the stimuli presented. The emotional context of the stimuli may differ depending on the relevance of the presented stimuli as well as on our predisposed characteristics (Lee, Heller, van Reekum, Nelson, & Davidson, 2012). For example, it was demonstrated that the individual differences in dispositional mindfulness can predict the neural activity (Modinos et al., 2010). In this study, more mindful traits were linked to increased activation in dmPFC when participants were instructed to regulate their emotions.

A different study, examining reappraisal-driven forgiveness, demonstrated that the ability to forgive can be linked to more activation of dlPFC, the precuneus and the inferior parietal lobe (Ricciardi et al., 2013). Moreover, the mental state that we are in before ER takes place can predict its success or failure. One recent study has shown that anticipation of the particular stimuli may change how emotions are processed on the neural level (Denny et al., 2012).

Exposure to stress can also contribute to altering neural responding in ER. Xiong and colleagues (2013) compared the neural responding in 20 healthy subjects, and 20 patients diagnosed with posttraumatic stress disorder while instructing them to reappraise their negative emotions. Their findings include that the diagnosed patients demonstrate decreased activation in inferior frontal and parietal cortex as well as the insula and putamen while regulating their emotions, compared to healthy subjects, in addition to increased activation in PCC and amygdala while increasing negative effect. Another study found that exposure to stress in childhood may affect the neural responding in adults while attempting to regulate their emotions (Kim et al., 2013). Also, in this specific case adults have been raised in poverty, which may have caused some of the stress they underwent in the childhood. Their participants showed decreased activity in the dlPFC and vlPFC and more response from amygdala when asked to regulate their emotions by cognitive reappraisal. They argued that these activations primarily mediated the link between childhood income and adult ER,

although exposure to chronic stress in childhood was linked to reduced dorso- and ventrolateral PFC activity.

There are also differences in how brain reacts (process stimuli) when faced with different emotional stimuli in various social contexts. Vrticka and colleagues (2011) have demonstrated distinct patterns of positive versus negative ER (as discussed above), in addition to the distinctive patterns of regulating social and non-social imagines. Data shows that compared to non-social images, regulation of social images recruited the mPFC, PCC, mOFC. In another study, stigma regulation was compared to non-stigma regulation by instructing participants to regulate their emotions by means of reappraisal (Krendl et al., 2012). More activation in the ACC, lPFC and mPFC was observed when regulating negative emotions to stigmatized pictures than non-stigmatized ones. The authors also stated, based on the comparison of two different ER strategies (reappraisal and suppression) that regulating stigmatized targets may reflect more instant response while common (regular) reappraisal can take little longer time to unfold. These studies show the impact that society, social environment and the individual bias have on the ongoing processes in the brain.

On the other hand, one more recent study (Grecucci, Giorgetta, van't Wout, Bonini, & Sanfey, 2013) investigated how reappraisal influences socioeconomics decisions. They instructed participants to regulate their emotions during Ultimatum Game and registered their brain activity in the process. It was found, compared to the control condition; that down-regulation resulted in acceptance of more unfair offers. Whereas, up-regulating emotions resulted in rejecting more unfair offers. In the former case more dominant activation was found in the left superior and middle frontal gyrus and the latter case recruited mainly the left inferior frontal gyrus. Accordingly, compared to the control condition, regulation of emotions by reappraisal overall recruited dlPFC, ACC and temporo-parietal areas as previously reported.

Heritability

As already presented; emotion is usually regulated in the human brain by a complex circuit consisting of PFC, OFC, ACC, amygdala, and several other interconnected regions. There are both genetic and environmental contributions to structure and function of the ER course (Canli, Ferri, & Duman, 2009). There is some evidence that individual differences in responding to emotional stimuli are partly moderated by genetic variables

(Hariri & Holmes, 2006), although studies addressing the specific questions of heritability of ER have barely been studied.

One cross-sectional twin study, individuals aged 25–74, found that the mean level of negative affect was partly heritable among these individuals. Although, there was no evidence for genetic influence on intra-individual variation, while shared environment was found to have an effect for monthly and daily levels of negative mood, as well as variation in daily mood (Neiss & Almeida, 2003). Considering the results it was proposed that baseline mood is heritable while variations around the baseline are primary due to the environment influence.

There is also evidence to the genetic contribution to the individual differences in processing ER (Canli et al., 2009). Although, interaction with the environment seems to be significant, specific genetic mechanisms involved in ER seem to be of difference when it comes to predisposition. On the other hand, one study has shown that an effortful action can effectively rectify genetic factors of emotional behavior (Schardt et al., 2010). These studies are demonstrating that voluntary ER can be effective in producing desired response, even though one is not genetically predisposed successfully to regulate one's emotions.

Psychopathology

In this section, summary of how people with two different mental disorders process cognitive reappraisal will be shortly presented. More precisely, mood and personality disorders will be discussed, considering that they have been mainly known to affect emotional processes. In line with that comparisons between healthy subjects (as it was the main focus in the previous section) and people diagnosed with a mental disorder will be presented.

fMRI studies of healthy human brain can explain a lot about human functioning. Although, it is not before these studies of healthy brains have been contrasted to the brains of people with impairments, that they become more valuable for further understanding of human-brain operations. Damages or impairments in any of the above-mentioned brain areas that have been linked to ER, can contribute to severe failures in human functioning (e.g. distress) and can contribute to the development of many mental disorders. The ability to appropriately regulate emotions is a critical and necessary skill for regular human functioning (Gross & Levenson, 1993), as well as mental health and well-being (Gross, 1998). Diverse

ER strategies may be beneficial for different individuals, construed from the relationship that was found between strategies and psychopathology (for rewire see Aldao, Nolen-Hoeksema, & Schweizer, 2010).

In particular, cognitive reappraisal has been shown to contribute to better mental health (Gross & John, 2003). Experiments done on the patients diagnosed with the mental disorders in the field of ER have mostly focused on studying personality disorders and mood disorders. Differences between healthy subjects and people with a diagnosis can contribute to better understanding effects that particular ER strategies have on the brain circuits. Furthermore, it can also indicate how the same information is processed by different individuals depending on their mental health.

Borderline Personality Disorder

Borderline personality disorder (BPD) is a mental disorder that is primarily characterized by persistent pattern of instability in the emotional processing (Lieb, Zanarini, Schmahl, Linehan, & Bohus, 2004). Given the fact that BPD is expressed by dysregulation in ER some of the studies directly examined neural correlates of ER in the BPD (Koenigsberg et al., 2010; Lang et al., 2012; Schulze et al., 2011). In these studies, the authors focused on reappraisal of negative emotions. While two of them instructed participants to regulate their responses to negative stimuli used pictures (e.g. Koenigsberg et al., 2010; Schulze et al., 2011), the third one presented script (verbal stimuli) to be regulated (e.g., Lang et al., 2012). All three studies did not find any differences in ER on their subjective ratings when comparing BPD individuals with controls, but did find somewhat different patterns in brain activation.

In the first study, BPD patients had to regulate their negative emotions to aversive imagines by distancing (Koenigsberg et al., 2010). Compared to healthy individuals, the BPD group showed less activation in dACC and inferior parietal lobe, followed by less deactivation in the amygdala and greater activation in the superior temporal sulcus and superior frontal gyrus. Schulze and colleagues (2011) investigated up- and down-regulation of negative eliciting picture by a cognitive reappraisal task. Compared to healthy subjects, BPD patients showed increased activation of the bilateral insula and decreased activity in the left OFC when attempting to decrease their negative emotional responses; there was none significant differences between the groups when individuals increased their emotions.

The third study investigated whether ER in BPD is due to the trauma-exposure. Their three conditions (non-traumatized healthy females; BPD women with a history of trauma; healthy females with a traumatic experience) were instructed to up- and down-regulate their emotions while engaging in a distancing strategy (Lang et al., 2012). When comparing to healthy individuals, BPD patients and healthy women with a traumatic experience showed early deactivation in the PFC and ACC during up-regulation of emotions. While decreasing their negative emotion, BPD patients showed activation in the right middle temporal gyrus and the superior temporal gyrus, while healthy individuals with a traumatic experience demonstrated greater bilateral activation in the middle temporal gyrus and parietal cortex.

Major Depression Disorder

Depression is the large cause of many mental disorders, as well as it impairs ordinal human functioning. Major Depression Disorder (MDD) has a broad definition and can cause severe problems in everyday life (Belmaker & Agam, 2008; Frewen et al., 2010). Early studies investigating ER found that MDD patients (compared to healthy controls) showed more activation in the right dACC, the right anterior temporal pole as well as amygdala and insula when attempting to decrease their negative emotions (Beauregard, Paquette, & Levesque, 2006).

The similar results were obtained in the study done by Erk and colleagues (2010), where self-reported regulation success was similar between groups. Compared to MDD patients, healthy subjects displayed more activation in dlPFC, vmPFC, iPC, posterior cingulated gyrus and left amygdala when decreasing negative emotions. In the same study, a sustained regulation effect was seen in amygdala, in healthy individuals while the lack of it was associated with reduced dlPFC in MDD patients.

Discussion

In broad-spectrum dorsal and lateral PFC, PC, ACC and OFC can be engaged by some form of cognitive ER strategy and can modify the activity in subcortical systems such as ventral striatum, insula and amygdala. These prefrontal systems that are employed by cognitive reappraisal support the use of various kinds of cognitive control processes, while subcortical systems are involved in the generation of emotions.

Person's emotional experience of a particular event is highly relevant to adaptive social behavior as well as mental and physical health. Different strategies may be adopted to achieve beneficial ER. There has been much research done on ER in the last decades, even though in a broader context there is none coherent answer in which one is most useful and how this is achieved. Although, there is promising evidence that we may know the answer on how specific strategies, such as cognitive reappraisal, operate on the neural level in the near future; given the grown interest in the field. Understanding underlying mechanisms in cognitive reappraisal, as well as other ER strategies, will help in further development of various interventions that are thought to people. Also, it may explain why some are more susceptible to specific interventions while others seem to not gain any effect at all of the same intervention. This knowledge is also valuable in correcting problems with ER that some may have.

The emotion-cognition debate has not been solved to date and if fundamental pillars ER (i.e. emotion and cognition) are not resolved and agreed on than some of problems in this field can be expected. Also, it can add to problems in defining ER, and by its extension cognitive reappraisal. Both more detailed (in e.g. individual research) and more general approach (in e.g. meta-analysis) to the phenomena is necessary if we are ever to understand how ER works in practice. All perspectives must be taken under consideration because it may lay some truth in all of them.

Favoring the primacy of the emotion over the cognition or vice versa seems to be an ongoing debate also in the current situation. The main problem arises in the definitions of these concepts. Considering the Zajonc-Lazarus debate, it was argued later that they may refer to different aspects of emotion (Lazarus, 1991). As there are contraindications in what emotions are and how they arise, there is even a bigger problem in the definition of term cognition. This expression is seen as being too including and difficult to distinguish from emotion sometimes, mostly because of its close relationship. Even thou distinction between affective processes (value) and cognitive processes (information) is possible to perceive on the neural basis, affect is processed by subcortical brain areas while cognition operates on cortical; mostly involving PFC activation (Cromwell & Panksepp, 2011).

Considering the value researchers put on the interpretation of emotional processes it is to some extent surprising that better more detailed definition have not been accepted. If we are ever to distinguish between these two somewhat broad terms, they need to

be better defined. Although, concepts can be hard to define in a precise / unique way then perhaps there is no definitive definition. Everything is connected in our brain and activation of one process will activate the other, so no matter if the emotion or the cognition is processed first they are influencing each other in the ways we are yet to understand and explain.

Furthermore, when it comes to ER, it may not be a question of cognition-emotion relationship and its primacy, although, it is important to distinguish between these processes. As previously studies report that dorso-caudal parts of the ACC and mPFC are involved in emotion generation while ventral-rostal portions of the ACC and mPFC are involved in their regulation (Etkin, Egner, & Kalisch, 2011). The stated is suggesting that both emotional processes are indeed produced by similar parts of the brain. The distinguishing feature is the direction these processes take in order to operate suitably.

Brain-imaging studies of cognitive reappraisal. Many of the brain imaging studies already illustrate how one can use top-down forms of cognitive control, e.g. cognitive reappraisal; to change the way one appraises the meaning of emotionally evocative stimuli, which will in turn change one's emotional response to the event. For the past decade, this has been the focus of the neuroscientific research in the field of ER. In general, it is clear that (typically lateral and medial parts of) prefrontal systems can modify subcortical systems (e.g., amygdala and insula). Indications have been made that the parts of PFC can increase, decrease or maintain activity in the subcortical systems, in accordance with its regulatory goals. Although, exactly how they achieve this effect is less clear. Brain imaging studies so far have focused on investigating voluntary (conscious) ER. It is the first step at identifying the neural responses activated when regulating emotional stimuli and much progress have been done in a short time. These studies are valuable in predicting how brain reacts when ER is in its process, but they do have some of the disadvantages.

It is important to remember that fMRI does not measure neuronal activity directly; it measures the response of the vascular system. The process is possible because neuronal activity is accompanied by changes in blood flow and oxygen use, changes in blood flow are measured by this instrument. Comparing these fMRI studies with other brain-imaging studies is fundamental if it is to be understood properly, especially considering the shortcomings (e.g. poor temporal resolution) that fMRI as an instrument has. Understandably, the different instruments may assess diverse aspects of brain functioning and thus complement each other and build further on understanding the gained knowledge.

Most of the imaging studies have tested for brain activation during specific ER strategy in healthy subjects under different conditions. There is no clear-cut explanation on which brain areas support ER process or how they go by in the modulating response to subcortical systems. The neuroscientific research in this field is still in its infancy, given the fact that the first brain imaging study ever done on reappraisal, known as mostly studied cognitive ER strategy, has been performed in 2001.

The studied ER-strategies. It can be to some extent difficult to state that the instructed, the ones that were supposed to be studied, ER strategies have been used by participants. Attempts at controlling for automatic regulations have been presumed to be achieved by "attend" or "maintain" trials in previous studies. However, the most ultimate would be developing some non-conscious measure or instrument of ER if one is to be certain as to what is measured. The proposed can be tricky to obtain, but considering that research is expanding rapidly in the last years it is an encouraged possibility.

The generalizability of the studies. Most of the studies have scanned brains on the middle-aged participants. As shown there are significant differences in functions of brains in older and younger participants, more diverse participants are needed if studies are to reflect more general public. The differences between genders have also been considered in some of the studies, and preliminary results show distinct patterns in neural responding between two sexes. Although, goal of these studies may be that only generalize to some ER process that goes on in these individuals are not included in the studies. Generalization to other individuals may be done more by replication on other individuals is in other studies. Meta-analyzes and integrative review can draw more general conclusions later on.

All of the different studies already mentioned are crucial and beneficial in defining the brain mechanisms of ER. The authors usually make conclusions from the results of a very specific population (or group usually consisting of 10-50 participants). The more generalizable conclusion is possible mainly by the meta-analysis, which uppermost increases the power of the statistical analysis. They present the population more accurately and allow for the better use of information gathered from individual studies.

The type of stimuli used. Most of the studies have focused on emotional eliciting pictured, and all are taken from the same set of pictures. More realistic elicitation is needed if they are to contribute to adaptive human functioning. Some of the recent studies have already

attempted at more detectives approach to evocative stimuli. In the future more will emerge, and better understanding of ER strategies is longtime awaited.

The valence of stimuli used. Many of the studies emerging have mostly looked at the decreasing of negative emotions. Different patterns of decreasing and increasing have been shown. Although, very little of progress has been made in determining the right cause of these differences. Differences' in regulation of different emotions needs to get more of the attention in the future if we are to understand how ER operates. A distinct pattern between regulation of positive and negative emotions have been shown in previous studies (Vtricka, 2011; Kim & Hamann, 2007; Mak et al. 2009). Emotions can be regulated to accomplish various goals. These processes have essentially allowed humans to enjoy positive and avoid negative emotions mostly by increasing or decreasing their emotional experience, although maintaining specific emotion is just as important. These controlled conditions may just reflect that, the third ER goal.

Correlating increase in PFC with decrease in amygdala. The connection has been made in many studies, but it does not directly mean that cognitive control (PFC) is modulating emotional parts of the brain (amygdala). More direct testing (e.g. Wager et al., 2008) is required in order better to test this theory. Correlations are by definition only connections; they do not tell us at what they are directed. Investigating more than correlations in responding is needed. As, for example, one study have shown a negative correlation between amygdala volume and thickness in the PFC has been demonstrated in the last year (Albaugh et al., 2013). The thickness of the cerebral cortex (especially PFC) and its connectivity to subcortical areas is valuable in determining underlying mechanisms of ER, both in how it is develop and the relationship it has to mental disorders.

Self-reported ER success. Limitations of self-reported emotions (and its regulation) can as ordinary cause problems when people interpret these according to what is considered to be relevant at the moment. Individuals do not always have insight into the internal mechanisms behind their answers and are not always good at predicting their behavior in a hypothetical future or reflect correctly over what has happened.

Individual differences. The ability to adaptively handle stressful life experience is necessary for our well-being. As already mentioned, impairments in ER can contribute to a variety of clinical disorders. History has shown that reappraisal seem to be more adaptive ER

than suppression (Richards & Gross, 2000). That it can promote better health and functioning in general, but can it be taken to the individual level. The effect of gene and environment connection on emotional processing, and by its extension ER have been documented in the past years (Canli et al., 2006). These are some of the first attempts at identifying what makes the individual differ in ER. The importance of examining stable individual differences in order to provide future insight into the neural basis of ER is crucial. Functional segregation between behavioral (expressive suppression) and cognitive (cognitive reappraisal) ER has already been suggested (Goldin et al., 2008). These are one of the first steps in the right direction if one is to find better definitions for process, as well as better measurements.

Conclusion

Brain imaging studies, thus far, have led to significant but yet confusing and sometimes conflicting findings. Despite some yet to be resolved challenges, the concept of ER has a broad and significant value for mental, physical and emotional health. The behavioral studies have shown that the acceptance of ongoing feelings can lead to less experience of stress, physiological response and behavioral avoidance (Wolgast, Lundh, Viborg, 2011). Increasing evidence demonstrates that deficits in the adaptive ability to regulate emotion are related to various forms of psychopathology. Because the first individual brain imaging study has emerged at the beginning of 2000 century, much progress has been made. The number of publication is rapidly growing, and more knowledge is being gained in the field by every passing day. Future seems promising especially considering the contributions neuroscience can make in understanding functions of ER on one hand and interventions implemented so far in better functioning due to the different ER-therapies on the other hand. In better understanding underlying mechanism of ER and finding better interventions for emotional dysregulation, one can hope to find better ways to handle emotional experience and response that follows it. Also, from a coaching perspective, passing on these teachings (e.g. interventions) on others.

Reference

Ahn, H. M., Kim, S. A., Hwang, I. J., Jeong, J. W., Kim, H. T., Hamann, S., & Kim, S. H. (2013). The effect of cognitive reappraisal on long-term emotional experience and emotional memory. *Journal of Neuropsychology*. doi: 10.1111/jnp.12035

Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review, 30*(2), 217–237.

Barrett, L. F., Mesquita, B., Ochsner, K. N., & Gross, J. J. (2007). The experience of emotion. *Annual Review of Psychology, 58*, 373–403.

Beauregard, M., Levesque, J., & Bourgouin, P. (2001). Neural correlates of conscious self-regulation of emotion. *The Journal of Neuroscience, 21,* RC165.

Beauregard, M., Paquette, V., & Levesque, J. (2006). Dysfunction in the neural circuitry of emotional self-regulation in major depressive disorder. *Neuroreport, 17*(8), 843–846.

Belmaker, R., & Agam, G. (2008). Major depressive disorder. *New England Journal of Medicine, 358*(1), 55–68.

Bouchard, S., Gauthier, J., Laberge, B., French, D., Pelletier, M.-H., & Godbout, C. (1996). Exposure versus cognitive restructuring in the treatment of panic disorder with agoraphobia. *Behaviour Research and Therapy, 34*(3), 213–224.

Buhle, J. T., Silvers, J. A., Wager, T. D., Lopez, R., Onyemekwu, C., Kober, H., ... & Ochsner, K. N. (2013). Cognitive reappraisal of emotion: a meta-analysis of human neuroimaging studies. *Cerebral Cortex*, bht154.

Campos, J. J., Campos, R. K., & Barrett, K. C. (1989). Emergent themes in the study of emotional development and emotion regulation. *Developmental Psychology, 25,* 394–402.

Campos, J. J., Frankel, C. B., & Camras, L. (2004). On the nature of emotion regulation. *Child Development, 75,* 277–394.

Canli, T., Ferri, J., & Duman, E. (2009). Genetics of emotion regulation. *Neuroscience, 164*(1), 43–54.

Cromwell, H. C., & Panksepp, J. (2011). Rethinking the cognitive revolution from a neural perspective: how overuse/misuse of the term ‘cognition’ and the neglect of affective controls in behavioral neuroscience could be delaying progress in understanding the BrainMind. *Neuroscience & Biobehavioral Reviews, 35*(9), 2026–2035.

Denny, B. T., Ochsner, K. N., Weber, J., & Wager, T. D. (2012). Anticipatory brain activity predicts the success or failure of subsequent emotion regulation. *Social Cognitive and Affective Neuroscience*, nss148.

Dixon, T. (2012). "Emotion": The history of a keyword in crisis. *Emotion Review, 4*(4), 1–7.

Domes, G., Schulze, L., Böttger, M., Grossmann, A., Hauenstein, K., Wirtz, P. H., . . . Herpertz, S. C. (2010). The neural correlates of sex differences in emotional reactivity and emotion regulation. *Human Brain Mapping, 31*(5), 758–769.

Drabant, E. M., McRae, K., Manuck, S. B., Hariri, A. R., & Gross, J. J. (2009). Individual differences in typical reappraisal use predict amygdala and prefrontal responses. *Biological Psychiatry, 65*(5), 367–373.

Erk, S., Mikschl, A., Stier, S., Ciaramidaro, A., Gapp, V., Weber, B., & Walter, H. (2010). Acute and sustained effects of cognitive emotion regulation in major depression. *The Journal of Neuroscience, 30*(47), 15726–15734.

Etkin, A., Egner, T., & Kalisch, R. (2011). Emotional processing in anterior cingulate and medial prefrontal cortex. *Trends in Cognitive Sciences, 15*(2), 85–93.

Foa, E. B., Hembree, E. A., Cahill, S. P., Rauch, S. A., Riggs, D. S., Feeny, N. C., & Yadin, E. (2005). Randomized trial of prolonged exposure for posttraumatic stress disorder with and without cognitive restructuring: outcome at academic and community clinics. *Journal of Consulting and Clinical Psychology, 73*(5), 953–764.

Fox, N. A., & Calkins, S. D. (2003). The development of self-control of emotion: Intrinsic and extrinsic influences. *Motivation and Emotion, 27*(1), 7–26.

Frewen, P. A., Dozois, D. J., & Lanius, R. A. (2010). Neuroimaging studies of psychological interventions for mood and anxiety disorders: empirical and methodological review. *FOCUS: The Journal of Lifelong Learning in Psychiatry, 8*(1), 92–109.

Grecucci, A., Giorgetta, C., van't Wout, M., Bonini, N., & Sanfey, A. G. (2013). Reappraising the ultimatum: an fMRI study of emotion regulation and decision making. *Cerebral Cortex, 23*(2), 399–410.

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology, 2,* 271–299.

Gross, J. J. (2013). Emotion regulation: Taking stock and moving forward. *Emotion, 13,* 359–365.

Gross, J. J. (2014). *Handbook of Emotion Regulation* (2 nd ed.). NY: Guilford Press.

Gross, J. J., & Barrett, L. F. (2011). Emotion generation and emotion regulation: One or two depends on your point of view. *Emotion Review, 3*(1), 8–16.

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology, 85*(2), 348–362.

Gross, J. J., & Levenson, R. W. (1993). Emotional suppression: physiology, self-report, and expressive behavior. *Journal of Personality and Social Psychology, 64,* 970–986.

Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: Conceptual foundations. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (pp. 3–24). NY: Guilford Press.

Harenski, C. L., & Hamann, S. (2006). Neural correlates of regulating negative emotions related to moral violations. *NeuroImage*, *30*(1), 313–324.

Hariri, A. R., & Holmes, A. (2006). Genetics of emotional regulation: the role of the serotonin transporter in neural function. *Trends in Cognitive Sciences*, *10*(4), 182–191.

Hayes, J. P., Morey, R. A., Petty, C. M., Seth, S., Smoski, M. J., McCarthy, G., & LaBar, K. S. (2010). Staying cool when things get hot: emotion regulation modulates neural mechanisms of memory encoding. *Frontiers in Human Neuroscience, 4*, 230. doi: 10.3389/fnhum.2010.00230.

Ichikawa, N., Siegle, G. J., Jones, N. P., Kamishima, K., Thompson, W. K., Gross, J. J., & Ohira, H. (2011). Feeling bad about screwing up: emotion regulation and action monitoring in the anterior cingulate cortex. *Cognitive, Affective, & Behavioral Neuroscience*, *11*(3), 354–371.

Johnstone, T., & Walter, H. (2014). The neural basis of emotion dysregulation. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (2 nd ed.). New York: Guilford Press.

Kalisch, R. (2009). The functional neuroanatomy of reappraisal: time matters. *Neuroscience & Biobehavioral Reviews*, *33*(8), 1215–1226.

Kanske, P., Heissler, J., Schönfelder, S., Bongers, A., & Wessa, M. (2011). How to regulate emotion? Neural networks for reappraisal and distraction. *Cerebral Cortex*, *21*(6), 1379–1388.

Kim, P., Evans, G. W., Angstadt, M., Ho, S. S., Sripada, C. S., Swain, J. E., ... & Phan, K. L. (2013). Effects of childhood poverty and chronic stress on emotion regulatory brain function in adulthood. *Proceedings of the National Academy of Sciences*, *110*(46), 18442–18447.

Kim, S. H., & Hamann, S. (2007). Neural correlates of positive and negative emotion regulation. *Journal of Cognitive Neuroscience*, *19*(5), 776–798.

Kober, H., Mende-Siedlecki, P., Kross, E. F., Weber, J., Mischel, W., Hart, C. L., & Ochsner, K. N. (2010). Prefrontal–striatal pathway underlies cognitive regulation of craving. *Proceedings of the National Academy of Sciences, 107*(33), 14811–14816.

Koenigsberg, H. W., Fan, J., Ochsner, K. N., Liu, X., Guise, K., Pizzarello, S., . . . Goodman, M. (2010). Neural correlates of using distancing to regulate emotional responses to social situations. *Neuropsychologia, 48*(6), 1813–1822.

Kohn, N., Eickhoff, S., Scheller, M., Laird, A., Fox, P., & Habel, U. (2014). Neural network of cognitive emotion regulation—An ALE meta-analysis and MACM analysis. *NeuroImage, 87*, 345–355.

Koole, S. L. (2009). The psychology of emotion regulation: An integrative review. *Cognition and Emotion, 23*, 4–41.

Krendl, A. C., Kensinger, E. A., & Ambady, N. (2012). How does the brain regulate negative bias to stigma? *Social Cognitive and Affective Neuroscience, 7*(6), 715–726.

Kross, E., Davidson, M., Weber, J., & Ochsner, K. (2009). Coping with emotions past: the neural bases of regulating affect associated with negative autobiographical memories. *Biological Psychiatry, 65*(5), 361–366.

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology, 30*(3), 261–273.

Lang, S., Kotchoubey, B., Frick, C., Spitzer, C., Grabe, H. J., & Barnow, S. (2012). Cognitive reappraisal in trauma-exposed women with borderline personality disorder. *NeuroImage, 59*(2), 1727–1734.

Lazarus, R. S. (1982). Thoughts on the relations between emotion and cognition. *American Psychologist, 37*, 1019–1024.

Lazarus, R. S. (1991). *Emotion and Adaptation*: Oxford University Press.

Lazarus, R. S. (1999). The cognition-emotion debate: A bit of history. In T. Dalgleish & M. J. Power (Eds.), *Handbook of Cognition and Emotion* (pp. 3–19). Chichester, UK: Wiley.

Leahy, R.L., Tirch, D. D., & Napolitano, L. A. (2012). *Emotion Regulation in Psychotherapy: A Practitioner's Guide*. Guilford Press.

LeDoux, J. E. (1995). Emotion: clues from the brain. *Annual Review of Psychology, 46*, 209–235.

LeDoux, J. (1998). *The Emotional Brain: The Mysterious Underpinnings of Emotional Life*. NY: Simon and Schuster.

LeDoux, J. E. (2000). Emotion circuits in the brain. *Annual Review of Neuroscience, 23,* 155–184.

Lee, H., Heller, A. S., Van Reekum, C. M., Nelson, B., & Davidson, R. J. (2012). Amygdala–prefrontal coupling underlies individual differences in emotion regulation. *NeuroImage, 62*(3), 1575–1581.

Leiberg, S., Eippert, F., Veit, R., & Anders, S. (2012). Intentional social distance regulation alters affective responses towards victims of violence: an FMRI study. *Human Brain Mapping, 33*(10), 2464–2476.

Lieb, K., Zanarini, M. C., Schmahl, C., Linehan, M. M., & Bohus, M. (2004). Borderline personality disorder. *The Lancet, 364*(9432), 453–461.

Linehan, M. M., Schmidt, H., Dimeff, L. A., Craft, J. C., Kanter, J., & Comtois, K. A. (1999). Dialectical Behavior Therapy for Patients with Borderline Personality Disorder and Drug-Dependence. *The American Journal on Addictions, 8*(4), 279–292.

Mak, A. K., Hu, Z.-g., Zhang, J. X., Xiao, Z.-w., & Lee, T. (2009). Neural correlates of regulation of positive and negative emotions: an fMRI study. *Neuroscience Letters, 457*(2), 101–106.

Mauss, I. B., Cook, C. L., Cheng, J. Y., & Gross, J. J. (2007). Individual differences in cognitive reappraisal: Experiential and physiological responses to an anger provocation. *International Journal of Psychophysiology, 66*(2), 116–124.

McRae, K., Gross, J. J., Weber, J., Robertson, E. R., Sokol-Hessner, P., Ray, R. D., . . . Ochsner, K. N. (2012). The development of emotion regulation: an fMRI study of cognitive reappraisal in children, adolescents and young adults. *Social Cognitive and Affective Neuroscience, 7*(1), 11–22.

McRae, K., Hughes, B., Chopra, S., Gabrieli, J. D., Gross, J. J., & Ochsner, K. N. (2010). The neural bases of distraction and reappraisal. *Journal of Cognitive Neuroscience, 22*(2), 248–262.

McRae, K., Misra, S., Prasad, A. K., Pereira, S. C., & Gross, J. J. (2012). Bottom-up and top-down emotion generation: implications for emotion regulation. *Social Cognitive and Affective Neuroscience, 7*(3), 253–262.

McRae, K., Ochsner, K. N., Mauss, I. B., Gabrieli, J. J., & Gross, J. J. (2008). Gender differences in emotion regulation: An fMRI study of cognitive reappraisal. *Group Processes and Intergroup Relations, 11*(2), 143–162.

Mennin, D. S. (2004). Emotion regulation therapy for generalized anxiety disorder. *Clinical Psychology & Psychotherapy, 11*(1), 17–29.

Mennin, D. S., & Fresco, M. D. (2014). Emotion regulation therapy. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (2 nd ed., pp. 469–490). NY: Guilford Press.

Modinos, G., Ormel, J., & Aleman, A. (2010). Individual differences in dispositional mindfulness and brain activity involved in reappraisal of emotion. *Social Cognitive and Affective Neuroscience, 5*(4), 369–377.

Neacsius, A. D., Bohus, M., & Linehan, M. M. (2014). Dialectical behavior therapy: an intervention for emotion regulation. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (2 nd ed., pp. 491–528). NY: Guilford Press.

Neiss, M., & Almeida, D. M. (2003). Age differences in the heritability of mean and intraindividual variation of psychological distress. *Gerontology, 50*, 22–27.

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. (2002). Rethinking feelings: An fMRI study of the cognitive regulation of emotion. *Journal of Cognitive Neuroscience, 14*(8), 1215–1229.

Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences, 9*, 242–249.

Ochsner, K. N., Ray, R. D., Cooper, J. C., Robertson, E. R., Chopra, S., Gabrieli, J. D. E., & Gross, J. J. (2004). For better or for worse: neural systems supporting the cognitive down-and up-regulation of negative emotion. *NeuroImage, 23*(2), 483–499.

Ochsner, K. N., Ray, R. R., Hughes, B., McRae, K., Cooper, J. C., Weber, J., . . . Gross, J. J. (2009). Bottom-up and top-down processes in emotion generation common and distinct neural mechanisms. *Psychological Science, 20*(11), 1322–1331.

Ochsner, K. N., Silvers, J. A., & Buhle, J. T. (2012). Functional imaging studies of emotion regulation: a synthetic review and evolving model of the cognitive control of emotion. *Annals of the New York Academy of Sciences, 1251*, E1–E24.

Opitz, P. C., Rauch, L. C., Terry, D. P., & Urry, H. L. (2012). Prefrontal mediation of age differences in cognitive reappraisal. *Neurobiology of Aging, 33*(4), 645–655.

Phan, K. L., Fitzgerald, D. A., Nathan, P. J., Moore, G. J., Uhde, T. W., & Tancer, M. E. (2005). Neural substrates for voluntary suppression of negative affect: a functional magnetic resonance imaging study. *Biological Psychiatry, 57*(3), 210–219.

Pitskel, N. B., Bolling, D. Z., Kaiser, M. D., Crowley, M. J., & Pelphrey, K. A. (2011). How grossed out are you? The neural bases of emotion regulation from childhood to adolescence. *Developmental Cognitive Neuroscience, 1*(3), 324–337.

Power, K., McGoldrick, T., Brown, K., Buchanan, R., Sharp, D., Swanson, V., & Karatzias, A. (2002). A controlled comparison of eye movement desensitization and reprocessing

versus exposure plus cognitive restructuring versus waiting list in the treatment of post-traumatic stress disorder. *Clinical Psychology & Psychotherapy, 9*(5), 299–318.

Raftery, J. N., & Bizer, G. Y. (2009). Negative feedback and performance: The moderating effect of emotion regulation. *Personality and Individual Differences, 47*(5), 481–486.

Ray, R. D., & Zald, D. H. (2012). Anatomical insights into the interaction of emotion and cognition in the prefrontal cortex. *Neuroscience & Biobehavioral Reviews, 36*(1), 479–501.

Ricciardi, E., Rota, G., Sani, L., Gentili, C., Gaglianese, A., Guazzelli, M., & Pietrini, P. (2013). How the brain heals emotional wounds: the functional neuroanatomy of forgiveness. *Frontiers in Human Neuroscience, 7*. 839. doi: 10.3389/fnhum

Rottenberg, J., & Gross, J. J. (2003). When emotion goes wrong: Realizing the promise of affective science. *Clinical Psychology Science and Practice, 10*, 227–232.

Schardt, D. M., Erk, S., Nüsser, C., Nöthen, M. M., Cichon, S., Rietschel, M., . . . Walter, H. (2010). Volition diminishes genetically mediated amygdala hyperreactivity. *NeuroImage, 53*(3), 943–951.

Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information, 44*, 695–729.

Schulze, L., Domes, G., Krüger, A., Berger, C., Fleischer, M., Prehn, K., . . . Herpertz, S. C. (2011). Neuronal correlates of cognitive reappraisal in borderline patients with affective instability. *Biological Psychiatry, 69*(6), 564–573.

Sheppes, G., & Gross, J. J. (2011). Is timing everything? Temporal considerations in emotion regulation. *Personality and Social Psychology Review, 15*(4), 319–331.

Shurick, A. A., Hamilton, J. R., Harris, L. T., Roy, A. K., Gross, J. J., & Phelps, E. A. (2012). Durable effects of cognitive restructuring on conditioned fear. *Emotion, 12*(6), 1393–1397.

Sripada, C., Angstadt, M., Kessler, D., Phan, K. L., Liberzon, I., Evans, G. W., . . . Swain, J. E. (2013). Volitional regulation of emotions produces distributed alterations in connectivity between visual, attention control, and default networks. *NeuroImage, 89*, 110-121.

Staudinger, M. R., Erk, S., Abler, B., & Walter, H. (2009). Cognitive reappraisal modulates expected value and prediction error encoding in the ventral striatum. *NeuroImage, 47*(2), 713–721.

Staudinger, M. R., Erk, S., & Walter, H. (2011). Dorsolateral prefrontal cortex modulates striatal reward encoding during reappraisal of reward anticipation. *Cerebral Cortex, 21*(11), 2578–2588.

Thompson, R. A. (1994). Emotion regulation: A theme in search of definition. *Monographs of the Society for Research in Child Development, 59,* 25–52.

Turner, R. M. (2000). Naturalistic evaluation of dialectical behavior therapy-oriented treatment for borderline personality disorder. *Cognitive and Behavioral Practice, 7*(4), 413–419.

Urry, H. L., van Reekum, C. M., Johnstone, T., & Davidson, R. J. (2009). Individual differences in some (but not all) medial prefrontal regions reflect cognitive demand while regulating unpleasant emotion. *NeuroImage, 47*(3), 852–863.

Urry, H. L., Van Reekum, C. M., Johnstone, T., Kalin, N. H., Thurow, M. E., Schaefer, H. S., . . . Alexander, A. L. (2006). Amygdala and ventromedial prefrontal cortex are inversely coupled during regulation of negative affect and predict the diurnal pattern of cortisol secretion among older adults. *The Journal of Neuroscience, 26*(16), 4415–4425.

Wager, T. D., Davidson, M. L., Hughes, B. L., Lindquist, M. A., & Ochsner, K. N. (2008). Prefrontal-subcortical pathways mediating successful emotion regulation. *Neuron, 59*(6), 1037–1050.

Walter, H., von Kalckreuth, A., Schardt, D., Stephan, A., Goschke, T., & Erk, S. (2009). The temporal dynamics of voluntary emotion regulation. *PLoS One, 4*(8), e6726.

van Reekum, C. M., Johnstone, T., Urry, H. L., Thurow, M. E., Schaefer, H. S., Alexander, A. L., & Davidson, R. J. (2007). Gaze fixations predict brain activation during the voluntary regulation of picture-induced negative affect. *NeuroImage, 36*(3), 1041–1055.

Winecoff, A., LaBar, K. S., Madden, D. J., Cabeza, R., & Huettel, S. A. (2011). Cognitive and neural contributors to emotion regulation in aging. *Social Cognitive and Affective Neuroscience, 6*(2), 165–176.

Viviani, R. (2013). Emotion regulation, attention to emotion, and the ventral attentional network. *Frontiers in Human Neuroscience, 7,* 746.

Volokhov, R. N., & Demaree, H. A. (2010). Spontaneous emotion regulation to positive and negative stimuli. *Brain and Cognition, 73,* 1–6.

Vrticka, P., Sander, D., & Vuilleumier, P. (2011). Effects of emotion regulation strategy on brain responses to the valence and social content of visual scenes. *Neuropsychologia, 49*(5), 1067–1082.

Xiong, K., Zhang, Y., Qiu, M., Zhang, J., Sang, L., Wang, L., . . . Li, M. (2013). Negative Emotion Regulation in Patients with Posttraumatic Stress Disorder. *PLoS One, 8*(12), e81957.

Zajonc, R. B. (1980). Feeling and thinking: preferences need no inferences. *American Psychologist, 35,* 151–175.

Zajonc, R. B. (2000). Feeling and thinking: Closing the debate over the independence of affect. In J. P. Forgas (Ed.), *Feeling and Thinking: The Role of Affect in Social Cognition* (pp. 31–58). Cambridge: Cambridge University Press.