ADVANCES IN EMOTION REGULATION: FROM NEUROSCIENCE TO PSYCHOTHERAPY

EDITED BY : Alessandro Grecucci, Remo Job and Jon J. Frederickson

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ADVANCES IN EMOTION REGULATION: FROM NEUROSCIENCE TO PSYCHOTHERAPY

Topic Editors:
Alessandro Grecucci, University of Trento, Italy
Remo Job, University of Trento, Italy
Jon J. Frederickson, Washington School of Psychiatry, United States and Intensive Short-Term Dynamic Therapy Institute, United States

Emotions are the gift nature gave us to help us connect with others. Emotions do not come from out of nowhere. Rather, they are constantly generated, usually by stimuli in our interpersonal world. They bond us to others, guide us in navigating our social interactions, and help us care for each other. Paraphrasing Shakespeare, "Our relationships are such stuff as emotions are made of". Emotions express our needs and desires. When problems happen in our relationships, emotions arise to help us fixing those problems. However, when emotions can become dysregulated, pathology begins. Almost all forms of psychopathology are associated with dysregulated emotions or dysregulatory mechanisms. These dysregulated emotions can become regulated when the therapist helps clients express, face and regulate their emotions, and channel them into healthy actions. This research topic gathers contributions from affective neuroscientists and psychotherapists to illustrate how our emotions become dysregulated in life and can become regulated through psychotherapy.

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Editorial: Advances in Emotion Regulation: From Neuroscience to Psychotherapy

Alessandro Grecucci[1]*, Jon Frederickson[2,3] and Remo Job[1]

[1] *Clinical and Affective Neuroscience Lab, Department of Psychology and Cognitive Sciences, University of Trento, Rovereto, Italy,* [2] *Washington School of Psychiatry, Washington, DC, United States,* [3] *ISTDP Institute, Washington, DC, United States*

Editorial on the Research Topic

Advances in Emotion Regulation: from Neuroscience to Psychotherapy

OVERVIEW

Emotions are the gift nature gave us to help us connect with others. Emotions do not come from out of nowhere. Rather, they are constantly generated, usually by stimuli in our interpersonal world. They bond us to others, guide us in navigating our social interactions, and help us care for each other. We love our partner, we get angry with a friend, we feel sad for the loss of a parent, and so on... Paraphrasing Shakespeare "*Our relationships* are such stuff as *emotions* are *made* of." Within our relationships, emotions express our needs and desires. When problems happen in our relationships, emotions arise to help us fixing such problems (Frederickson, 2013). However, sometimes emotions can become dysregulated and pathology begin. It is now widely accepted that almost all forms of psychopathologies are associated with specific dysregulated emotions or dysregulatory mechanisms (Grecucci et al., 2016a). If it is true that problems occur within relationships, it is also true that *the solution occurs there*. We are hurt *in a relationship*, and we are healed *in a relationship*. That is why and how psychotherapy works. Emotions that becomes dysregulated inside our relationships, can become regulated in an *ad hoc designed therapeutic relationship* where the therapist helps the client to express, face and regulate her/his emotions, and channel them into healthy actions. The idea behind this research topic is to gather contributions for the first time from both affective neuroscientists and psychotherapists to shed light on the ways our emotions become dysregulated in life and can become regulated through psychotherapy. We present novel approaches and strategies to regulate emotions that are strongly grounded in affective neuroscience and experimental research. We strongly believe it is time that researchers in affective science and clinicians make a collective effort to deepen the understanding and the practice of how emotions can be usefully elaborated in clinical settings. The Topic is divided in two sections, the first more experimental and the second more clinical.

PART 1: ADVANCES IN THE NEUROCOGNITIVE MECHANISMS OF EMOTION REGULATION AND DYSREGULATION

The first section of the special issue starts with a reflection on the importance of distinguishing *explicit* emotion regulation based on conscious and effortful application of strategies from *implicit* emotion regulation based on automatically and unconsciously designed mechanisms (Rice). Parallels are made with the psychoanalytic concept of defense mechanisms as a form

of implicit emotion regulation. Another aspect explored in this part is the role of empathy in mediating the association between difficulties in emotion regulation and hostility (Contardi et al.). Cai et al. explore how sex and extraversion modulate self-reported emotional experience in an ERP experiment. The authors suggest that there is a male advantage for using expressive suppression for emotion regulation in non-extraverted, ambivert individuals. Deficits in the regulation of interpersonal emotions have been linked to severe psychiatric disorders. Understanding how patients experience and fail to regulate such emotions is of fundamental importance (Grecucci et al., 2015a). Depression is strongly characterized by difficulties in regulating unpleasant emotions. An intriguing psychodynamic hypothesis considers depression as a failure in mother-infant interactions during childhood that affects the construction of the representation of the self, others, and relationships. Messina et al. provide a link between abnormal activation of the default system in the brain observed in depression and the exaggerated negative self-focus and rumination that lead to emotion dysregulation in these patients. Clinical implications are also discussed.

Individuals with marked autistic traits display several features of social and emotion dysregulation. Imageability ratings of word classes denoting proprioceptive, emotional, and theoretical words predict whether people have low or high autistic traits, or, to put it differently, whether they have more or less marked empathic inclinations (Esposito et al.). People with anxiety disorders suffer from severe emotion dysregulation and subsequent cognitive biases. Cui et al. explore how the emotional context affects successful and unsuccessful source retrieval amongst high-trait-anxiety college students by using event-related potentials (ERPs).

PART 2: NEW THERAPEUTIC PROTOCOLS TO FOSTER EMOTION REGULATION IN PSYCHOTHERAPY

The ability to regulate emotions is essential for healthy psychological functioning and is a key focus of psychotherapy. Working actively with emotion has been empirically shown to be of central importance in psychotherapy. Different therapeutic models from different theoretical orientations have incorporated principles and techniques to work on dysregulated emotions. In this section, we present novel models of treatments to regulate emotions that therapists can use in clinical practice. We start by presenting Emotion Regulation Therapy (ERT) (Renna et al.), an evidence-based treatment that integrates contemporary psychotherapy modalities with basic and translational affective science to offer a framework for improving emotion regulation in patients. Strategies, technique and clinical examples are provided to illustrate principles of ERT. Another promising approach, namely Schema Therapy (Fassbinder et al.) is presented for its potential to foster emotion regulation in severely disturbed patients (Dadomo et al., 2016). A comparison with Dialectical Behavior Therapy (Linehan, 1993) is made to illustrate different ways the clinician can help patients to regulate

emotions. The importance of mindfulness and mindfulness based therapy to produce emotion regulation (Grecucci et al., 2015b) is also explored in this section (Guendelman et al.). The relevance for therapy of motor behavior, with its connection to proprioceptive and interoceptive mechanisms, is also discussed (Shafir). Another paper explores the possibility of improving parenting programs for behavioral disorders in children using the Rational Positive Parenting Program (rPPP), a program with a special focus on parent emotion-regulation functional reappraisal strategies, which has recently received consistent support for reducing child externalizing and internalizing disorder (David et al.). Dingle et al. present evidence of *Tuned In*, a new emotion regulation intervention that uses dedicated music to evoke emotions in session and teaches participants emotional awareness and regulation skills. The special issue ends with reflections on synchrony and psychotherapy, illustrating the Interpersonal Synchrony (In-Sync) model of psychotherapy (Koole and Tschacher). This model considers the alliance between patient and client as grounded in the coupling of the patient's and therapist's brains. Because brains do not interact directly, movement synchrony may help to establish inter-brain coupling.

TWO KEYS TO THE FUTURE OF THE FIELD OF EMOTION REGULATION

This area of research is young, complex, and challenging, but also exciting. While scientific evidence is slowly and partially emerging, no general consensus has been reached yet on how to interpret these early findings. Starting from the papers in this issue, we propose two key questions that scientists and clinicians may want to concentrate on in the near future.

Cognitive or Experiential Regulation of Emotions?

In the widely accepted Cognitive Emotion Regulation (CER) model of Gross (1998), following classic Appraisal theory, cognitive appraisals of events generate the emotional response. Emotion dysregulation occurs due to the failure to apply appropriate cognitive, attentive, and behavioral regulatory strategies. Cognitive behavioral therapies follow this model, teaching patients to apply behavioral strategies (exposure for example), attentional strategies (increasing attentional flexibility), and cognitive strategies (cognitive restructuring) (see Renna et al. this issue, for an example). An alternative emerging model, known as Experiential-Dynamic Emotion Regulation (EDER) (Grecucci et al., 2015a, 2016a), based on Affective Neuroscience findings (Panksepp, 1998; Damasio, 1999; Panksepp and Biven, 2012; Grecucci and Job, 2015), posits that events trigger emotional responses prewired at birth with inborn adaptive action tendencies. The brain regulates emotions through a biological mechanism. Emotions rise in intensity, peak, and then go flat once the emotion adaptive action tendency has been expressed. The resulting shape of the affective experience is a Gaussian-like shape, proportional to

the intensity of the stimulus. This model posits that emotions are not inherently dysregulated. Dysregulation results when emotions are paired with excessive conditioned anxiety, or when affects are triggered by certain defensive strategies, both of which lead to dysregulated-affective states (DASs) (Grecucci et al., 2015a, 2016a). To regulate DAS, the clinician regulates the dysregulating anxiety paired with the emotion or removes defenses which cause the dysregulated affects. These models offer differing conceptualizations for: (1) the generation of emotional response; (2) the causation of dysregulated affects; and (3) the strategies for affect regulation (see Fassbinder et al. this issue, Dadomo et al., 2016; Grecucci et al., 2016b for applications). Research is needed to clarify these mechanisms and how to integrate them. We hypothesize that both processes act as a dual system to foster top-down (cognitive), and bottom-up (experiential) regulation. The clinician can choose moment by moment whether affect regulation would be fostered best by either top-down (cognitive) or bottom up (experiential) strategies.

What Are the Basic Neurocognitive Mechanisms Behind the Regulation of Emotions?

Before the 1990s, neuroscientists agreed that once an emotional learning took place, it was "forever" (LeDoux et al., 1989). The only possible means to "change" that learning was to suppress it with a procedure known as extinction. Extinction offers new learning to decrease the conditioned response when the conditioned stimulus is presented. We hypothesize that cognitive therapies (Renna et al.) rely mainly on extinction to foster emotion regulation through the use of new cognitive strategies. However, extinction based approaches suffer from relapse over time. Luckily, in 1997 evidence of a complete erasure of emotional learning was experimentally provided (Roullet and Sara, 1998; Przybyslawski et al., 1999; Nader et al., 2000; Nader

and Einarsson, 2010; Ecker et al., 2013). This process is known as Memory Reconsolidation (Nader et al., 2000; Nader and Einarsson, 2010). The target emotional learning is reactivated in a labile (plastic) state that allows the learning to be erased by offering the experience of an opposite emotional experience (see Ecker et al., 2012 for its clinical applications). We hypothesize that once a Memory Reconsolidation process is reached in the therapeutic setting, the patient can bear the feelings his defenses formerly warded off. Since the defense is no longer necessary, it no longer provokes the dysregulated affects. Likewise, since the patient is able to bear the formerly warded off feelings, they no longer trigger the previous level of anxiety which was dysregulating. As a result, the dysregulated affect and the associated mechanisms that produce the dysregulation cease to exist. Interestingly, different models of therapy (primarily, but not exclusively, experiential approaches) have recently arrived at similar conclusions and implemented similar processes in their practice even before Memory Reconsolidation was discovered. We believe all treatment modalities based on active working and reworking of target emotional learnings (by means of experiential techniques, such as mindfulness (Guendelman et al.), psychodynamic therapy (Rice), and Schema Therapy (Fassbinder et al.) foster Memory Reconsolidation. Research is needed to understand the roles of extinction and memory consolidation in emotion regulation and how to foster them in therapeutic settings.

AUTHOR CONTRIBUTIONS

AG wrote this editorial, RJ and JF corrected it and added some observations.

ACKNOWLEDGMENTS

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Abnormal Default System Functioning in Depression: Implications for Emotion Regulation

Irene Messina*, Francesca Bianco, Maria Cusinato, Vincenzo Calvo and Marco Sambin

Department of Philosophy, Sociology, Pedagogy and Applied Psychology, University of Padova, Padova, Italy

Depression is widely seen as the result of difficulties in regulating emotions. Based on neuroimaging studies on voluntary emotion regulation, neurobiological models have focused on the concept of cognitive control, considering emotion regulation as a shift toward involving controlled processes associated with activation of the prefrontal and parietal executive areas, instead of responding automatically to emotional stimuli. According to such models, the weaker executive area activation observed in depressed patients is attributable to a lack of cognitive control over negative emotions. Going beyond the concept of cognitive control, psychodynamic models describe the development of individuals' capacity to regulate their emotional states in mother-infant interactions during childhood, through the construction of the representation of the self, others, and relationships. In this mini-review, we link these psychodynamic models with recent findings regarding the abnormal functioning of the default system in depression. Consistently with psychodynamic models, psychological functions associated with the default system include self-related processing, semantic processes, and implicit forms of emotion regulation. The abnormal activation of the default system observed in depression may explain the dysfunctional aspects of emotion regulation typical of the condition, such as an exaggerated negative self-focus and rumination on self-esteem issues. We also discuss the clinical implications of these findings with reference to the therapeutic relationship as a key tool for revisiting impaired or distorted representations of the self and relational objects.

Keywords: depression, default system, emotion regulation, self, psychodynamic, psychotherapy, neuroimaging

INTRODUCTION

Depression is generally considered as the outcome of difficulties in regulating emotions (for reviews see Campbell-Sills and Barlow, 2007; Aldao et al., 2010). When dealing with their own emotions, depressed individuals tend to ruminate on (Nolen-Hoeksema, 2000; Garnefski and Kraaij, 2006), avoid or suppress thoughts and emotions associated with negative events (Wenzlaff and Rude, 2002; Campbell-Sills et al., 2006), whereas a reappraisal of the event from a different perspective (Gross, 2002; Webb et al., 2012) or a non-judgmental acceptance (Liverant et al., 2008; Kohl et al., 2012) would be more effective for the purpose of containing negative emotional activation and its physiological correlates. Given its importance for psychological wellbeing, emotion regulation is attributed a key role in psychological treatments for depression (Messina et al., 2013; Grecucci et al., 2015).

Within the emerging field of affective neuroscience, the concept of voluntary emotion regulation has been widely used to explain the findings of functional neuroimaging studies conducted to elucidate the neural correlates of affective dysfunctions (for reviews, see Taylor and Liberzon, 2007; Menon, 2011). These studies have amply documented that individuals suffering from depression have a decreased activation of prefrontal cortex areas involved in executive control (including the dorsolateral prefrontal cortex – dlPFC –, and the dorsal anterior cingulate cortex – dACC), suggesting a weaker top–down control over their emotional reactivity deriving from the activation of limbic structures such as the amygdala (Drevets, 2001; Siegle et al., 2007). This interpretation is in line with fMRI studies concerning the neural correlates of emotion regulation that have revealed an increased activation of the prefrontal areas and a decreased activation of the amygdala in tasks involving the cognitive control of emotions by comparison with the spontaneous response to emotional stimuli (Ochsner and Gross, 2005; Buhle et al., 2014). Even if other authors have found that depressed individuals can display impaired emotion regulation despite preserved recruitment of dlPFC (Greening et al., 2014) and increased dlPFC recruitment during emotion regulation attempts (Johnstone et al., 2007), the emotion dysregulation seen in depression is consistently interpreted as a lack of cognitive control over emotional states (see **Figure 1**, the part in red, for a graphic representation of the executive areas involved in voluntary emotion regulation).

In addition to investigating brain activity in response to stimuli or during cognitive tasks, neuroscientists have become increasingly interested in the brain's intrinsic activity in resting state. Studying resting state activity has led to the identification of the "default system," a set of regions – including the ventral medial prefrontal cortex (vmPFC), the posterior cingulate cortex (pCC), the posterior parietal lobe, and the lateral, inferior and medial temporal cortices (see **Figure 1**, in blue) – that are usually activated at rest and deactivated during cognitively effortful

tasks (Raichle et al., 2001a; Raichle and Snyder, 2007). Research on resting state activity has also been applied to investigating emotional disorders, comparing the resting-state brain signals of patients and healthy subjects (Broyd et al., 2009; Whitfield-Gabrieli and Ford, 2012). This field of research is generating new lines of inquiry for neurobiological models of emotion regulation and their application to interpreting the brain correlates of emotional disorders. In the present mini-review, we address this issue by examining the findings on the abnormal functioning of resting-state brain activity in depressed patients. We specifically consider these findings in the light of clinical concept, coming from psychodynamic tradition, which underscore the role of internal representations of the self and others in emotion dysregulation.

PSYCHOLOGICAL MECHANISMS: INTERNAL REPRESENTATIONS AND EMOTION REGULATION

While the neurobiological models have conceptualized emotion regulation as a form of cognitive control, the psychodynamic tradition has concentrated more on investigating how individuals develop the ability to regulate their emotions in the course of their childhood, collecting evidence of the importance to emotion regulation of constructing a representation of the self and of relationships with others in their primary relationships. This interest is apparent in the works of Ferenczi (1933), Spitz (1945, 1965), Freud (1955), Bion (1959, 1967), Winnicott (1965), and Freud and Burlingham (1974), among others. These authors take the view that emotion regulation in infants depends on their caregivers' contingent responses (on "good enough" parenting; Winnicott, 1965). For instance, Bion (1967) pointed out the caregivers' important role in the infants' acquisition of a comprehension and containment of their inner world through the transformation of the infant's
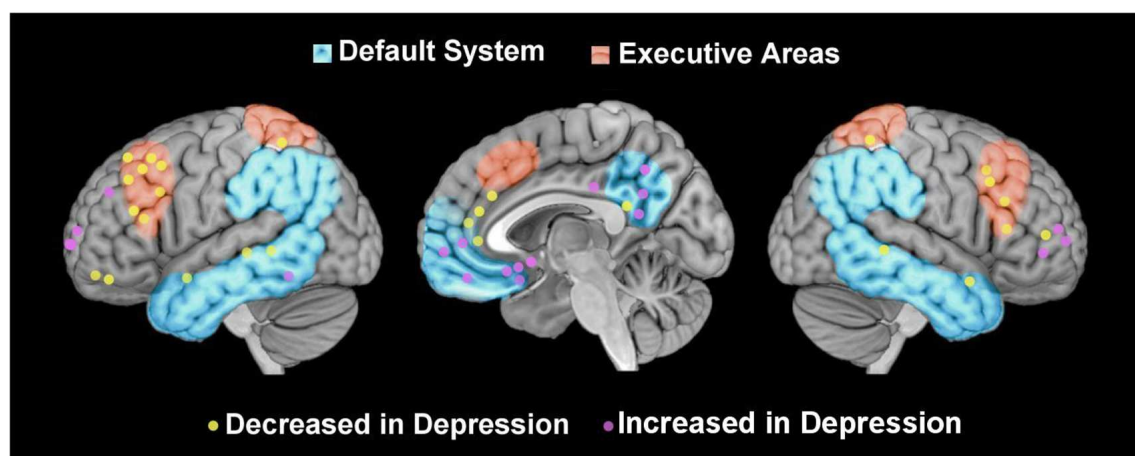
FIGURE 1 | Graphical representation of foci of perfusion reported in association with depression. Graphical representation of foci of brain activity reported in studies that have compared depressed patients and healthy controls (in yellow decreased activations, in violet increased activations), located in executive areas [in red, retrieved from http://neurosynth.org/; (Yarkoni et al., 2011)], and default system (Raichle et al., 2001b).

projected psychological experience in a "metabolized" form. Children can thus internalize the mother's function and, with time, they learn to regulate their negative affective states.

Internalizing the mother's function coincides with a self-building process described by Kernberg (1976) as the product of introjection and identification of the child's significant relationship with the mother. Failure to achieve an interpersonal regulation in the mother-infant interaction may interfere with the construction of the self, and of its regulatory functions. Winnicott (1967) and Kohut (1971) used the term "weakened self" to describe the effects of a caregiver's incongruous mirroring that oblige children to internalize distorted parental representations, which take the place of their subjective experience, preventing them from regulating that subjective experience. This is also implicit in Kernberg's (1976) model, according to which a lack of differentiation between the internal representations of the self and others is an important factor contributing to emotional instability. With specific regard to depression, a mother's inadequate mirroring function induces the child to internalize a rigid or even sadistic super-ego that implies a poor self-representation in which the subject feels helpless (Kohut, 1971, 1977; Kohut and Wolf, 1978).

The assumption that an individual's internal representation of the self and others is important to emotion regulation has been the object of empirical investigation in the field of attachment theory (Bowlby, 1969, 1973, 1980). The attachment patterns characterizing the relationship between children and their caregivers can be seen as a particular form of dyadic regulation, in which the infant experiences the caregiver's emotional availability (Cassidy, 1994). Within the primary relationship, adaptive emotion regulation strategies are learned by building "internal working models" (IWM; Bowlby, 1969), which are mental representations of the self and others based on the child's daily experiences and expectations regarding a given caregiver's response to attachment behavior. When the primary attachment figure is available and responsive to their needs, infants develop a sense of attachment security characterized by IWM that include positive beliefs regarding the self and others, the accessibility of others and their ability to alleviate distress, thus shaping affect regulation in the event of distress (Feeney and Cassidy, 2003; Fraley et al., 2006). But if infants have caregivers who are inconsistent and fail to respond adequately to their attachment needs, they develop a sense of attachment insecurity characterized by IWM that include negative representations of the self, low self-esteem and parenting self-esteem (Calvo and Bianco, 2015), difficulty in relying on others when their own emotional resources are insufficient, low dyadic adjustment, and loneliness (Shaver and Hazan, 1987; Kobak and Sceery, 1988; Sroufe, 2005). In recent years, insecure attachment has been quantitatively operationalized in terms of self-reported anxiety and avoidance in adult attachment relationships (Brennan et al., 1998), which imply two different maladaptive affect regulation strategies, called "secondary strategies" (Mikulincer et al., 2003; Shaver and Mikulincer, 2007): (i) strategies based on over-activation of the attachment system, including relational overdependence, desire to minimize physical, cognitive, and emotional distance from others; (ii) strategies based on deactivation of the attachment system, featuring the creation of emotional distance from others, avoidance of intimacy, and the suppression of negative feelings and memories. In the attachment literature, there is large evidence of depressive symptoms being associated with the chronic use of secondary emotion regulation strategies (Cole-Detke and Kobak, 1996; Rosenstein and Horowitz, 1996; Mickelson et al., 1997; Malik et al., 2015).

Recent contributions to this line of research have shown that the mirroring function of their attachment figures enables children to internalize the ability to think for themselves and perceive themselves as a thinking entity, a process called "mentalization" (Fonagy et al., 2007, 2011). In conditions of attachment security, children's affective states are accurately (but not overwhelmingly) reflected back to them, whereas attachment insecurity and a lack of mirroring interfere with this mentalization process, giving rise to emotional disorders (Fonagy and Target, 1997; Bateman and Fonagy, 2004).

NEURAL MECHANISMS: THE DEFAULT SYSTEM IN EMOTION REGULATION

While psychodynamic models of emotion regulation emphasize the importance of the internal representation of the self and others in explaining emotional disorders, neuroscience has concentrated more on emotion regulation as a form of cognitive control, neglecting the importance of the semantic representations on which controlling processes may act. Considering the default system in association with emotion dysregulation can compensate for this shortcoming.

Default System Functions Linked to Emotion Regulation

The main feature of the default system is that it is activated during rest (Raichle et al., 2001a; Raichle and Snyder, 2007). It has been amply documented that, in the absence of a task that demands voluntary attention, the mind usually tends to wander (Mason et al., 2007). Activation of the default system is generally anti-correlated with activation of the executive areas (Fox et al., 2005), a situation reflecting the opposition between internal (default system) and external (executive functions) addressed attention.

In task-related studies, activation of the default system has been associated with cognitive tasks that include aspects of self-representation (Northoff et al., 2006) and self-projection, described as the capacity to project oneself mentally from the present into the past or future, but also from other people's perspectives (Buckner and Carroll, 2007; Spreng et al., 2009). Self-projection underlies several processes that may be associated with emotional dysregulation, such as access to autobiographical memories (self-projection into the past) or future plans (self-projection into the future), but also with empathy and theory of mind (self-projection from others' perspectives). In line with psychodynamic theory and research showing the importance of self-representation for emotion regulation, the evidence of the

default system being activated in self-related processes suggests its involvement in emotion regulation. Intriguingly, the overlap between brain structures that are activated for self-representation and in theory of mind (Saxe et al., 2006) seems to confirm the psychodynamic view of a common source for the representations of the self and others constructed in infants' primary relationships with their caregivers.

Another point in common with the psychodynamic models is the similarity between the default system and the semantic system, a set of regions activated by the retrieval and manipulation of conceptual knowledge gained from capturing regularities in the outside world (Binder et al., 2009). Semantic memory may include more complex representations of clinical relevance, however, such as those of relationships governing social interactions (Zahn et al., 2007), and representations of the self (Lou et al., 2004). In this setting, IWM can be seen as an example of representations that capture regularities in interpersonal relationships. Indeed, semantic areas are modulated by the exposition to attachment-related experimental stimuli, such as familiar faces (Gobbini et al., 2004) or of attachment eliciting pictures (Buchheim et al., 2006).

The activation of semantic areas is commonly described in voluntary emotion regulation studies, such as reappraisal (Buhle et al., 2014; Messina et al., 2015), but also in association with implicit forms of regulation in which executive functions are not involved, such as spontaneous avoidance (Benelli et al., 2012). Psychotherapeutic action has also been found associated with changes in semantic area activation (Messina et al., 2013). Going beyond the concept of emotion regulation as a form of cognitive control, recent recent contributions have begun to take into consideration the importance of semantic representation on which controlling processes may act (Blair and Mitchell, 2009; Buhle et al., 2014; Greening et al., 2014). According to recent models, semantic areas may play a key role in emotion regulation by conveying information about motivational priorities and facilitating processing of behaviorally relevant inputs (see Viviani, 2013, 2014; Messina et al., 2015).

Abnormal Default System Activity in Depression

Due to the default system's involvement in the self-related processing and semantic representation of repeated past experiences, an abnormal default system activity should be expected in depressed patients. Several studies have tried to clarify the specificity of resting-state brain functioning in depression, using positron emission tomography (PET) or the perfusion MRI technique known as arterial spin labeling (ASL). The methodological features of these studies are listed in **Table 1**.

Both PET and ASL studies have produced evidence of less activity in the frontal executive areas of the brains of depressed patients compared with healthy controls, especially in the dlPFC (Mayberg et al., 1997; Kennedy et al., 2001; Lui et al., 2009; Monkul et al., 2012), but also in the dACC (Mayberg et al., 1997; Monkul et al., 2012) (see **Figure 1**). A greater activation has also often been reported in subcortical areas, including the amygdala, in depressed patients (Drevets, 2001; Lui et al., 2009; Duhameau

et al., 2010). These results are consistent with the neurobiological model of emotion regulation that postulates a weaker cognitive control of emotions in depression.

In addition to the prefrontal-subcortical network of voluntary emotion regulation, studies on resting-state brain activity have reported foci of increased activation located in the anterior part of the default system, extending from the subgenual ACC to the anterior portion of the ACC or the vmPFC (Drevets, 2001; Kennedy et al., 2001; Duhameau et al., 2010), and also to posterior portions of the default system such as the PCC and precuneus (Lui et al., 2009; Monkul et al., 2012). Judging from evidence of how the default system functions, these results may suggest a greater negative self-focus and attention to internal thoughts in depressed patients than in controls, coinciding with the rumination processes characteristic of depression. Consistently with this hypothesis, increased default system activation has been associated to individual differences in maladaptive rumination (Hamilton et al., 2011). In psychodynamic terms, this rumination can be described as an "internal dialog": if they have failed to mentalize some emotional states (which are often relational needs that have been not mirrored in primary relationships), individuals use forms of emotion regulation based on suppression or avoidance ("defense mechanisms" in psychodynamic terms– Freud, 1967), instead of mentalizing their emotional responses flexibly to suit their relational needs.

Clinical Implications: Therapy and Changing Internal Representations

If representations of the self and others are constructed within a close relationship, these internal representations may also be changed by means of a close relationship. The therapeutic relationship can be seen as a relational context in which patients act out their attachment patterns and can make changes to the internal representations of the self and others (Lyddon and Sherry, 2001; Dales, 2008). Researchers have provided strong empirical evidence of the outcome of psychotherapy being mediated by the quality of the therapeutic relationship (Horvath, 2002), with includes the therapist's empathy (Burns and Nolen-Hoeksema, 1992; Elliott et al., 2011) and ability to engage the patient in a therapeutic alliance (Martin et al., 2000). The importance of therapeutic relationships is a factor spanning all psychotherapy techniques (Meares et al., 2005; Norcross and Lambert, 2011).

In psychodynamic psychotherapy, the work on internal representations of the self and others is also expressed in specific techniques that aim to explore how patients' internal models influence their relationship with the therapist in order to arrive at cognitive but also emotional insights on the influence of their primary relationships on their current relationships. The most popular example is transference interpretation (Freud, 1912). An evolution of transference interpretation is the "triangle of insight" (Menninger, 1958), widely used in brief psychodynamic psychotherapy (Malan, 1976; Davanloo, 1980), but with potential applications also in other psychotherapeutic approaches. Using the triangle of insight, therapists and patients observe together how past experiences (the first vertex of the triangle) influence

TABLE 1 | List of studies on resting state in depression.

Studies	Experimental design	N	Patients details	Depression measure	Increased activation in depression	Decreased activation in depression	Positive correlation with depression	Negative correlation with depression
Drevets et al., 1992	PET 40 s Eyes closed and relax	13 DD 33 HC	>3 weeks medication washout	HDRS	L/R DMPFC L VLPFC L MPFC RL amygdala and other subcortical areas	L/R occipitalcortex R medialtemporalgyrus R/L medial caudate	Amygdala	L PFC
Mayberg et al., 1997	PET 40 min Eyes closed, ears uncovered, and resting state	18 DD 15 HC	Treatment with antidepressant medications	HAMD	–	R/L anterior cingulated R/L anterior insula R/L premotor cortex R/L DLPFC R/L IPL R/L inferiortemporal	–	–
Brody et al., 2001	PET 40 min Resting not specified	13 DD 24 HC	>4 weeks Medication washout	HAMD GDS	LR anterior inferior temporal	R/L DLPFC L/R dorsal caudate L/R thalamus	–	–
Saxena et al., 2001	PET 40 min Eyes and ears open	27 DD 17 HC	No antidepressant medications	HDRS GAS SADS-L	L/R Thalamus	L hippocampus	–	L hippocampus
Videbech et al., 2001	PET 15 min Relax and look at a tread-cross on a computer monitor	42 DD 47 HC	Treatment with antidepressant medications included	HDRS	R hippocampus L cerebellum L occipito-temporal gyrus	–	–	–
Kennedy et al., 2001	PET 35 min Resting not specified	13 DD	>2 weeks medication washout	HDRS	R sgACC	L DLPFC R ventral striatum	–	–
Dotson et al., 2009 (1)*	PET 60 s Resting not specified	34 HC	Older males Treatment with antidepressant medications included	CES-D	–	–	–	Precentral gyrus VLPFC Temporal pole Cerebellum L IPL
Dotson et al., 2009 (2)*	PET 60 s Resting not specified	26 HC	Older females Treatment with antidepressant medications included	CES-D	–	–	L/R IPL L Angular gyrus L middle occipital gyrus	cerebellum R VLPFC R inferior temporal gyrus R orbitofrontal gyrus R middle occipital gyrus insula R IPL R middle temporal gyrus

(Continued)

TABLE 1 | Continued

Studies	Experimental design	N	Patients details	Depression measure	Increased activation in depression	Decreased activation in depression	Positive correlation with depression	Negative correlation with depression
Monkul et al., 2012	PET 10 sessions of 50 s 10 Resting (eyes closed and rest)	20 DD 21 HC	No antidepressant medications	HDRS	PCC Caudate Parahippocampal gyrus	ACC DLPFC VLPFC	Thalamus Putamen	DLPFC VLPFC ACC
Roffman et al., 2014	PET 15 min Resting (not specified)	16 DD	Treatment with antidepressant medications	HAMD	–	–	R insula Precuneus	–
Lui et al., 2009 (1)*	ASL Resting (eyes closed and relax)	24 DD 42 HC	Recurrent depressive disorder No antidepressant medications	HAMD CGISS	–	L DLPFC L occipital lobe R VLPFC L/R thalamus	–	
Lui et al., 2009 (2)*	ASL Resting (eyes closed and relax)	37 DD 42 HC	Non recurrent depressive disorder No antidepressant medications	HAMD CGISS	R/L occipital lobe R amygdala and other subcortical areas PCC/precuneus	L DLPFC	–	–
Duhameau et al., 2010	ASL 4 min Resting (not specified)	6 DD 6 HC	Drug resistant and chronic depression Treatment with antidepressant medications	HDRS	R sgACC L sgACC Corpus callosum L DMPFC L ACC L amygdala and other subcortical areas	–	–	–
Orosz et al., 2012	ASL 12 min Resting	22 DD 22 HC	Treatment with antidepressant medications	BDI HAMD MADRS	–	–	–	PCC IPL

*We reported separately different comparison published in the same article. DD, Depressive Disorder patients; HC, healthy controls; BDI, Beck Depression Inventory (Beck et al., 1961); HAMD, Hamilton Depression Rating Scale (Hamilton, 1960); MADRS, Montgomery-Asberg Depression Rating (Montgomery et al., 1985); GDS, Geriatric Depression Scale (Brink et al., 1982); CGISS, Clinical Global Impression of Severity scale (Guy, 1976). (Hamilton, 1960; Beck et al., 1961; Guy, 1976; Brink et al., 1982; Montgomery et al., 1985; Drevets et al., 1992; Mayberg et al., 1997; Brody et al., 2001; Kennedy et al., 2001; Saxena et al., 2001; Videbech et al., 2001; Dotson et al., 2009; Lui et al., 2009; Duhameau et al., 2010; Monkul et al., 2012; Orosz et al., 2012; Roffman et al., 2014).

current life experiences (the second vertex), and are manifested in the here-and-now of the therapeutic relationship (the third vertex). In the following transcript of psychotherapy intervention, we provide an example of the triangle of insight in Intensive Transactional Analysis Therapy:

T: *What's the problem?* (current problem)
P: *Well... I have a lot of anxiety when I have to speak in front of lots of people*
T: *Even now?* (Therapist links patient's current life experience with the here-and-now of the therapeutic relationship)
P: *Yes*
T: *Okay! Where is this anxiety?*
P: *Here* (points to chest). *My heart is racing and I am sweating*
T: *Your heart is racing...and...is something else that is happening?*
P: *Eh... I have confusion in my head*
T: *Do you have confusion now?*
P: (nods)
T: *Can you explain what this confusion is...* (Therapist continues the exploration of third vertex of triangle of insight and patient's emotion regulation)

Conclusion, Outstanding Questions, and Future Directions

The core idea emerging from the present mini-review is that the default system is abnormally activated in patients with depression, consistently with the observation of negative self-focus and rumination in such patients. In line with clinical models coming from psychodynamic theory, these difficulties in emotion regulation can be seen as associated with the existence of rigid, negative internal representations of the self and others. Considering such processes in neurobiological models of emotion dysregulation helps us to build bridges between the theories behind clinical psychology and neuroscience. Several gaps remain, however, in this attempt at integration. One question remaining to be answered concerns how processes of cognitive control and internal representation of the self and others interact in engendering rumination and avoidance instead of adaptive strategies for regulating emotions. With this in mind, future studies should clarify how individual differences in default system activation, and this system's correlations with other brain networks are associated with the complexity and flexibility of internal representation.

AUTHOR CONTRIBUTIONS

IM conceived the review and wrote the sections "Introduction," "Neural mechanisms," and "Conclusion" of the manuscript. FB wrote "Psychological mechanisms" and MC wrote "Clinical implications". VC and MS supervised the manuscript. All authors listed, have made substantial, direct and intellectual contribution to the work, and approved it for publication.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Commentary: The Neural Bases of Emotion Regulation

Timothy R. Rice *

Psychiatry, Icahn School of Medicine at Mount Sinai, New York, NY, USA

A commentary on

The Neural Bases of Emotion Regulation

by Etkin, A., Büchel, C., and Gross, J. J. (2015) Nat. Rev. Neurosci. 16, 693–700. doi: 10.1038/nrn4044

Amit Etkin, Christian Büchel, and James Gross make a valuable contribution in their article "The neural bases of emotion regulation" in the November 2015 issue of *Nature reviews: Neuroscience* (Etkin et al., 2015). Their review article concludes a process of gradual elevation of implicit emotion regulation to an equal footing with explicit emotion regulation. Whereas, explicit processes of emotion regulation refers to those that demand conscious, effortful application, implicit refers to those that proceed automatically and unconsciously. In this commentary, I suggest that the increased recognition and neural definition of implicit emotion regulation processes offers a unique opportunity for psychodynamic psychotherapy. The postulated equivalence of defense mechanisms with implicit emotion regulation (Rice and Hoffman, 2014) extends an opportunity to ground a key psychodynamic construct in defined neural correlates.

Etkin and colleagues' article is not the first time that the implicit emotion regulation construct has been identified. In a 2011 article Etkin's group introduced "two theoretical and empirical spheres that organize different areas of emotion regulation and label these as 'explicit' and 'implicit'" (Gyurak et al., 2011). The authors note that there was some precedent to this organization in the work of Bargh and Williams' conceptualizations of effortful and automatic processes (Bargh and Williams, 2007), a work preceded by Bargh's early interests in automaticity in social cognition (Bargh, 1994). The organization of Bargh and Williams' work parallels those of Susan Andersen and others, where the study of transference phenomenon and other unconscious processes developed a valuable scientific base to key psychodynamic principles (Berk and Andersen, 2000; Andersen and Przybylinski, 2012).

The explicit-implicit distinction offers a similar opportunity for the psychodynamic construct of defense mechanisms. Gross notes that past studies of emotion regulation include Freud's studies of how people unconsciously defend against anxiety-inducing impulses (Gross, 2013). Etkin and colleagues' valuation of implicit process emphasizes these unconscious processes as central to the field of neurobiological study of emotion regulation. The distinction between ventromedially-mediated implicit processes and more dorsolaterally-mediated explicit processes in the prefrontal cortex offers a means to observe these distinct unconscious processes. Because implicit emotion regulation is postulated to be equivalent to defense mechanisms (Rice and Hoffman, 2014), a key psychodynamic construct gains a neural signature and a valuable place in the study of the affective neurosciences. Establishing brain-based, neurobiological correlates to traditionally psychological constructs advances the goals of the Research Domain Criteria (RDoC) project (Insel et al., 2010) and furthers the rapprochement between psychodynamics and contemporary medicine.

Implicit regulation originates in the inhibitory action of the ventral prefrontal cortex (vPFC), which includes the orbitofrontal cortex (OFC), ventromedial PFC (vmPFC), and ventral anterior

cingulate cortex (vACC; Etkin et al., 2013). Bidirectional inhibitory action from these centers modulates lower brain structures including the amygdala, ventral striatum, hypothalamus, and brainstem nuclei. These pathways are distinct from those in explicit emotion regulation that originate in areas including the dorsal anterior cingulate cortex (dACC) and the dorsolateral PFC (dPFC). The successful modulation of these limbic and visceromotor centers by these PFC regulators leads to decreased sympathetic arousal and increased parasympathetic or vagal tone (Lane et al., 2009). This results in a measurable neurochemical state of phenotypic calmness.

Regional differentials in synaptogenesis, myelination, and pruning create earlier maturity in ventral as opposed to dorsal areas (Fuster, 2002), leaving children and adolescents without explicit cognitive emotional controls (Casey et al., 2011). Normative development in the implicit ER system thus may be extremely important in children to promote self-regulation when the neurobiological substrates to employ explicit ER are lacking.

Operationalized defense analysis may progress implicit ER development. Contributions beyond Freud, particularly those made in the subspecialty of child and adolescent psychoanalysis, make the parallel between implicit emotion regulation and defense mechanisms clear. Sigmund Freud's daughter Anna significantly developed the defense mechanism construct (Freud, 1936). The shift from understanding defenses as protecting against theoretical, immeasurable drives to protecting against observable and measurable affective states occurred through the groundbreaking work of Bornstein (1945, 1949) and the subsequent generational line of child analysts to the present (Becker, 1974; Hoffman, 2007). This shift and its contemporary acceptance emphasize that children employ a range of defenses to help themselves tolerate unbearable, discomforting feelings. The parallels between implicit emotion regulation and defense mechanisms is quite clear.

To date, no author has offered a biological substrate to defense mechanisms, though broader efforts at defining the neural bases of the dynamic unconscious have been made (Berlin, 2011). This makes this contribution that is made possible by the scientific works of Etkin, Bargh, and Gross unique and valuable.

The relative isolation of the child psychoanalytic literature may have served to hinder awareness of the parallels between defense mechanisms and implicit emotion. This may have prevented the spread of established therapeutic interventions focused on defense mechanisms beyond psychoanalytic circles. The operationalization of defense analysis into a manualized, short-term psychotherapy termed Regulation Focused Psychotherapy for Children (RFP-C; Hoffman et al., 2016) is one means to interface this therapeutic intervention targeting implicit ER with contemporary models of health care provision. This approach maintains focus on the disruptive child's aggression as maladaptive defense mechanisms against sadness, loss, loneliness, and trauma. The approach helps the child to recognize that the feared feelings will not overwhelm him or her, and that alternative strategies are available. Through this approach children develop a wider range of adaptive defense mechanisms and employ them more flexibly, leading to health and developmental progression (Hoffman, 2007).

The observed parallels between defense mechanisms and the implicit emotion regulation system (Rice and Hoffman, 2014) enable us to hypothesize that this manualized procedure will strengthen implicit emotion regulation processes. Children who participate in the treatment will show improvements in validated measures of emotion regulation. Further elaboration of the implicit emotion regulation system and its neural correlates and of this psychodynamic treatment may one day enable measurement of change at the neural system level, through electroencephalogram or functional magnetic resonance imaging. The affective neurosciences offer rich opportunities for psychodynamic psychiatry, and Etkin and colleague's work offer a special one for defense analysis.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and approved it for publication.

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The Association among Difficulties in Emotion Regulation, Hostility, and Empathy in a Sample of Young Italian Adults

Anna Contardi*, Claudio Imperatori, Ilaria Penzo, Claudia Del Gatto and Benedetto Farina

Department of Human Science, European University of Rome, Rome, Italy

The aim of the present study was to assess the role of empathy in mediating the association between difficulties in emotion regulation and hostility. Three hundred and sixty young Italian adults (220 women and 140 men) were enrolled in the study. Psychopathological assessments included the Difficulties in Emotion Regulation Scale (DERS), the Interpersonal Reactivity Index and the Buss–Durkee Hostility Inventory (BDHI). Perspective taking (PT) and Personal distress (PD) are significantly associated with both DERS total score and BDHI total score. A mediational model analyzing the direct and indirect effects of DERS on BDHI through the mediating role of PT and PD showed that the relation between DERS and BDHI was partially mediated by PT total score ($b = 0.16$; $se = 0.01$; $p = 0.02$). Taken together our findings support the possibility that PT skills could play a crucial role in inhibiting hostility behaviors.

Keywords: emotion regulation, hostility, empathy, difficulties in emotion regulation, mediational model

INTRODUCTION

Emotion regulation consists of *"the extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features, to accomplish one's goals"* (Thompson, 1994). This involves: (1) emotional clarity, awareness, and acceptance; (2) the capacity to control impulsive behaviors when feeling negative emotions; (3) the ability to choose contextually suitable emotion regulation strategies in order to meet personal goals and situational demands (Gratz and Roemer, 2004).

In recent years, difficulties in emotion regulation have been increasingly associated with the development and maintenance of several mental-health problems and maladaptive behaviors (Amstadter, 2008; Gillanders et al., 2008; Aldao et al., 2010; Jimenez et al., 2010; Marroquín, 2011; Aldao and Mennin, 2012; Berking et al., 2012; Svaldi et al., 2012). Furthermore, it has been observed (Berking and Whitley, 2014) that difficulties in emotion regulation are detected in almost all mental disorders included in the 5th edition of Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013). For example, difficulties in emotion regulation seem to be related with both internalizing (e.g., major depression and anxiety disorders) (Mennin et al., 2007; Nolen-Hoeksema et al., 2008; Contardi et al., 2013) and externalizing behavior problems (e.g., attention-deficit/hyperactivity disorder) in adolescents and young adults (for a review see Steinberg and Drabick, 2015).

Among the behavioral correlates of the difficulties in emotion regulation, expressing hostility has been particularly investigated in both clinical and non-clinical settings (Bowie, 2010; McLaughlin et al., 2011; Carrère and Bowie, 2012; Mitrofan and Ciuluvică, 2012; Roberton et al., 2012). Hostility is conceptualized as a multidimensional construct including cognitive (i.e., negative thoughts, cynicism, or resentment), affective (i.e., negative emotions, including distaste, and anger), and behavioral components (i.e., verbal and physical aggression) (Garcia-Leon et al., 2002). A recent review of longitudinal studies investigating the association between emotion regulation and aggressiveness in adolescents suggested that deficits in emotion regulation are an important risk factor for aggressive behaviors (Roll et al., 2012). Similarly, a lower emotion regulation predicted subsequent relationship aggressiveness (Bowie, 2010). Moreover, Mitrofan and Ciuluvică (2012) reported that several components of emotion regulation (i.e., acceptance of emotions, ability to control impulses) should be enhanced in order to reduce the expression of anger and hostility as well as to increase life satisfaction in adolescents.

Both difficulties in emotion regulation and hostility seem to be closely related with trait (or dispositional) empathy (Jolliffe and Farrington, 2004; Decety, 2010). As defined by Davis (1994), dispositional empathy is a multidimensional construct with both emotional (i.e., the tendency to worry or feel solidarity with others) and cognitive (i.e., the tendency to identify with others and take into consideration their point of view) components. It has been proposed that emotion regulation may be one of the core components (together with affective arousal and emotion understanding) of human empathy (Decety, 2010). Furthermore, experimental studies reported that both cognitive and emotional components of empathy are related with emotion regulation (Eisenberg et al., 1994; Okun et al., 2000).

Similarly, the association between empathy and hostility has been widely detected. Low levels of empathy may be positively associated with more aggressiveness and disruptive behavior disorders (Jolliffe and Farrington, 2004; de Wied et al., 2010). Furthermore, higher levels of empathy increase prosocial behaviors (Davis et al., 1994; McMahon et al., 2006; Gini et al., 2008; Masten et al., 2011) and moderate the expression of aggressive behaviors and different types of violence, such as delinquent bullying behavior, alcohol-related and sexual aggressions (Wheeler et al., 2002; Giancola, 2003; Lovett and Sheffield, 2007; Jolliffe and Farrington, 2011).

Despite the strong association between difficulties in emotion regulation and hostility, no study so far has investigated the association between these two constructs while considering the possible role of empathy as a mediating factor. Therefore, the aim of the present study was to investigate in a sample of young Italian adults (i) the association between self-reported difficulties in emotion regulation and hostility, and (ii) whether this association was mediated by self-reported deficits in empathy. We decided to focus on this developmental stage because it is known that the onset of several mental disorders, characterized by severe emotion dysregulation, such as addictive disorders and impulse control disorders, occurs in young adulthood (Christie et al., 1988; Jones, 2013). We hypothesized that more severe difficulties in emotion regulation were associated with increased hostility, and that this association was partially mediated by empathy.

MATERIALS AND METHODS

Participants and Procedure

Participants were 360 young Italian adults (220 women and 140 men). Inclusion criteria were: (i) age range between 18 and 34 years, (ii) good ability to understand written Italian. Exclusion criteria were the presence of factors that impeded complete assessment, such as the refusal of informed consent. The sample was recruited through accidental sampling. University psychology students ($N = 267$) were enrolled at the European University of Rome and completed the assessment during normal academic activities at their teaching sites. The non-university sample ($N = 93$) was recruited through advertisements for established community groups (e.g., hospitals, shopping malls, church groups operating in Rome).

Participation rate was 98%. There were no sociodemographic differences between responders and non-responders as well as between university students and the non-university sample. All subjects participated voluntarily and anonymously in the study after providing written informed consent; they did not receive payment or any other compensation (i.e., academic credit).

Mean age of the respondents was 23.17 years ($SD = 3.72$). Of the respondents, 23.6% had a college degree, while the remaining were middle and high school graduates (no one attended school for less than 8 years). Around 94% were single, 3.6% were married, and 2.5% were either widowed or divorced. Other characteristics of the sample are reported in **Table 1**.

After receiving information about the aims of the study, subjects provided written consent to participate in the study, which was performed according to the Helsinki declaration standards and was approved by the European University's ethics review board.

Measures

The Italian versions of the Difficulties in Emotion Regulation Scale (DERS) (Gratz and Roemer, 2004; Sighinolfi et al., 2010), the Interpersonal Reactivity Index (IRI) (Davis, 1980, 1983; Albiero et al., 2006), and the Buss–Durkee Hostility Inventory (BDHI) (Buss and Durkee, 1957; Castrogiovanni et al., 1993) were administered in the present study.

The DERS is a 36-item multidimensional self-report measure assessing individual's characteristic patterns of emotion regulation. Items are rated on a 5-point Likert-type scale (from $1 = almost\ never$ to $5 = almost\ always$) indicating the degree to which each statement describes the respondent's behavior. Scores range from 36 to 180; greater scores on the DERS reflect greater difficulties with emotion regulation. This test consists of the following six subscales, theoretically formulated and confirmed through factor analysis: (1) *Non-acceptance*, referred to non-acceptance of emotion responses (e.g., "When I'm upset, I feel guilty for feeling that way"); (2) *Goals*, related to the difficulty in engaging in a goal-directed behavior while experiencing negative emotions (e.g., "When I'm upset, I have

TABLE 1 | Descriptive statistics of all participants (*N* = 360).

Variables	Count/M	%/(SD)
Females	220	61.1
Age − M (SD)	23.17	(3.72)
Job status		
Employed	93	25.8
Students	267	74.2
School attainment > 13 years	85	23.6
Marital status		
Unmarried	338	93.9
Married	13	3.6
DERS total scores − M (SD)	86.91	(20.70)
Non-acceptance − M (SD)	13.34	(4.80)
Goals − M (SD)	14.11	(4.41)
Impulse − M (SD)	14.04	(5.12)
Awareness − M (SD)	15.20	(4.37)
Strategies − M (SD)	18.26	(6.33)
Clarity − M (SD)	11.95	(4.10)
IRI		
FS − M (SD)	2.18	0.67
EC − M (SD)	2.70	0.54
PT − M (SD)	2.31	0.64
PD − M (SD)	1.62	0.64
BDHI − M (SD)	35.16	(10.10)
Covert − M (SD)	10.89	(4.50)
Overt − M (SD)	24.26	(7.50)

DERS, Difficulties in Emotion Regulation Scale; IRI, Interpersonal reactivity index; FS, Fantasy; EC, Empathic concern; PT, Perspective taking; PD, Personal distress; BDHI, Buss–Durkee hostility inventory.

difficulty concentrating"); (3) *Impulse*, referring to the impulse control difficulty when experiencing negative emotions (e.g., "When I'm upset, I have difficulty controlling my behaviors"); (4) *Awareness*, related to emotional awareness (e.g., "I am attentive to my feelings"); (5) *Strategies*, concerning the limited access to emotion regulation strategies that are perceived as effective (e.g., "When I'm upset, I start to feel very bad about myself"); and (6) *Clarity*, related to the lack of emotional clarity (e.g., "I'm confused about how I feel"). The DERS showed a good level of internal consistency for both total score (Cronbach's α = 0.93) and the six subscales (Cronbach's α > 0.80) (Gratz and Roemer, 2004). The instrument also revealed an adequate concurrent validity with measures of emotion dysregulation and emotional avoidance, as well as a good predictive validity with behaviors associated with emotion dysregulation, such as self-harm and marital violence (Gratz and Roemer, 2004). In the present sample Cronbach's α for the DERS total score was 0.91.

The IRI is a 28-item self-report measure of dispositional empathy. Each item is rated on a 5-point Likert-type scale, ranging from 1 (*Does not describe me well*) to 5 (*Describes me very well*). Scores range from 28 to 140; greater scores on the IRI reflect greater dispositional empathy. The IRI measures four dimensions of empathy: (1) *Perspective taking* (PT), measuring the reported tendency to spontaneously adopt the psychological point of view of others in everyday life (e.g., "I sometimes try to understand my friends better by imagining how things look

from their perspective"); (2) *Empathic concern* (EC), measuring the tendency to experience feelings of sympathy and compassion for unfortunate others (e.g., "I often have tender, concerned feelings for people less fortunate than me"); (3) *Personal distress* (PD), assessing the tendency to experience severe discomfort in response to extreme distress in others during a tense emotional situation (e.g., "In emergency situations, I feel apprehensive and ill-at-ease"); (4) *Fantasy* (FS) measuring the tendency to imaginatively transpose oneself into fictional situations (e.g., "I daydream and fantasize, with some regularity, about things that might happen to me"). Although several self-report measures of empathy have been developed (for a review see Pedersen, 2009), currently the IRI is the most widely and frequently used scale to measure individual differences in empathic tendencies (Spreng et al., 2009). We decided to use IRI because it is based on a multidimensional conceptualization of empathy and it is considered the most comprehensive measure of self-reported empathic dispositions (De Corte et al., 2007; Ingoglia et al., 2016). Finally, under the psychometric point of view, the IRI is characterized by several good psychometric properties, such as good internal consistency (Davis, 1994) as well as high replicability of the four-factor model in many countries (Ingoglia et al., 2016), including Italy (Albiero et al., 2006). In the present sample all IRI dimensions had Cronbach's α of 0.78 or higher.

The BDHI consists of 75 dichotomous items (i.e., true–false answers). It was specifically developed to tap seven different subtypes of hostility (66 items) and guilt (9 items). Scores range from 28 to 140; greater scores on the BDHI reflect greater hostility. The dimensions of the BDHI, based on a theoretical classification of subtypes of hostility, are: (i) *Assault* (e.g., "If somebody hits me first, I let him have it"); (ii) *Indirect Hostility* (e.g., "I sometimes spread gossip about people I don't like"); (iii) *Irritability* (e.g., "I often feel like a powder keg ready to explode"); (iv) *Negativism* (e.g., "When someone is bossy, I do the opposite of what he asks"), (v) *Resentment* (e.g., "Almost every week I see someone I dislike"); (vi) *Suspicion* (e.g., "I know that people tend to talk about me behind my back"); (vii) *Verbal Hostility* (e.g., "If someone annoys me, I am apt to tell him what I think of him"). Factor analysis of the BDHI has yielded two factors, one related to overt expression of hostility, generally consisting of *Assault*, *Indirect Hostility*, *Irritability* and *Verbal Hostility* and the other linked to covert expression of hostility, consisting of *Resentment* and *Suspicion* subscales (Buss and Durkee, 1957; Sarason, 1961; Bendig, 1962; Musante et al., 1989; Bushman et al., 1991). Two-week test-retest reliability coefficients have been reported to range from 0.64 to 0.78 for the subscales, and to be 0.82 for the total score (Biaggio et al., 1981). The BDHI revealed a good convergent validity with other self-report measures of anger, hostility, and aggression (Matthews et al., 1985). In the present sample Cronbach's α for the BDHI total score was 0.85.

Statistical Analysis

Relationships between variables were computed through Pearson's indices of associations (*r*).

To determine whether the relationship between difficulties in emotion regulation and hostility severity was partially mediated by empathy, we used the Preacher and Hayes' (2008) strategy,

which assesses *"how, or by what means, an independent variable (X) affects a dependent variable (Y) through one or more potential intervening variables, or mediators (M)"* (Preacher and Hayes, 2008, p. 879).

This strategy tests mediation with a product-of-coefficients approach via a series of regressions analysis (Pompili et al., 2015). In the present analyses, we used standardized variables to generate standardized coefficients and the corresponding p values. As suggested by Preacher and Hayes (2008), for indirect effects, we also calculated bias-corrected and accelerated 95% CI produced using a bootstrapping method.

In the present study, we tested a model in which hostility severity (BDHI total score) was the dependent variable and difficulties in emotion regulation (DERS total score) were the independent variable. IRI dimensions, significantly associated with both the DERS and the BDHI at the bivariate analyses, were examined as a potential mediator. Additionally, we included age and gender in the model, which are known to be related with both emotion regulation (Blanchard-Fields et al., 2004; Nolen-Hoeksema, 2012) and hostility (Barefoot et al., 1993; Davidson and Hall, 1995). In order to test the adequacy of the model, we have also performed a reverse mediational model, in which hostility is the independent variable and difficulties in emotion regulation is the dependent variable.

It should be noticed that in the mediational models, the relations between variables are supposed to be causal, and mediational processes usually develop over time (Pompili et al., 2015). For this reason, several researchers questioned the use of cross-sectional data in mediation models. However, it is also argued that the use of prospective studies does not always prove causality (Hayes, 2013). Furthermore, according to Salthouse (2011), mediation strategies can also be viewed as a type of variance partitioning, similar to other methods (e.g., partial correlation), and they can also be useful when investigating whether the relation between two variables is reduced when a mediating variable is considered.

All analyses were performed with the statistical package for the social sciences (SPSS) version 19.0 (IBM, Armonk, NY, USA) and the macro for SPSS Indirect (Preacher and Hayes, 2008).

RESULTS

In the present sample the mean score of DERS, BDHI, and IRI subscales were comparable to those reported in previous studies which investigated these variables in non-clinical subjects having similar socio-demographic characteristics to our sample (Fossati et al., 2004; Albiero et al., 2006; Giromini et al., 2012).

Associations among Difficulties in Emotion Regulation, Hostility, and Empathy

Correlations between variables are reported in **Table 2**. The DERS total score was positively and strongly associated with the BDHI total score ($r = 0.51$; $p < 0.001$). The DERS total score was also positively associated with FS ($r = 0.12$; $p = 0.02$) and PD ($r = 0.38$; $p < 0.001$) total score, and negatively associated with

PT total score ($r = -0.13$; $p = 0.01$). PD ($r = 0.17$; $p = 0.002$) and PT ($r = -0.31$; $p < 0.001$) were also associated with the BDHI total score.

The mediational model explained 30% of data variability ($F_{5,354} = 33.88$; $p < 0.001$). Preacher and Hayes' (2008) strategy indicated that the total effect of the DERS on the BDHI was significant ($b = 0.25$; $se = 0.02$; $p < 0.001$), with more severe difficulties in emotion regulation being associated with more severe hostility (**Figure 1**). Moreover, the relationship between difficulties in emotion regulation and hostility was partially mediated only by PT, with higher scores on the DERS being associated with lower PT scores, which were associated with higher BDHI scores [$b = 0.02$; $se = 0.01$; $p = 0.02$; (95% CI: 0.01/0.04)]. No significant effect was observed for PD [$b = -0.01$; $se = 0.01$; $p = 0.75$; (95% CI: −0.02/0.02)]. Age and gender had no effects on BDHI total score (Age: $b = 0.19$; $se = 0.12$; $p = 0.88$; Gender: $b = -0.40$; $se = 0.99$; $p = 0.69$). A second mediational model with only PT as mediator was also significant explaining 32% of data variability ($F_{4,355} = 42.41$; $p < 0.001$).

Finally, the reverse mediational model, with BDHI total score as the independent variable and DERS total score as the dependent variable, explained 27% of data variability ($F_{4,355} = 34.58$; $p < 0.001$). Although Preacher and Hayes' (2008) strategy indicated that the total effect of the BDHI on the DERS was significant ($b = 1.03$; $se = 0.09$; $p < 0.001$), no significant mediational effect was observed for PT [$b = -0.02$; $se = 0.03$; (95% CI: −0.08/0.04)].

DISCUSSION

The main aim of the present study was to assess the association between emotion regulation and hostility, exploring the role of empathy as a 'mediator.' Our results showed that: (i) difficulties in emotion regulation are positively associated with hostility, (ii) personal distress dimension is positively related with both difficulties in emotion regulation and hostility, (iii) perspective taking dimension is negatively associated with both difficulties in emotion regulation and hostility, (iv) fantasy dimension is positively related with difficulties in emotion regulation but not with hostility, and (v) more severe difficulties in emotion regulation are associated with increased severity of hostility, and this association was partially counterbalanced only by the mediational effect of perspective taking.

The association between difficulties in emotion regulation and hostility has been consistently detected in both clinical and non-clinical settings (Bowie, 2010; McLaughlin et al., 2011; Carrère and Bowie, 2012; Mitrofan and Ciuluvică, 2012; Roberton et al., 2012). For example, Roll et al. (2012), reviewing longitudinal studies, investigating the relationship between emotion regulation and aggressive behavior in childhood, concluded that emotion dysregulation is an important risk factor for aggressive behaviors (Roll et al., 2012). In line with previous data, our results also showed that empathy dimensions (i.e., personal distress and perspective taking) were related with both difficulties in emotion regulation (Eisenberg et al., 1994; Okun et al., 2000) and hostility (Gini et al., 2007; Fernández et al., 2011;

TABLE 2 | Association between the DERS, the BDHI, and IRI dimensions (N = 360).

	DERS	FS	EC	PT	PD	BDHI
DERS	—					
FS	0.12*	—				
EC	−0.05	0.33***	—			
PT	−0.13*	0.30***	0.44***	—		
PD	0.38**	0.25***	0.15**	0.20	—	
BDHI	0.51***	0.07	−0.10	−0.31***	0.17**	—

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. DERS, Difficulties in Emotion Regulation Scale; FS, Fantasy; EC, Empathic concern; PT, Perspective taking; PD, Personal distress; BDHI, Buss–Durkee hostility inventory.

FIGURE 1 | Test of effect of difficulties in emotion regulation on hostility through perspective taking (PT) and personal distress (PD).
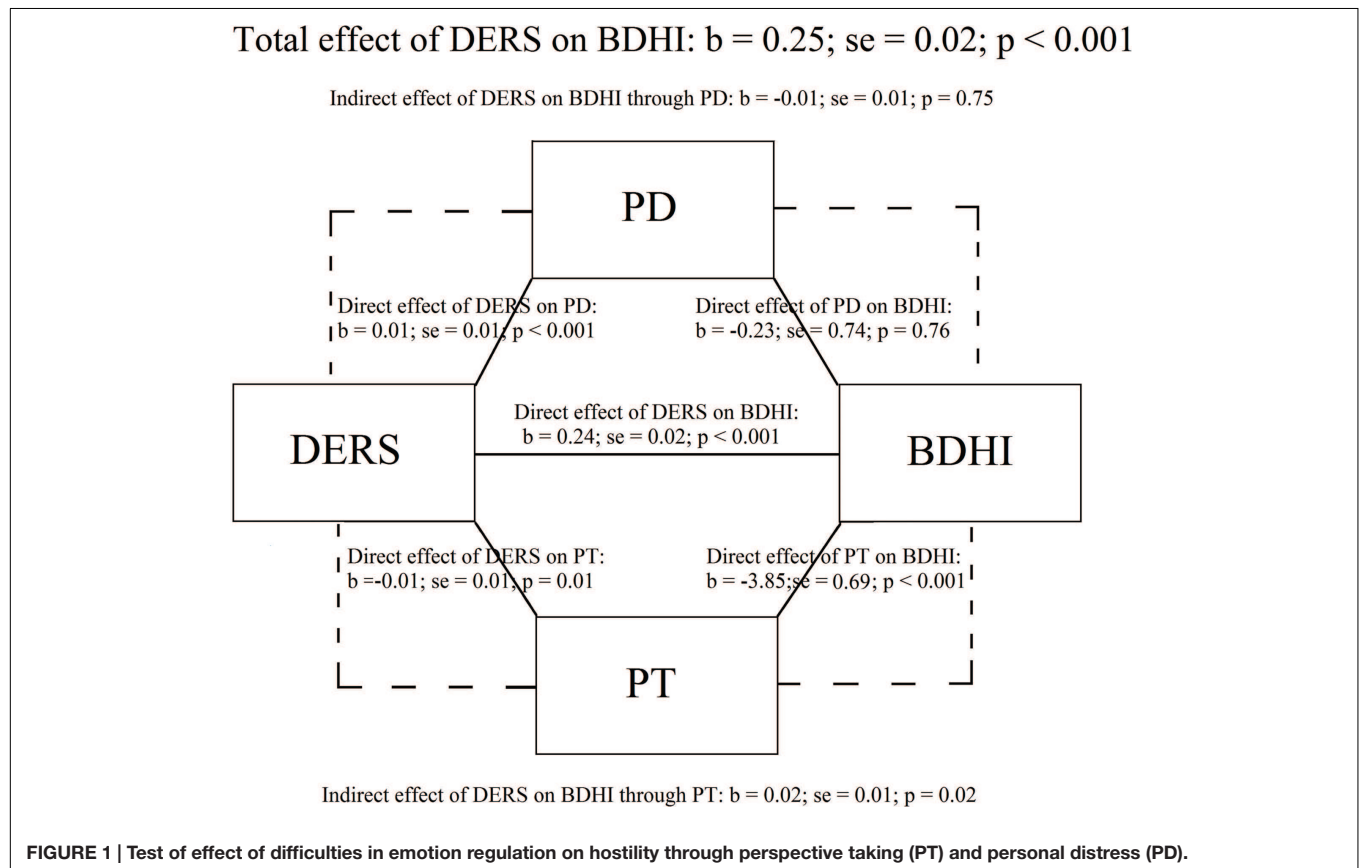
Day et al., 2012). Previous data showed that low levels of empathy are positively associated with more aggressive behaviors and disruptive behavior disorders (Jolliffe and Farrington, 2004; de Wied et al., 2010). Conversely, higher levels of empathy moderate the expression of different kinds of aggressive behaviors (Wheeler et al., 2002; Giancola, 2003; Lovett and Sheffield, 2007; Jolliffe and Farrington, 2011) and increase prosocial behaviors (Davis et al., 1994; McMahon et al., 2006; Gini et al., 2008; Masten et al., 2011).

In our study, while the personal distress dimension was positively related with both difficulties in emotion regulation and hostility, perspective taking was negatively associated with both difficulties in emotion regulation and hostility. These results could be interpreted according to several models of emotion regulation (Rottenberg and Gross, 2003; Koole, 2009; Aldao et al., 2010) suggesting that individuals use different strategies

(i.e., automatic or controlled, adaptive or maladaptive) to cope with their emotional experiences as well as to respond to environmental demands (Rottenberg and Gross, 2003; Koole, 2009; Aldao et al., 2010). It has been observed that while adaptive strategies (e.g., reappraisal and problem solving) are related with good health outcomes, dysfunctional strategies (e.g., suppression and avoidance) are associated with mental disorders and behavioral problems (Aldao et al., 2010).

The personal distress dimension assesses the tendency to experience severe discomfort in response to extreme distress in others during a tense emotional situation (Davis, 1980, 1983), and high personal distress scores has been positively associated with irritability, resentment, and suspicion (Davis, 1983). Therefore, during stressful interpersonal settings, individuals with high scores in this empathy dimension, may use hostile behaviors as

a dysfunctional coping strategy to escape from that unpleasant state and/or self-regulate emotions. This is in line with several studies suggesting that subjects may engage in aggressive behaviors in order to regulate and/or improve their own affective states (Bushman, 2002). Conversely, perspective taking assess *"the tendency to spontaneously adopt the psychological point of view of others"* (Davis, 1983, pp. 113–114). Previous research reported that perspective taking was positively associated with high levels of self-esteem (Davis, 1983), as well as with prosocial behaviors (Davis et al., 1994; McMahon et al., 2006; Gini et al., 2008; Masten et al., 2011). Therefore, during stressful interpersonal situations, individuals with high scores in this empathy dimension may regulate emotion engaging in functional behaviors (e.g., prosocial behavior) rather than hostile behaviors.

It is also interesting to notice that IRI's fantasy dimension was positively associated with difficulties in emotion regulation, but not with hostility. Previous studies reported that this dimension of empathy was positively associated with emotional vulnerability (Davis, 1983; Kawakami and Katahira, 2015) as well as with sensitivity to others, and introversion (Davis, 1983). It is known that individuals with high introversive personality, are more worried and uncertain in social situations and frequently suppress/avoid their emotions (Aldao et al., 2010; Gresham and Gullone, 2012; Vantieghem et al., 2016). Thus, according to our results (i.e., positive correlation between fantasy and DERS and no significant correlation between fantasy and BDHI), in stressful interpersonal settings, people with higher fantasy may experience difficulties in emotion regulation and use dysfunctional coping strategies, such as avoidance, rather than hostile behaviors. However, it is important to notice that our interpretation remains largely speculative because, in the present study, we did not assess coping strategies. Furthermore, the small correlation between DERS and fantasy should be considered when drawing definitive conclusions from our data.

Our mediation model indicated that more severe difficulties in emotion regulation were associated with higher hostility and that perspective taking partially counterbalanced this relationship. Conversely, personal distress does not seem to mediate the association between emotion regulation and hostility (**Figure 1**), suggesting the crucial role of perspective taking skills in our mediation model. It is also interesting to underline that in the reverse mediational model, no significant effect was observed for perspective taking. This dimension is considered a key component of empathy (Gerace et al., 2013). Mohr et al. (2007), showed that lower perspective taking scores were a crucial predictor of anger in students as well as in violent offenders. The same results were observed by Day et al. (2012), who proposed that the perspective taking ability may play a crucial role in inhibiting anger arousal and behavioral aggressions.

Our results could be interpreted in line with Decety's (2010) model of empathy. The author reported that the development of emotion regulation, through the maturation of crucial brain areas [i.e., the anterior cingulate cortex (ACC) and prefrontal cortex (PFC)], is functionally linked to the development of executive and metacognition functions, which are closely related to the cognitive aspects of empathy (i.e., perspective taking) (Decety, 2010). Thus, as suggested by our results, it is possible that deficits

in emotion regulation could lead to impairment in perspective taking, which make manifestations of hostility and aggressive behaviors more likely.

Moreover, our mediation model results may reflect several recent neuroimaging studies which detected some overlapping in the brain's regions involved in emotion regulation, hostility, and empathy. From a neurobiological point of view, several brain regions, such as PFC, ACC, the insular cortex and the amygdala, play a crucial role in various aspects of emotion and emotion regulation (for a review see Davidson et al., 2000a; Arnsten and Rubia, 2012). It has been hypothesized (Davidson et al., 2000b) that functional and/or structural abnormalities in this brain areas (e.g., hypo-activation of PFC) or in the functional integration among them, may increase the tendency of hostile and aggressive behaviors. Coherently, recent studies have shown the involvement of these brain structures in empathy dimensions (for a review see Singer and Lamm, 2009). For example, Haas et al. (2015) reported that higher scores in perspective taking were associated with increased prefrontal cortex activity during an emotion attribution task. Furthermore, Banissy et al. (2012) showed that the perspective taking total score was positively correlated with gray matter volume of the anterior cingulate.

Although the present findings are promising, some issues which limit the generalizability of our results include: (i) a non-clinical sample; (ii) the use of self-report measures, which are known to be potentially affected by social desirability (Arnold and Feldman, 1981); (iii) the enrollment of a young adult cohort; (iv) the non-assessment of the diagnostic status/history of participants and several socioeconomic variables (e.g., income or ethnicity) which may affect the relationship among emotion regulation, hostility and empathy. Moreover, although BDHI was the dependent variable and DERS was the independent variable in our model, it is important to underline that the statistical design, we used is correlational in nature, which precludes a definitive causal interpretation of the association between these variables. Finally, we have assessed empathy using only IRI subscales. Therefore, it is possible that other general measures of empathy, such as the Empathy Quotient (Lawrence et al., 2004), might provide important insights on other mediators between difficulties in emotion regulation and hostility. Although these ideas are purely hypothetical, they might be useful in guiding future research studies with clinical and non-clinical samples and with longitudinal designs.

CONCLUSION

Our results suggest that (i) high scores in difficulties in emotion regulation are strongly associated with high hostility, and (ii) this association is partially counterbalanced by high levels of perspective taking. From a clinical point of view, our results highlight the importance of those therapeutic approaches which focus on the enhancement of perspective taking in people with deficits in emotion regulation as well as with aggressive behavioral problems (i.e., Violent Offenders) (Hanson and Scott, 1995).

AUTHOR CONTRIBUTIONS

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The Sex Differences in Regulating Unpleasant Emotion by Expressive Suppression: Extraversion Matters

Ayan Cai[1,2], Yixue Lou[1,2], Quanshan Long[1,2] and Jiajin Yuan[1,2]*

[1] The Laboratory for Affect Cognition and Regulation, Key Laboratory of Cognition and Personality of Ministry of Education, Faculty of Psychology, Southwest University, Chongqing, China, [2] School of Psychology, Southwest University, Chongqing, China

Males are known for more suppression of emotional displays than females. However, when the emotion regulation effect of expressive suppression is greater in males, and how this sex difference varies with emotion display-related personality (e.g., extraversion), are undetermined. Event-related potentials were recorded while male and female participants different in extraversion were required to attend to or suppress emotional expression to negative pictures. Sex and extraversion did not modulate self-reported emotional experience. However, late positive potential (LPP) amplitudes showed an extraversion-moderated sex difference in the 2000–3000 ms and the 3000–4000 ms time epochs. LPP amplitudes were decreased during suppression versus viewing conditions in ambivert males, while this effect was absent in ambivert females. However, the LPP amplitudes of extraverts were similar for suppression and viewing conditions, irrespective of sex and timing. Regardless of early, middle, or late time windows, LPP amplitudes were positively related to self-reported emotion. These results suggest a male advantage for using expressive suppression for emotion regulation in non-extraverted, ambivert individuals.

Keywords: sex difference, extraversion, expressive suppression, event-related potentials, late positive potentials

INTRODUCTION

Expressive suppression is a widely used emotion regulation strategy, and this strategy has been proved particularly effective in regulating emotional consequences in East Asian societies (Butler et al., 2007; Yuan et al., 2014a,b). The suppression of inappropriate emotion-expressive behaviors, especially unpleasant ones, plays an important role in humans' social adaptation and the maintenance of relational harmony (Kitayama et al., 2000; Mesquita, 2001; Murata et al., 2013). As we known, males are less emotionally expressive in humans' daily communication and engage more emotion-expressive suppression than females, supported by a number of empirical studies (Buck et al., 1974; Kring et al., 1994; Barrett et al., 1998; Kring and Gordon, 1998; Hess et al., 2000; Parkins, 2012; Chaplin and Aldao, 2013). For example, females cry more often than males (Lombardo et al., 1983; Ross and Mirowsky, 1984). Matud (2004) has observed that females have more chronic and daily stress than males, which is closely associated with sex differences in stress coping: Females used more emotional and avoidance coping styles, whereas males adopted more rational coping and emotional-expressive suppression (Matud, 2004).

Using the Emotion Regulation Questionnaire (ERQ), Gross and John (2003) found that males scored significantly higher than females in suppression scales when investigating individual differences in emotion regulation. This finding was confirmed by subsequent researchers using ERQ (Haga et al., 2009). Chen et al. (2005) examined the construct of ambivalence over emotion expression in Chinese culture, and found that males are more likely to suppress emotions than females. It is noteworthy that what these research measured is the frequency of using suppression strategy, rather than how effectively the suppression strategy regulates emotional reaction. Despite abundant research showing more frequent suppression of emotional expressions in males than in females, little evidence has shown that males are better than females in dampening negative emotions by expressive suppression. A recent study in our lab, using an experiment to explore sex differences in emotion regulation, has found that males did outperform females in regulating negative emotion by expressive suppression (Cai et al., 2016). It is noteworthy that the effect of sex observed in this study is based on general population, and it may not apply to specific individuals. Particularly, the sex differences in expressive suppression may be moderated by personality trait like extraversion.

Prior studies have also indicated that the tendency of emotional expressiveness is moderated by personality traits like extraversion (Riggio and Riggio, 2002; 양세경 and OhSoosung, 2009). Extraversion is an emotion-related personality trait characterized by the tendency to experience positive emotions, activity, and sociability (Lischetzke and Eid, 2006; Tamir, 2009; Yuan et al., 2009). Along the personality dimension of extraversion, people scoring high are considered as extraverts who are described as being outgoing, talkative, impulsive and uninhibited, with many social contacts and being frequently involved in group activities (Costa and McCrae, 1992; Ashton et al., 2002). By contrast, those scoring low are described as quiet, retiring, introspective, not socially active (Costa and McCrae, 1992; Krentzman et al., 2012) and reluctant to communicate through facial displays (Riggio and Riggio, 2002), as is typical of introverts. It has been indicated that higher extraversion is associated with greater excitability, increased emotional expressivity and better communication of non-verbal emotional information (Buck et al., 1972; Riggio and Riggio, 2002; Chen et al., 2005). Consistent with these findings, there is recent evidence showing that high extraversion is associated with increased difficulty in the suppression of emotional displays (Peña-Gómez et al., 2011). However, no study to date has tested whether emotion display-related personality traits, like extraversion, influence the sex differences in regulation of unpleasant emotion by expressive suppression. Based on the evidence described above, we hypothesized that expressive suppression is most likely ineffective for regulating negative emotion in extraverts, irrespective of sex, and that the sex difference in regulating negative emotion by expressive suppression just applies to a less extraverted population.

To directly test whether the effect of gender in regulating unpleasant emotions by expressive suppression varies as a function of extraversion, the current study used the event-related potential (ERP) technique, by classifying subjects into different groups according to sex and extraversion. Numerous researchers have shown that late positive potential (LPP), a posterior-parietal positive slow ERP (Hajcak and Nieuwenhuis, 2006; Foti and Hajcak, 2008) that reaches its largest amplitudes at 500–700 ms post-stimulus and lasts for several 100 ms, was more pronounced for emotionally salient than for neutral stimuli (Cuthbert et al., 2000; Schupp et al., 2000, 2004). Moreover, LPP amplitude has been accepted as an ideal index for the intensity of emotional experience (Cuthbert et al., 2000; Amrhein et al., 2004; Olofsson et al., 2008). The LPP amplitudes decrease with the reduction of emotional experience during emotion regulation (Hajcak and Nieuwenhuis, 2006; Moser et al., 2006, 2010; Krompinger et al., 2008; Thiruchselvam et al., 2011). Thus, the LPP in brain potentials was chosen as a direct index in the current study to study the temporal dynamics of emotion arousal during expressive suppression and its modulations by sex and extraversion. We hypothesized that LPP amplitudes of ambivert males are significantly smaller during expressive suppression compared to viewing conditions, and this amplitude reduction would be less prominent in ambivert females. By contrast, this emotion regulation effect is probably absent in extraverts, irrespective of sex, based on the studies mentioned above.

MATERIALS AND METHODS

Subjects

As paid volunteers, 68 right-handed undergraduate students with no history of major psychiatric or neurological disorders participated in this experiment. All of the subjects completed the NEO Five-Factor Inventory (NEO-FFI, Chinese version; internal consistency coefficient = 0.878; Wang et al., 2010), a five-point (from −2 to 2), 240-item questionnaire that is widely used in personality assessments (Canli et al., 2002; Amin et al., 2004). The four experimental samples were determined by subjects' sex and scores in the extraversion subscale (48 items; internal consistency coefficient = 0.88; Wang et al., 2010) of the NEO-FFI.

Participants whose extraversion scores were above the 50th percentile were categorized as extraverts, while the rest were categorized as ambiverts. We labeled subjects whose extraversion scores were below the 50th percentile as ambiverts rather than introverts, because their extraversion scores were centered around zero, the neutral point along the extraversion-introversion continuum (see **Figure 1**). The 4-group subjects, including 17 extravert males (aged 18–29, mean 21.4; extraversion score: $M \pm SE$: 35.76 ± 2.96), 16 ambivert males (aged 18–24, mean 21.06; extraversion score: −0.44 ± 3.05), 18 extravert females (aged 17–25, mean 20.89; extraversion score: 30.83 ± 2.88) and 17 ambivert females (aged 17–23, mean 20.53; extraversion score: 3.0 ± 2.96), were similar in the habitual use of cognitive reappraisal [$F(3,64) = 0.77$, $p = 0.51$, $\eta_p^2 = 0.04$] and expressive suppression [$F(3,64) = 1.06$, $p = 0.37$, $\eta_p^2 = 0.05$] in the Emotion Regulation Questionnaire (ERQ). T-test showed no significant differences in extraversion scores
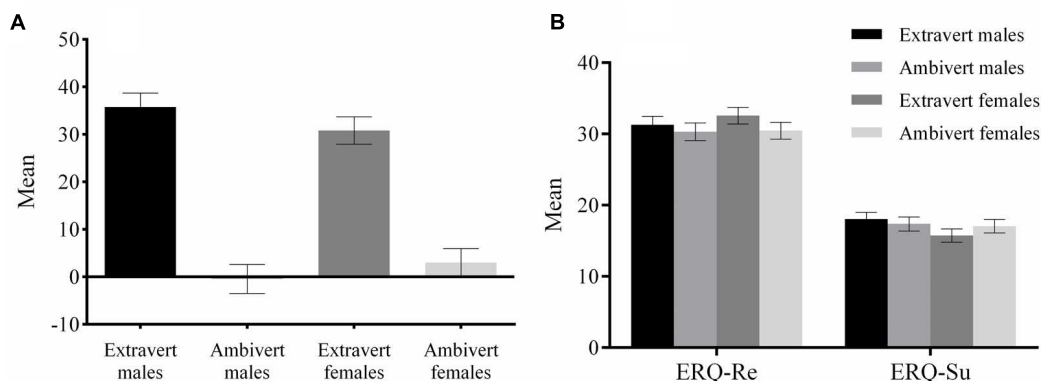
FIGURE 1 | Means of the scores on the Extraversion subscale of the NEO-FFI (A) and ERQ (B) for the four groups. The error bar represents standard error.
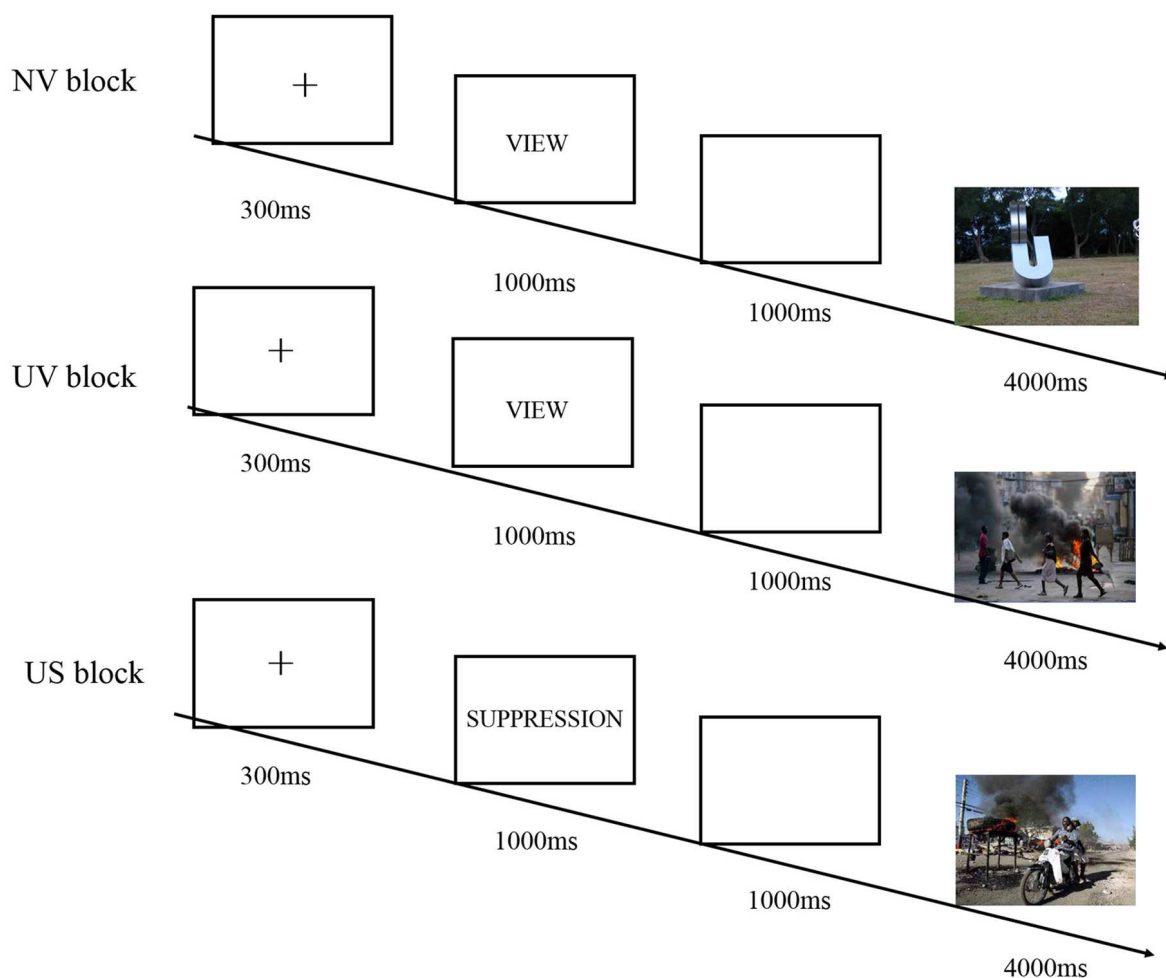
FIGURE 2 | Schematic illustration of the experimental procedure.

between extravert males and extravert females [$t(33) = 1.06$; $p = 0.30$], nor between the ambivert males and ambivert females [$t(31) = -0.95$; $p = 0.35$]. Additionally, the extraversion scores were significantly different between extravert males and ambivert males [$t(31) = 7.30$, $p < 0.001$], and between extravert females and ambivert females [$t(33) = 8.26$, $p < 0.001$; see **Figure 1**]. We measured the neuroticism subscale of the NEO Personality Inventory to ensure that all subjects

were emotionally stable, since neuroticism assesses affective adjustment and emotional instability (Piedmont, 2000). Indeed, neuroticism assesses six facets, including anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability. The significant below-threshold (0) score in anxiety [$t(67) = 6.31$, $p < 0.001$] and depression [$t(67) = 8.30$, $p < 0.01$] subscales of neuroticism assessment, suggested that our subjects were emotionally stable and free of depression and anxiety. The averaged depression (or anxiety) scores were -7.35 (or -5.12) for extravert males, -2.63 (or -0.38) for ambivert males, -5.39 (or -3.17) for extravert females, and -3.29 (-3.24) for ambivert females. The participants of both samples were right handed and had normal or corrected to normal vision. The study was approved by the local Review Board for Human Participant Research, and each participant signed an informed consent form before the experiment. The study was conducted following the ethical principles of the Helsinki Declaration regarding human experimentation (World Medical Organization, 1996).

Stimuli and Procedures

The present study used a block-design picture viewing task (see **Figure 2**). The task consisted of three blocks, and each block included 40 picture stimuli that were taken from the International Affective Picture System (IAPS) and its Chinese adapted Version (Chinese Affective Picture System, CAPS). The picture stimuli were neutral, emotionally irrelevant in the first block, as a non-emotional baseline for computing emotion effect in later conditions (Neutral-View, NV). The last two blocks required subjects to either view 40 unpleasant pictures without using any emotion regulation strategies (Unpleasant-View, UV) or view pictures while regulating unpleasant emotion by expressive suppression (Unpleasant-Suppression, US). The order of the UV and US blocks was counterbalanced across subjects. Unpleasant pictures were composed of the scenes of frightening animals, human attack and body mutilations while neutral pictures depicted the scenes of neutral animals and human activities.

In order to avoid emotional habituation or sensitization when a single set of pictures are repeatedly presented, the current study randomly selected two different sets of unpleasant pictures for the UV and US. Also, there was evidence showing a cultural bias when IAPS was applied to Chinese subjects (Bai et al., 2005). In order to control these influences and attribute differences in dependent variables solely to emotion regulation, we conducted a separate procedure checking whether the two sets of pictures were similar in emotional parameters for Chinese people (Yuan et al., 2014b). For this purpose, four trained judges (two males) blind to research purposes were invited to rate the valence (9-point scale, from 1: extremely unpleasant to 9: extremely pleasant) and arousal (9-point scale, from 1: very calm to 9: very excited) of the pictures. The four judges were highly consistent in assessing the emotionality of the pictures. The inter-rater reliability (Kendall's coefficient of concordance) was 0.83 [$\chi^2(3) = 9.9$; $p < 0.05$] for both valence and arousal dimensions. Therefore, we averaged the rating data across the four judges for each picture, and then conducted a one-way ANOVA for the valence and arousal of pictures with experimental condition as a predictor. The condition effect for arousal was highly significant

[$F(2,117) = 318.85$, $p < 0.001$]. The pairwise comparisons showed significantly higher arousal values for UV ($M = 7.20$) and US (6.97) conditions than the NV (3.03) condition (ps < 0.001). In addition, the arousal values were not significantly different during the UV and US conditions ($p = 0.21$ for UV-US). Similarly, the condition effect for valence was also significant [$F(2,117) = 312.74$, $p < 0.001$]. The pairwise comparisons showed significantly lower valence values for UV (1.73) and US (1.83) conditions in comparison with the NV (4.71) condition (ps < 0.001). In addition, the valence values were not significantly different during the UV and US conditions ($p = 0.43$). Thus, the pictures used for UV and US conditions were valid in inducing unpleasant emotions, and the emotion attributes of the pictures were kept similar across the two unpleasant conditions.

Subjects were seated in a quiet room approximately 150 cm from the computer screen with the horizontal and vertical visual angles below 6°. Prior to each block, subjects were instructed on how to do the task and were presented with eight trials for practice, where the eight pictures were emotionally similar to the pictures used in the experiment. In block NV and UV, each trial was initiated by a small black fixation cross on the white computer screen for 300 ms. The offset of the cross was followed by a 1000 ms presentation of a word "view," reminding subjects of the task in this block. Then, a 1000 ms blank screen was presented, followed by the onset of pictures for 4000 ms. *Subjects were instructed to pay close attention and react normally to each stimulus, and experience any feelings it elicited naturally* (Ohira et al., 2006). Between blocks; 2 min of rest, which was the maximal time used by another 10 subjects to rest in a pilot study, were used for subjects to recover their mood to the baseline level.

In the US block, the stimulus stream was the same as that of the NV and the UV, except that the word changed into "suppression," reminding subjects to use expressive suppression to regulate unpleasant emotion. Participants were trained in the suppression strategy during practice trials. *Suppression instructions trained participants to intentionally suppress the expression of emotion responses to pictures, by keeping their facial expressions unchanged so that someone watching their face would be unable to detect what was being experienced subjectively* (Goldin et al., 2008). At the end of each block, subjects were required to rate their mood state by a self-report 7-point scale (1: neutral, non-emotional to 7: extremely unpleasant). Also, they were asked to rate how successfully they suppressed emotion-expressive behaviors or attended to the pictures by a 7-point scale (1: not successful at all; 7: completely successful). At the end of the experiment, subjects rated the pleasantness of every picture (1: extremely unpleasant; 5: neutral, non-emotional; 9: extremely pleasant).

ERP Recording and Analysis

The EEG was recorded from 64 scalp sites using tin electrodes mounted in an elastic cap (Brain Products, Munich, Germany), with the reference electrodes on the left and right mastoids (average mastoid reference; Luck, 2005), and the ground electrode on the medial of the frontal aspect. The Vertical electrooculograms (EOGs) were recorded below the right eye, and the horizontal EOGs were recorded on the right side of the right eye. The EEG and EOG were amplified using a

DC ~100 Hz band-pass and were continuously sampled at 500 Hz/channel. All inter-electrode impedance was maintained below 5 kΩ. The averaging of ERPs was computed off-line. Eye movement artifacts (blinks and eye movements) were corrected offline and a 24-Hz low-pass filter was used. Trials with EOG artifacts (mean EOG voltage exceeding ±100 μV) and those contaminated with artifacts due to amplifier clipping of peak-to-peak deflection that exceeded ±100 μV were excluded from averaging. Rejected trials were rare. There was an average of 38.49 trials for NV, 38.83 trials for UV, and 38.90 trials for US conditions obtained for ERP averaging. EEG in each block was averaged separately. The ERP waveforms were time-locked to the onset of stimuli and the averaged epoch for ERPs was 4500 ms including a 500 ms pre-stimulus baseline. According to the literature, LPP is a positive slow wave of the ERP with a centroparietal midline maximum scalp distribution (Cuthbert et al., 2000; Schupp et al., 2000; Hajcak and Nieuwenhuis, 2006). We measured average amplitudes for LPP amplitudes at midline central and centroparietal regions (six sites: C1, Cz, C2, CP1, CPz, and CP2), and segmented 500–4000 ms into three consecutive time windows, 500–2000, 2000–3000, and 3000–4000 ms, separately representing early, middle, and late windows of LPP, according to the results of Principal Component Analysis (PCA, see Supplementary Material) (Smith et al., 2003).

We took two steps for ERP analysis: (1) A repeated-measure ANOVA of LPP amplitudes in each time window was conducted to examine whether unpleasant pictures validly induced unpleasant emotional arousal (with stimulus type [NV, UV] as a within-subjects factor while sex [males, females] and extraversion [extravert, ambivert] as between-subjects factors). (2) A repeated-measures ANOVA was conducted to examine the emotional regulation effect (with regulation strategy [UV, US] as within-subjects factor, sex [males, females] and extraversion [extravert, ambivert] as between-subjects factors). Since the present study focused on the moderation of extraversion on emotional regulation of males and females to unpleasant stimuli, we focused the statistical analysis on the three-way interaction involving regulation strategy, sex and extraversion. The degrees of freedom of the F-ratio were corrected according to the Greenhouse–Geisser method for any violations of sphericity, and the Bonferroni–Holm method was used to adjust the p-value during *post hoc* pairwise comparisons if significant main or interaction effects were detected. The effect sizes were shown as partial eta squared (η_p^2).

RESULTS

Manipulation Check

The analysis of the instruction confirmation data (responses to the question "how successfully did you attend to the pictures, or suppress your expression of emotion?") showed that subjects successfully attended to the pictures during NV ($M = 5.32$) and UV conditions (6.16), and successfully suppressed their emotion expression during the US condition (6.35). The scores for each condition were significantly higher than the midpoint of the rating scale (i.e., 4) [$t(67) = 6.68$–25.93, $p_s < 0.001$]. The

instruction confirmation was not significantly different between UV and US conditions [$t(67) = -1.72$, $p > 0.09$].

The Mood Assessment
Emotional Arousal Effect
The repeated-measures ANOVA of mood rating scores, with stimulus type (NV, UV) as within-subjects factor, and sex and extraversion as the between-subjects factors, showed no other significant main or interaction effects (all $ps > 0.19$), except for a significant main effect of stimulus type [$F(1,64) = 18.33$, $p < 0.001$, $\eta_p^2 = 0.23$]. Follow-up contrast showed that the negative affect was significantly greater when watching negative pictures (3.78) than neutral pictures (2.89), irrespective of sex or extraversion (see **Figure 3**).

Emotion Regulation Effect
We conducted a 2(Sex) × 2(Extraversion) × 2(regulation strategy: UV, US) repeated-measure ANOVA. The results showed no significant main effects or interaction effects (all $ps > 0.06$).

The ERP Analysis
LPP: Early Window (500–2000 ms)
Emotional arousal effect
The results showed a significant main effect of stimulus type [$F(1,64) = 35.99$, $p < 0.001$, $\eta_p^2 = 0.36$]. The emotional arousal effect was due to the larger LPP amplitudes for negative (2.05 μV) versus neutral (−0.11 μV) pictures. The interactions between factors were not significant (all $ps > 0.06$).

Emotional regulation effect
Neither main effects nor interactions between factors reached statistical significance (all $ps > 0.08$).

LPP: Middle Window (2000–3000 ms)
Emotional arousal effect
The results only showed a significant main effect of stimulus type [$F(1,64) = 21.76$, $p < 0.001$, $\eta_p^2 = 0.25$], with larger amplitudes elicited for negative (1.51 μV) versus neutral (−0.22 μV) pictures.

Emotion regulation effect
There was a significant three-way interaction of regulation strategy, sex and extraversion [$F(1,64) = 8.63$, $p = 0.005$, $\eta_p^2 = 0.20$]. We tested the interaction of sex and regulation strategies in extravert and ambivert subjects, respectively. In the ambivert group, there was a significant sex by strategy interaction [$F(1,31) = 11.60$, $p = 0.002$, $\eta_p^2 = 0.27$], which was analyzed by examining the emotion regulation effect in ambivert males and ambivert females, separately. The regulation effect was significant in ambivert males [$F(1,15) = 8.27$, $p = 0.012$, $\eta_p^2 = 0.36$] but not in ambivert females [$F(1,16) = 3.02$, $p = 0.10$, $\eta_p^2 = 0.16$; see **Figures 4** and **5**]. Ambivert males displayed smaller amplitudes during US condition (0.46 μV) than during UV condition (2.35 μV). By contrast, the sex by strategy interaction [$F(1,33) = 0.98$, $p = 0.33$, $\eta_p^2 = 0.03$], and the main effect of sex or strategy (all $ps > 0.31$), were all non-significant in extraverts. This implies that there was no significant emotion regulation effect in extraverted groups, irrespective of sex.
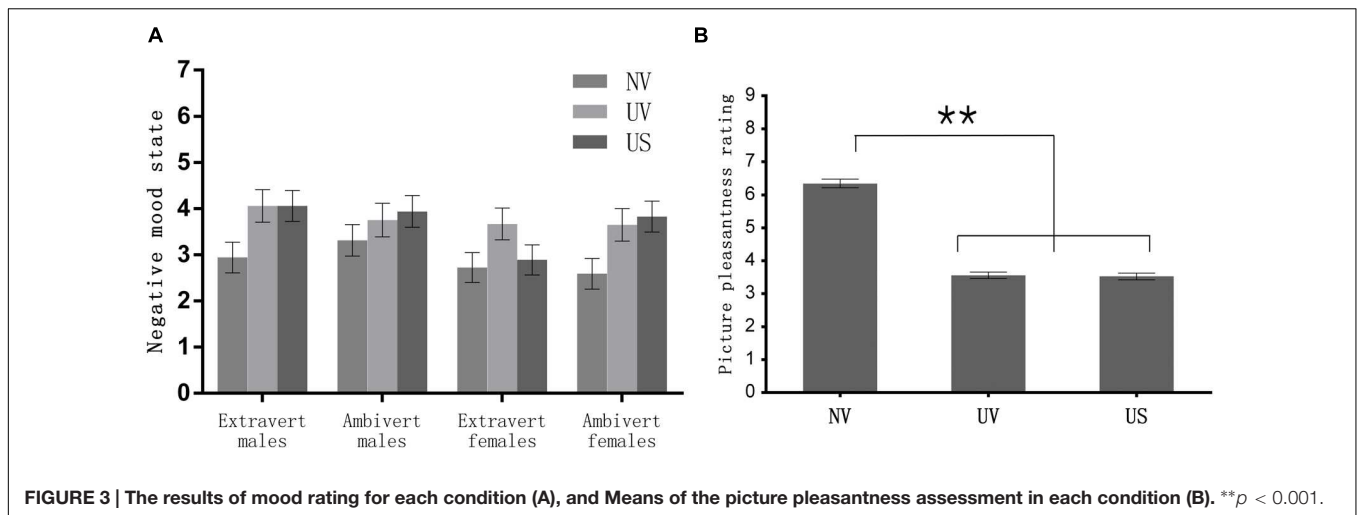
FIGURE 3 | The results of mood rating for each condition (A), and Means of the picture pleasantness assessment in each condition (B). **$p < 0.001$.

To assess the timing of these results, a 5 (segment: 2000–2200, 2200–2400, 2400–2600, 2600–2800, and 2800–3000 ms) × 2 (regulation strategy) × 2 (sex) × 2 (extraversion) repeated-measures ANOVA was performed. Neither the main effect of a segment [$F(4,154) = 2.10$, $p = 0.12$, $\eta_p^2 = 0.03$] nor the interactions involving a segment and other factors (all $ps > 0.09$) reached significance. This suggests that the above findings are reliable, as neither overall LPP amplitudes nor the group-specific emotion regulation effect varied across time segments in the 2000–3000 ms.

LPP: Late Window (3000–4000 ms)
Emotional arousal effect
The results showed a significant main effect of stimulus type [$F(1,64) = 13.88$, $p < 0.001$, $\eta_p^2 = 0.18$]. The unpleasant pictures (1.23 μV) elicited larger LPP amplitude relative to neutral pictures (−0.19 μV). The interactions between factors were not significant (all $ps > 0.57$).

Emotional regulation effect
We observed a significant three-way interaction of regulation strategy, sex and extraversion [$F(1,64) = 6.31$, $p = 0.015$, $\eta_p^2 = 0.09$]. We then analyzed the sex by regulation interaction in extraverts and ambiverts, respectively. The sex by regulation interaction [$F(1,31) = 6.32$, $p = 0.017$, $\eta_p^2 = 0.17$] was significant in ambiverts. The subsequent analysis showed a significant emotion regulation effect in ambivert males [$F(1,15) = 4.60$, $p = 0.049$, $\eta_p^2 = 0.24$], with smaller amplitudes during the US condition (−0.21μV) than during the UV condition (1.70μV), whereas the effect was not significant in ambivert females [$F(1,16) = 1.51$, $p = 0.24$, $\eta_p^2 = 0.09$; see **Figures 4** and **5**]. However, there was neither a significant main effect of regulation ($p > 0.21$), nor a significant sex by regulation interaction in the extravert group [$F(1,33) = 1.02$, $p = 0.32$, $\eta_p^2 = 0.03$], suggesting that expressive suppression produced no significant emotion regulation effect in extraverts, irrespective of sex.

Also, neither the main effect of a segment [$F(4,147) = 0.84$, $p = 0.45$, $\eta_p^2 = 0.01$] nor the interactions involving a segment

(all $ps > 0.11$) reached significance in the analysis of the timing effect, suggesting that neither overall amplitudes nor the group-specific regulation effect varied across time in the 3000–4000 ms.

Emotion Assessment
The repeated-measures ANOVA of picture pleasantness ratings, with conditions as repeated factor, sex and extraversion as the between-subjects factors, showed no other significant main or interaction effects ($ps > 0.18$), except for a significant main effect of condition [$F(1,67) = 215.57$, $p < 0.001$, $\eta_p^2 = 0.77$]. Subjects rated UV ($M \pm SE$: 3.56 ± 0.10; $p < 0.001$) and US (3.53 ± 0.10; $p < 0.001$, see **Figure 3**) pictures as more unpleasant than NV (6.35 ± 0.14) pictures. In addition, the rating scores for the UV [$t(67) = -14.97$, $p < 0.001$] and US [$t(67) = -14.64$, $p < 0.001$] pictures were both significantly lower than the midpoint of the rating scale (i.e., 5), while the ratings were not significantly different between UV and US conditions [$t(67) = 0.94$, $p = 0.35$]. Thus, the pictures used for UV and US conditions were valid in inducing unpleasant emotion, and the pictures' unpleasant strength was similar across UV and US conditions.

Correlation Analyses
To verify whether LPP amplitudes during the US condition reflect subjective emotion intensity, a Pearson correlation was computed between the LPP amplitude differences and subjective emotion differences during UV relative to US conditions in the LPP time window. We found that the reduction of subjective emotional intensity increased significantly with the LPP amplitude reduction in each of the three LPP windows (see **Figure 6**).

DISCUSSION

Negative pictures elicited greater unpleasant feelings, and greater positive amplitudes across each time window of LPP component
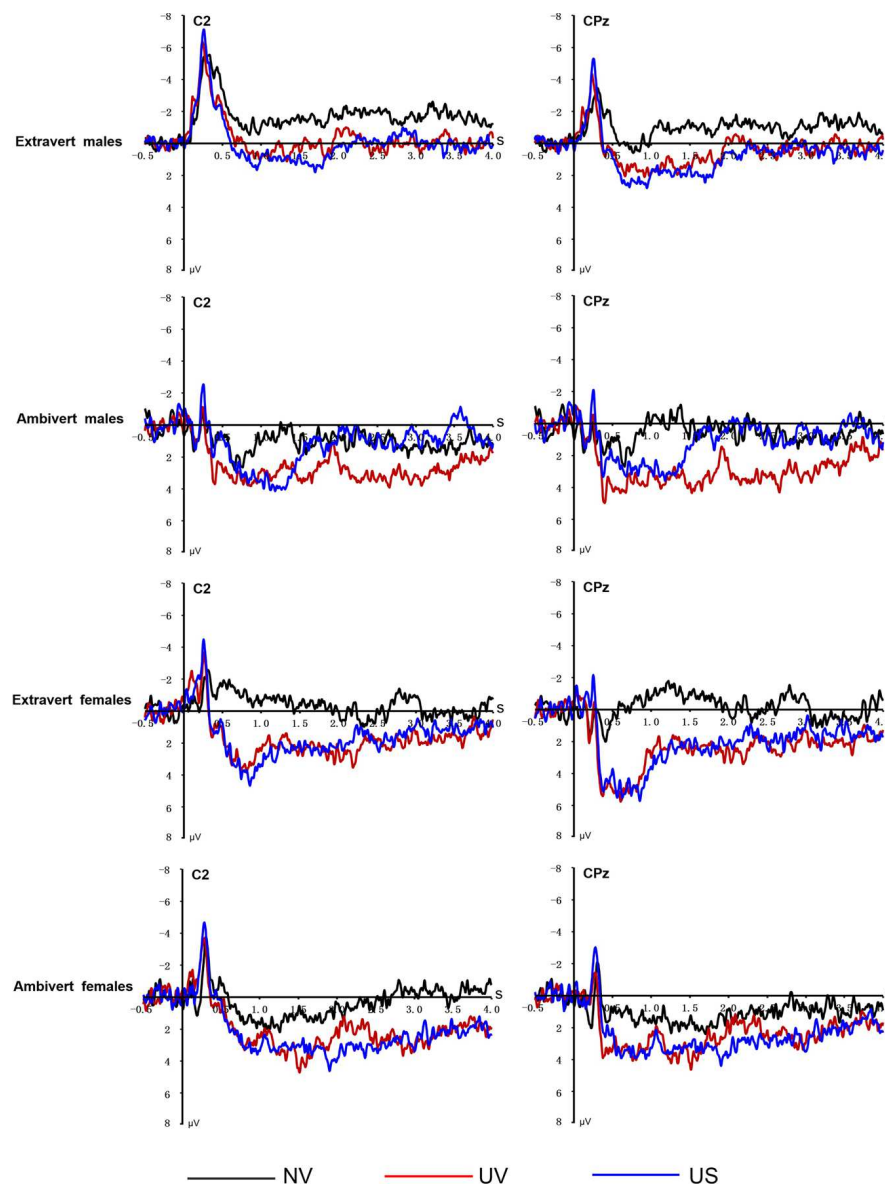
FIGURE 4 | Averaged ERPs elicited by NV, UV, US conditions at C2 and CPz electrode sites in each group.

in comparison with neutral pictures, suggesting that our selection of negative pictures was successful. Though all the samples showed no significant reduction in emotional experiences after suppressing unpleasant emotions, ambivert males, rather than ambivert females, were associated with significantly smaller LPP amplitudes during expressive suppression relative to viewing conditions in the 2000–4000 ms at midline, central, and centroparietal regions. But LPP amplitudes of extraverts were similar for suppression and viewing conditions in all time windows, irrespective of sex.

On the one hand, the current study observed that expressive suppression produced a better regulation of unpleasant emotional reactions in ambivert men than in ambivert women, as reflected by the LPP amplitude differences between UV

and US conditions. Ambiverts, a group of non-extraverted and non-introverted persons located in the median of the bell-shaped distribution of extraversion (McCrae and Costa, 2003; Yuan et al., 2012; Grant, 2013), are more representative of the general population when compared with typical extraverts or introverts. Thus, the above findings may have implications for the general population in that expressive suppression of negative emotion produces better, more adaptive emotional physiological consequences in males than in females. LPP has been accepted to serve as an electrophysiological marker of emotional arousal evoked by salient pictures (Hajcak and Nieuwenhuis, 2006; Moser et al., 2006; Krompinger et al., 2008). Consistent with the evidence, the current study observed a significant positive correlation between LPP amplitudes

FIGURE 5 | (Top) US-UV difference waveform at CPz for males (red) and females (blue) in the extravert and ambivert samples. **(Bottom)** Topographical maps of the voltage amplitudes of US-UV difference waves for males and females in extraverts and ambiverts from 500 to 4000 ms post stimulus.

FIGURE 6 | Change in LPP amplitude (UV-US) plotted as a function of change in self-reported emotional intensity (view minus suppression) in 500–2000, 2000–3000, 3000–4000 ms. Each dot represents an individual participant.

and self-reported emotion intensity during viewing versus suppression conditions. This further suggests that LPP amplitude is most likely a physiological reflection of subjective emotional arousal, and that LPP amplitude reduction in males versus females represents sex differences in the reduction of emotional reaction.

Prior studies have indicated a systematic sex difference in emotional expression. Women reported more intense emotional expression and feelings, and a greater tendency to seek emotional experiences than men (Allen and Hamsher, 1974; Allen and Haccoun, 1976; Balswick and Avertt, 1977; Larsen and Diener, 1987; Hampson et al., 2006) and exhibited greater facial EMG activity during the viewing of emotion-inducing slides

(Grossman and Wood, 1993), in comparison to men. Kring and Gordon (1998) required subjects to view film clips including happy, sad and fear types. They observed that, compared with men, women were more facially expressive, though they did not differ from men in reports of experienced emotion. Grossman and Wood (1993) pointed out that this sex difference may be due to the sex role diversification between males and females, and this explanation was later confirmed by the study of Kring and Gordon (1998). Haga et al. (2009) explained that emotion-expressive suppression is central to the norms of masculinity and is consistent with the cultural expectations for masculine gender-role; that is, men are expected not to show as much emotion as women and are therefore

strongly encouraged to suppress their feelings (Broverman et al., 1972; Roseman, 1984; Eccles et al., 1990; Brooks, 1998). Males may unconsciously follow the norms of masculinity to suppress their unpleasant emotions in daily life, consequently leading to a greater skill at regulating unpleasant emotion by suppressing emotional expression. However, the current study did not directly assess gender roles. Thus, we need to be cautious with this gender role explanation. Whether the gender role mediates the male advantage at regulating unpleasant emotion with expressive suppression needs direct examination in future studies.

On the other hand, the results confirmed our hypothesis that this pattern of sex differences disappeared in extraverts. At the higher side of the continuum of extraversion, none of the extravert males and extravert females effectively decreased unpleasant emotions by expressive suppression. Amin et al. (2004) found that participants scoring high in extraversion exhibited significantly faster RTs in a dot-probe attention task, when the probe was placed behind the neutral rather than behind the negative stimulus locations when a negative/neural composite picture was used. This suggests that extraverts tend to shift their attention away from a negative stimulus, and they may be inclined to adopt other strategies such as distraction to regulate unpleasant emotion. There was abundant evidence showing that higher extraversion is linked with more emotional expression and less emotion-expressive suppression (Carver and Scheier, 2000; Gross and John, 2003; Chen et al., 2005). For instance, Gross and John (2003) observed that trait extraversion is negatively associated with habitual suppression of emotional expression, with higher extraversion predicting less emotion-expressive suppression. This negative correlation was later replicated by Chen et al. (2005), who further demonstrated that extraverts are less ambivalent over emotional expression, that is, more consistent in internal expressive intention and overt expressive behaviors, in comparison with those lower in trait extraversion. Furthermore, Peña-Gómez et al. (2011) recently reported that the improvement of emotional inhibition decreased as a function of increasing extraversion, when subjects received anodal transcranial direct current stimulation of the prefrontal inhibitory network. In this regard, it is probably the increased tendency for emotional expression, which characterizes people high in extraversion, that has contributed to the extraverts' absence of emotion regulation effect during expressive suppression in the current study, irrespective of sex.

One may question that the ERQ assessment showed similar self-reported suppression across the four samples, which may contradict abundant evidence of sex differences in suppression. However, in real life settings, the self-reported suppression is not equal to the actual use of suppression, as many studies indicate that emotion regulation strategies may work unconsciously, in the absence of overt instructions, particularly as a result of training (e.g., Tran et al., 2011; Heeren et al., 2012). For instance, after the training of attention focus on non-emotional or positive stimuli, socially anxious participants showed significantly reduced experiential anxiety and decreased physiological activations when watching negative facial expressions as compared to those without training, though there was no explicit request of emotion regulation

(Heeren et al., 2012). This effect is not merely prominent in adults but is also observable in children (MacLeod and Holmes, 2012). Similarly, there is abundant evidence that subjects receiving positive interpretation training tend to automatically interpret novel situations as positive, showing reduced negative emotional consequences during stress induction, despite no explicit instruction of positive interpretation (Wilson et al., 2006; Tran et al., 2011). It has been suggested that the culturally shaped or personality- determined coping style works rather automatically, and the practice of habitual coping is more an unconscious process than a controlled deliberate process (Mauss et al., 2007). Thus, due to social or cultural training, ambivert males down-regulated unpleasant emotional reaction to a greater extent by expressive suppression than females, though they are not necessarily conscious of more suppression. On the other hand, prior studies consistently indicate that the more an adaptive strategy is used, the higher the emotion regulation effect is. For instance, shifting attention from negative to positive stimuli is linked with extraversion-related happiness (Amin et al., 2004), higher reappraisal is linked with decreased negative affect (Gross and John, 2003), and greater suppression is linked with reduced negative emotion in Asian cultures (Butler et al., 2007). Thus, the fact that we observed this pattern of sex difference after controlling for self-reported suppression in itself strengthens the validity of the current finding. This suggests that extraversion-moderated sex difference exists reliably, irrespective of whether or not ambivert males are conscious of more habitual suppression than females.

AUTHOR CONTRIBUTIONS

JY designed experiments; AC, YL, and QL carried out experiments; AC analyzed experimental results. AC and JY wrote the manuscript.

FUNDING

ACKNOWLEDGMENTS

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: http://journal.frontiersin.org/article/10.3389/fpsyg.2016.01011

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Axiom, Anguish, and Amazement: How Autistic Traits Modulate Emotional Mental Imagery

Gianluca Esposito[1,2]*, Sara Dellantonio[1], Claudio Mulatti[3] and Remo Job[1]

[1] Department of Psychology and Cognitive Science, University of Trento, Rovereto, Italy, [2] Division of Psychology, Nanyang Technological University, Singapore, Singapore, [3] Department of Developmental Psychology and Socialization, University of Padua, Padua, Italy

Individuals differ in their ability to feel their own and others' internal states, with those that have more autistic and less empathic traits clustering at the clinical end of the spectrum. However, when we consider semantic competence, this group could compensate with a higher capacity to imagine the meaning of words referring to emotions. This is indeed what we found when we asked people with different levels of autistic and empathic traits to rate the degree of imageability of various kinds of words. But this was not the whole story. Individuals with marked autistic traits demonstrated outstanding ability to imagine theoretical concepts, i.e., concepts that are commonly grasped linguistically through their definitions. This distinctive characteristic was so pronounced that, using tree-based predictive models, it was possible to accurately predict participants' inclination to manifest autistic traits, as well as their adherence to autistic profiles – including whether they fell above or below the diagnostic threshold – from their imageability ratings. We speculate that this quasi-perceptual ability to imagine theoretical concepts represents a specific cognitive pattern that, while hindering social interaction, may favor problem solving in abstract, non-socially related tasks. This would allow people with marked autistic traits to make use of perceptual, possibly visuo-spatial, information for "higher" cognitive processing.

Keywords: mental imagery, autistic traits, emotion recognition, emotion regulation, proprioception

INTRODUCTION

The imageability scale is a classical psycholinguistic measure for assessing the degree to which words evoke mental images (Paivio et al., 1968; Connell and Lynott, 2012). Mental images (or imageries) are non-verbal re-presentations (i.e., re-calls) of any kind of sensory experience we were exposed to in the past (Roeckelein, 2004). They are associated with words, reflect the strength of the link between specific words and sensory experiences, and have behavioral consequences as high-imageability items are more easily processed and understood than low-imageability items (Paivio, 1971, 1986, 1991, 2007). In this study we want to assess how this specific psycholinguistic construct interacts with individuals' ability to understand their own and others' internal states. Specifically, we want to explore whether the imageability ratings of specific word categories predict an individual's autistic or empathic traits, measuring levels of autistic and empathy traits along a

continuum in which all of us lie that goes from very low to very high (on the link between empathy and autism see e.g., Dalsant et al., 2015; Gentili et al., 2015).

Usually the link between imagery and words is investigated in relation to the external senses. Studies on imagery show, however, that we form mental images of all kinds of sensory experiences, including motor, kinaesthetic proprioceptive, interoceptive, and emotional experiences (see e.g., Switras, 1978; Gollnisch and Averill, 1993; Acerra and Moseley, 2005; Anema and Dijkerman, 2013). In line with these results, in previous research we showed that the imageability scale developed by Paivio captures not only the degree of imageability of words that denote things that can be perceived by the external senses, but also that of words that denote internal states, specifically those referring to emotive, proprioceptive, and interoceptive states (Dellantonio et al., 2014a,b; Pastore et al., 2015).

As individuals differ in their ability to recognize their own and others' internal states, with those with higher levels of autistic traits and lower empathy traits clustering at the lower end of the spectrum (Ronald et al., 2006), people belonging to this group could compensate for this gap by being more able than others to form mental images associated with emotive, proprioceptive, and interoceptive words[1]. Since the imageability scale also assesses the degree to which words referring to internal states evoke mental images, the imageability rating of word classes denoting these states could allow us to predict whether people have low or high autistic traits, or, in other words, whether they have more or less marked empathic inclinations.

Autistic Traits, Imageability, and Word Classes

The main tools to detect individuals' levels of autistic traits are two self-report questionnaires developed by Baron-Cohen et al. (2001), the Autism Quotient and the Empathy Quotient. A person's Autism Quotient score represents the quantity of Autism Spectrum Disorder (ASD) traits s/he shows in her/his behavior, whereas the Empathy Quotient measures empathy traits related to the recognition of others' emotions and moods, the lack of which is involved in ASD impairments. As is already suggested by the link between autism and empathy, people with marked autistic traits are less able than others to identify internal states. Specifically, they have difficulties recognizing both their own and others' emotions and introspective feelings (Gaigg, 2012; Matsuda and Yamamoto, 2015). For this reason, one would expect them to also have a lower capacity to imagine (i.e., to dynamically form and mentally re-evoke) emotional and introspective experiences.

The aim of this study is to test whether autistic traits correlate with the capacity to imagine different kinds of words and thus whether the imageability scale, and specifically the ratings obtained by it (Paivio et al., 1968; Coltheart, 1981; Wilson, 1988; Connell and Lynott, 2012), can be used as a means to predict how many autistic or, at the other end of the continuum, empathic traits a person possesses. A correlation of this kind would not only

offer a new and unexpected psycholinguistic instrument to assess whether people are characterized by varying degrees of autistic traits, but it would also provide important cues concerning the cognitive 'styles' and the semantic competence of persons with more or less marked autistic traits. Specifically, it might allow us to understand whether and in which cases people with varying degrees of autistic traits tend to strongly associate words with perceptual representations.

Different words refer to concepts that rely to different degrees on three main kinds of information: external sensory information (e.g., 'table,' 'fennel,' and 'candle'), internal sensory information (i.e., proprioceptive and emotional information, e.g., 'pain,' 'hunger,' 'fever,' and 'cramp' as well as 'happiness,' 'anger,' and 'disgust') and linguistic information (e.g., 'fallacy,' 'hypothesis,' 'axiom,' 'fraud,' and 'democracy'; Barsalou, 1999, 2008; Prinz, 2002; Barsalou et al., 2003; Barsalou and Wiemer-Hastings, 2005; Vigliocco et al., 2009; Kousta et al., 2011). Imagery is a measure of the link between words and sensory information, therefore words with high imagery ratings will be more strongly linked with perception (either internal or external), while words with low imagery ratings will rely more heavily on linguistic information and be understood mainly on the basis of linguistic definitions: they will be more abstract or, more precisely, theoretical ('abstract' is often used for describing 'non-material' objects; in this sense, words denoting emotions or feelings would also be abstract). On the basis of this analysis we identified four word classes: the first two include words referring to internal states, i.e., specifically (i) proprioceptive and (ii) emotional states; (iii) the third consists of theoretical words and (iv) the last consists uniquely of *concrete* nouns; this last group also serves as a control since it is matched with the others for frequency and length.

Since people with autism have a limited capacity to recognize internal feelings, we expect that they will be less able to imagine words referring to emotional and proprioceptive states and that therefore imageability ratings assigned to these word classes will negatively correlate with autistic traits. On the other hand, there is no evidence that more or less marked autistic traits will influence the way people perceive the external world or the way they grasp verbal definitions. Thus, imageability ratings of concrete and of theoretical words should remain stable independently of the degree of autistic traits. To assess this hypothesis, we tested whether the imageability ratings assigned to the four classes of words correlates with the degree of participants' autistic/empathic traits as calculated by the Autism Quotient and the Empathy Quotient.

Aim of the Study

This study aims at investigating whether more or less marked autistic and/or empathic traits modulate semantic competence with specific word classes. We hypothesize that individuals with higher autistic traits and lower empathic skills have a less developed capacity to imagine the meaning of words referring to emotions and proprioceptive feelings. To test this hypothesis, imageability judgements were submitted to recursive partitioning (also known as tree-based models; Costello et al., 2003) to analyze how the words' category (theoretical, emotional,

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[1]Because 'proprioception' can be used in a wide sense to include also interoception, in the following we will speak in general of proprioceptive states/words.

proprioceptive, and concrete) predicts the amount of autistic (or empathy) traits. Given a set of independent variables (word category) and a dependent variable (level of autistic or empathy traits), tree-based models provide unique information about the (1) hierarchy of contributions from independent variables in explaining the distribution of the dependent variable and (2) which value of the independent variable subdivides the dependent variable into statistically different groups. To evaluate whether the results were broadly general or clinically specific, we selected adults along a continuum, from low to high autistic traits.

MATERIALS AND METHODS

Participants

One-hundred and seventy-one participants aged between 18 and 58 years ($N = 171$; $M = 31.6$ years; $SD = 10.9$ years), 104 female ($M = 30.62$ years; $SD = 10.8$ years), 67 male ($M = 33.1$ year; $SD = 10.9$ years) participated in the study. Their educational level was medium-high (with all the participants having at least completed high school). Participants were recruited through the Department of Psychology and Cognitive Science electronic notice board. Furthermore, to increase variability in the level of autistic/empathy traits, invitation to participate in the study was electronically sent to an association of people with Asperger Syndrome. Although we were able to differentiate among the participants that were recruited from the Asperger Syndrome association ($N = 62$; 31 m/31f) from those that were recruited from the general population ($N = 109$; 36 m/73f), we were not able to confirm their clinical diagnosis. For these reasons we grouped all the participants together assuming a continuous distribution of autistic and empathy traits between clinical and sub-clinical (normal) populations. We used the Autism Quotient Questionnaire (AQ) and the Empathy Questionnaire (EQ) to assess each participant's location along the spectrum of Autistic/Empathy traits. Participants recruited from the Asperger Syndrome association had significantly [$F(1,169) = 151.1$, $p < 0.001$] higher levels of AQ ($M = 35.4$; $SD = 7.3$) than participants from the subclinical group ($M = 18.3$; $SD = 9.5$) and had significantly [$F(1,169) = 125.7$, $p < 0.001$] lower levels of EQ ($M = 21.8$; $SD = 10.2$) than participants from the subclinical group ($M = 43.3$; $SD = 12.9$). However, using the Kolmogorov–Smirnov test we confirmed the normality of our AQ ($D = 0.11$, $p = 0.24$) and EQ ($D = 0.11$, $p = 0.19$) score distributions. In spite of this, we cannot exclude the possibility that the extreme group of participants with a potential diagnosis of Asperger Syndrome might have had a relatively strong effect on the final results.

Participants were provided with information on the basic background of the study and the procedure before giving their consent. Participants did not receive any monetary incentive to participate in the study. The study was approved by the Internal Ethical Committee of the University of Padova, and was conducted according to the principles expressed in the Declaration of Helsinki. Informed consent was obtained from the participants.

Materials
Words

One hundred and eighty Italian words were selected as experimental stimuli. Each word fell in one of three categories ($N = 60$): emotional words, proprioceptive words, theoretical words. In addition, 180 words were selected as control stimuli. Experimental and control stimuli were balanced in terms of written frequency (67.2 vs. 67.3, respectively; $t < |1|$) and in terms of letter length (8.5 vs. 8.5; $t < |1|$).

(i) Words denoting proprioceptive states were selected starting from the examples considered in the studies of Berthoz (2000) and Craig (2003, 2009, 2010). Some examples are 'agitation,' 'balance,' 'blush,' 'cramp,' 'spasm,' 'pain,' 'hunger,' 'cold,' 'fullness,' 'fever,' 'malaise,' 'relaxation,' and 'wheeze.' (ii) The group of emotion words includes both transient emotions and moods. The list was freely composed starting from the examples given in a number of salient studies on the matter. We included only emotions that are considered to be culturally stable (more basic; Tomkins, 1962, 1963; Plutchik, 1980; Ekman, 1984, 1994, 1999; Reizenzein, 2009; Kassam et al., 2013). As for moods, we composed our list starting from the cases discussed by Ekman (1994), Damasio (1999), and Prinz (2004). Among the words we used were, e.g., 'anguish,' 'amazement,' 'joy,' 'happiness,' 'sadness,' 'unhappiness,' 'disappointment,' 'love,' 'fear,' 'anger,' 'depression,' 'boredom,' 'distress,' 'indolence,' and 'relief.' (iii) For the list of theoretical words we could not rely on previous databases of abstract words. In fact, as we already mentioned, theoretical words are not just abstract words, since many words which are considered abstract (not directly related to external perception), are indeed linked to internal – emotional or proprioceptive – sensory information (e.g., 'friendship,' 'love,' 'freedom,' or 'wellness' etc.; on this see also Vigliocco et al., 2009; Kousta et al., 2011). Thus, the class of *theoretical* words was defined *a priori*, with the intent of individuating a set of terms which rely primarily on verbal definitions like 'axiom,' 'fallacy,' hypothesis,' 'fraud,' 'democracy,' 'definition,' 'exception,' 'unanimity,' 'protocol,' etc. (iv) Finally, we created a control set (matched for length and frequency with the others) composed uniquely of concrete words, i.e., of words which strongly rely on external sensory information. We included in this class terms like 'table,' 'fennel,' 'candle,' 'juice,' 'cork,' 'pillow,' 'melon,' 'book,' 'stem glass,' and 'airplane.'

Questionnaires
Autistic traits (AQ)

Participants were administered the full 50-item Autism Quotient questionnaire (Baron-Cohen et al., 2001). Answering each question on the survey was mandatory, so there were no missing data for any participants who completed it. The results were scored according to Baron-Cohen et al.'s (2001) criteria, resulting in an "AQ score" for each participant. The AQ score represents the level of autistic traits/characteristics that participants possess.

Empathy traits (EQ)

Participants answered the 40-item short version of the Empathy Quotient questionnaire (Baron-Cohen and Wheelwright, 2004). The results were scored to obtain an "EQ score" for each

participant, which represents their level of empathy traits, i.e., the ability to understand others' emotions and moods.

Procedure

The survey was created and run between July 2014 and November 2014 using Google Forms Online Surveys.

Participants were asked to fill in two questionnaires (AQ, and EQ, Baron-Cohen et al., 2001; Baron-Cohen and Wheelwright, 2004) and to rate the imageability of a set of 360 words. Imageability was rated for each word on a 7-point Likert-like scale (one is the low and seven is the high imagery end of the scale). Instructions to participants were the Italian translation of Paivio et al.'s (1968) original instructions: "Nouns differ in their capacity to arouse mental images of things or events. Some words arouse a sensory experience, such as a mental picture or sound, very quickly and easily, whereas others may do so only with difficulty (i.e., after a long delay) or not at all. The purpose of this experiment is to rate a list of words as to the ease or difficulty with which they arouse mental images. Any word which, in your estimation, arouses a mental image (i.e., a mental picture, or sound, or other sensory experience) very quickly and easily should be given a high imagery rating: any word that arouses a mental image with difficulty or not at all should be given a low imagery rating. Think of the words 'apple' or 'fact.' Apple would probably arouse an image relatively easily and would be rated as high imagery; fact would probably do so with difficulty and would be rated as low imagery" (Paivio et al., 1968, p. 4; for an analysis of these instructions and of how people might plausibly interpret them to assign their ratings, see Pastore et al., 2015).

The experiment was conducted in two parts, each involving completion of an online form. In the first part, participants dealt with the form containing the AQ and a random selection of 180 words; in the second part, they dealt with the EQ and the remaining 180 words. Only the data from participants that completed all the four tasks (AQ, EQ, rating of word set 1 and word set 2) were used for the analyses.

Analytic Plan

First, for the whole group, we calculated correlations of AQ scores and EQ scores with the mean imageability ratings. We then determined correlations of AQ scores and EQ scores with the mean of the judgments of imageability for each of the word clusters (theoretical, emotional, proprioceptive, and control) for male and female participants. Statistical significance was set at $p < 0.01$.

Finally, imageability ratings were submitted to recursive partitioning (also known as tree-based models; Costello et al., 2003) to analyze how either the words' category (theoretical, emotional, proprioceptive, control) or the single words predict the AQ and EQ scores.

RESULTS

Preliminary Analysis

The data were explored and analyzed using R-project (version 3.1.1). Prior to data analysis, univariate and multivariate distributions of AQ, EQ and imageability judgment scores were examined for normality, homogeneity of variance, outliers, and influential cases (Fox, 1997). All these variables were normally distributed. The distance of each case to the center was evaluated to screen for multidimensional outliers (Fox, 1997). Autism Quotient scores and Empathy Quotient scores were, as expected, negatively correlated, $r = -0.85$, $p < 0.001$ sharing 72.3% of their common variance.

No significant differences emerged between female and male participants for the imageability judgment scores (F range = 0.01–1.8; ns). However, significant differences emerged between male and female for AQ [male $M = 27.4$; $SD = 11.9$; female $M = 22.7$; $SD = 11.8$; $F(1,169) = 6.4$; $p < 0.05$] and for EQ [male $M = 30.5$; $SD = 14.3$; female $M = 38.6$; $SD = 16.0$; $F(1,169) = 11.2$; $p < 0.001$].

Correlational Analysis

For the whole group, neither AQ nor EQ were significantly correlated with mean imageability ratings (respectively, $r = 0.07$, ns and $r = -0.08$, ns).

Figure 1 shows the linear correlations among the AQ scores and imageability ratings for each of the word clusters (theoretical, emotional, proprioceptive, and control) for male and female participants. There was a significant positive correlation for males (but not for females) between AQ and the imageability ratings of theoretical words ($r = 0.37$, $p < 0.01$), with the explained variance as low as 13.7%. There was a significant positive correlation for males (but not for females) between AQ and the imageability ratings of emotional words ($r = 0.31$, $p < 0.01$), with the explained variance as low as 9.6%. AQ was not significantly correlated for either males or for females with the imageability ratings of either proprioceptive words (male $r = 0.20$, ns; female $r = 0.04$, ns), or control words (male $r = 0.02$, ns; female $r = -0.17$, ns).

Figure 2 shows the linear correlations among the EQ scores and the imageability ratings for each of the word clusters (theoretical, emotional, proprioceptive, and control) for male and female participants. There was a significant negative correlation for males (but not for females) between EQ and the imageability ratings of theoretical words ($r = -0.43$, $p < 0.01$), with the explained variance as low as 18.5%. There was a significant negative correlation for males (but not for females) between EQ and the imageability ratings of emotional words ($r = -0.33$, $p < 0.01$), with the explained variance as low as 10.9%. EQ was not significantly correlated for either males or for females with the imageability ratings of either proprioceptive words (male $r = -0.22$, ns; female $r = -0.05$, ns), or control words (male $r = -0.01$, ns; female $r = 0.21$, ns).

Tree-Base Model Analysis
Category-Words Level

Figure 3 shows the optimal tree that describes how imageability ratings of the word categories (theoretical, emotional, proprioceptive, and control) predict the AQ (**Figure 3A**) and EQ (**Figure 3B**) scores. For both AQ and EQ scores, the judgment of *theoretical* words was the best measure that statistically differentiated the distribution. Specifically, participants with
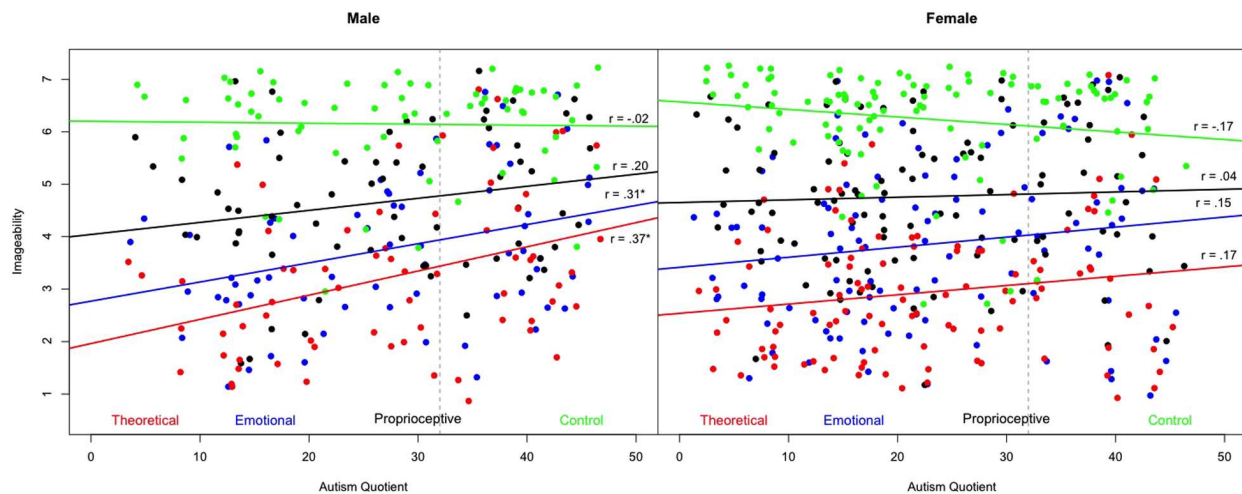
FIGURE 1 | Distributions of the Autism Spectrum Quotient (AQ) score and imageability ratings for each of the words clusters (theoretical, emotional, proprioceptive, and control) for male and female participants.
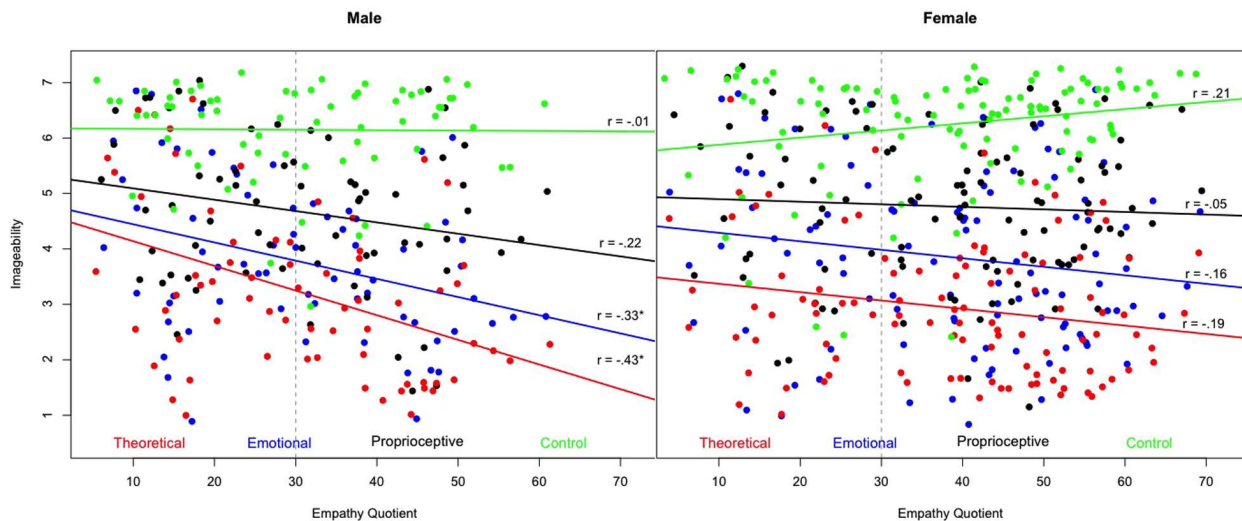
FIGURE 2 | Distributions of the Empathy Quotient (EQ) score and imageability ratings for each of the words clusters (theoretical, emotional, proprioceptive, and control) for male and female participants.

higher AQ (and conversely lower EQ) scores gave higher imageability ratings of the theoretical words (>4.6) than those with lower AQ (and higher EQ) scores. Next, the imageability ratings of the control and the theoretical words hierarchically stratified the AQ and EQ distributions, respectively. Finally, only for those participants with lower AQ (<30), the imageability ratings of the emotional and proprioceptive words affected the stratification of the population. Gender hierarchically stratified the distribution only for the EQ scores, with females having higher scores.

Single-Word Level

Figure 4 shows the optimal tree which describes how imageability ratings at the single word level (all 360 words were considered independently) predicts the AQ (**Figure 4A**) and EQ (**Figure 4B**) scores. For both AQ and EQ scores, the ratings of the single word *anguish* were the best measure that statistically differentiated the distribution. Specifically, participants with higher AQ (and conversely lower EQ) scores gave lower (<5.55) imageability ratings to the word *anguish* than those with lower AQ (higher EQ) scores. Next for the AQ scores, the imageability judgments of the words *toy* (>4.5), *amazement* (<3.5), and *unanimity* (<2.5), hierarchically stratified the population. For the EQ scores, the imageability judgments of the words *toy* (>4.5) and *chocolate candy* (>6.5) hierarchically stratified the population. Gender hierarchically stratified the distribution only for the EQ scores, with females having higher scores.
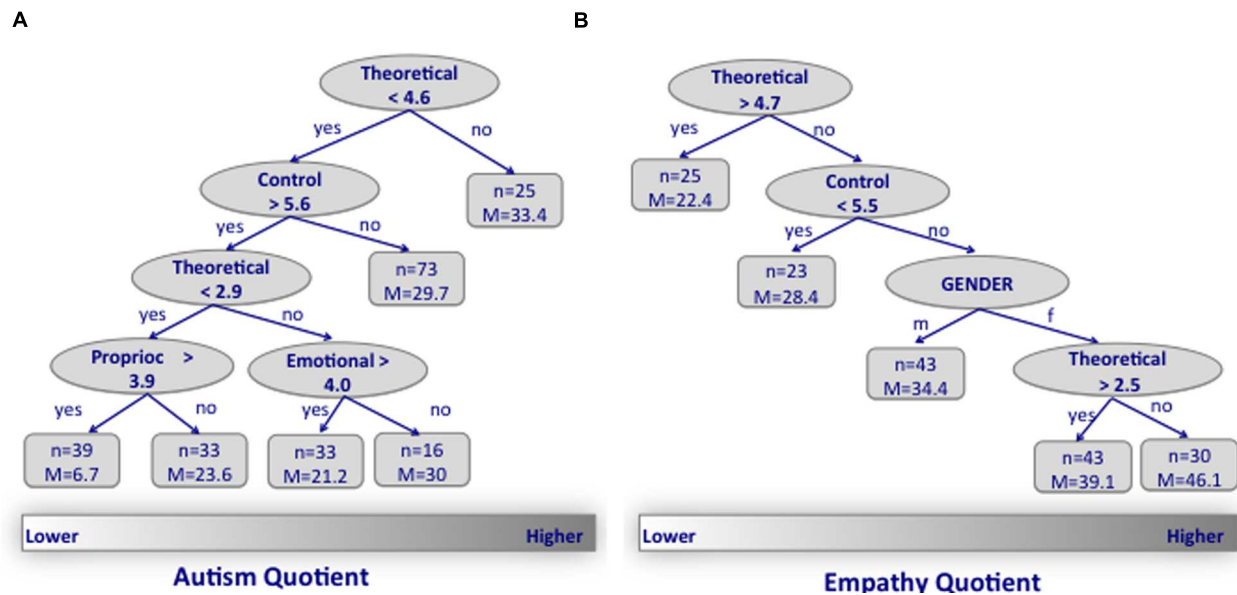
FIGURE 3 | (A) The optimal tree that describes how imageability ratings of words' category (theoretical, emotional, proprioceptive, and control) predict the AQ. The regression tree or tree-based model provides information about (1) the hierarchy of the importance of independent variables in explaining the distribution of the dependent variable and (2) which value of the independent variable divides the dependent variable in two groups that differ statistically. The bottom rectangle shows the distribution of expressed distress from lower (left) to higher (right). The values in the oval leaves of the tree refer to the condition of the independent variable that statistically divides the distribution of the dependent variable. Below each oval leaf, the indications "yes" or "no" refer to whether or not the condition is met. For the categorical variable "Gender" m, male and f, female. Each leaf is divided in two sub-leaves. The terminal leaves (quadrangles) represent subgroups that cannot be further subdivided. The n-value in the terminal leaves represents the size of the group, and M is the mean value of the group for the dependent variable. **(B)** The optimal tree for EQ.
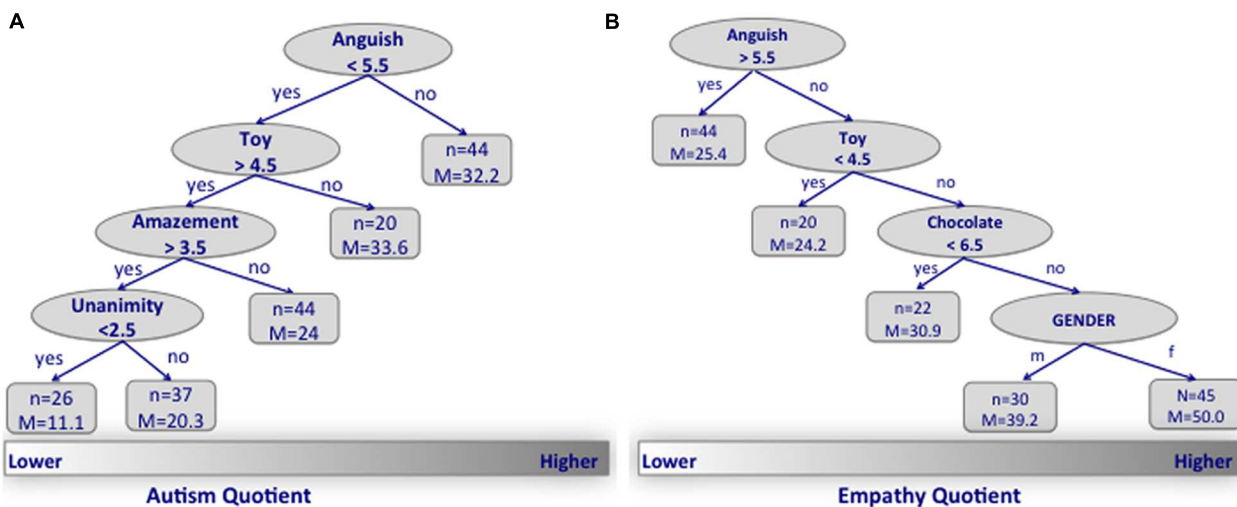
FIGURE 4 | (A) The optimal tree that describes how imageability ratings of single words' predict the AQ. **(B)** The optimal tree for EQ.

DISCUSSION

The notion of mental imagery describes both the capacity to dynamically form and mentally recall representations of past sensory experience and the quasi-perceptual representations evoked by this process. Since they are private and subjective experiences, mental images are particularly difficult to investigate scientifically, even though they are crucial for understanding non-verbal thought and the relationship between verbal and non-verbal thought. This study offers a contribution to the comprehension of this phenomenon. Indeed, it allows us to establish a link between people's lower vs. higher autistic traits (which we know to be related to a higher/lower ability to feel their own and others' internal states, respectively) and their capacity

to imagine specific word classes, i.e., to link specific words with quasi-perceptual information related to them. As has been reported in other studies on cognitive style in Autism (Kana et al., 2006; Mottron et al., 2006), this group probably compensates for the lack of direct emotional experience by developing a higher capacity to imagine emotions in a visual manner. This same tendency – even if to a lesser and non-significant degree – is discernible also in the case of proprioceptive terms referring to bodily (proprioceptive and interoceptive) states.

Conversely, we were also able to ascertain that people with high levels of autistic traits and lower levels of empathic traits have a more developed capacity to imagine theoretical words and this is compatible with the common knowledge that they are outstanding in understanding theoretical issues and in accomplishing abstract tasks. Thus, we can conclude that the capacity to dynamically form and mentally recall representations of past sensory experience associated with a word is in general positively related with a better grasp of the phenomena denoted by the words.

Furthermore, this study may also be relevant from a clinical perspective since the imageability ratings of word classes denoting proprioceptive, emotional and theoretical words allow us to predict whether people have low or high autistic traits, or, to put it differently, whether they have more or less marked empathic inclinations. In the DSM-5 it is at last acknowledged that people with autistic traits tend to belong to a spectrum. However, there are no specific markers that can easily predict where in the spectrum a person falls. Our study shows that a simple task such as rating mental imagery may be useful for performing a stratification of the population.

The effects we found are higher for the male than for the female participants. This is consistent with the so-called "extreme male brain theory of autism" and with the finding that autistic traits in men are generally more severe than those in women (Baron-Cohen, 2002).

Some limitations of this study point to future directions of study. Firstly, we can imagine that cognitive level may be a strong predictor of word imageability, so it is a limitation that no measures of cognitive performance were taken into account. However, in the current study we decided not to collect any IQ measure for technical reasons. Specifically, our procedure was very long (∼2 h in two sessions) and many participants had to be excluded because they did not finish the experiment. Adding another IQ test would have made our experiment even longer. However, we strongly believe that a follow-up study should include measures of the cognitive performance of the participants. Secondly, we tested our sample on ratings for a large number of words, and the task was long and demanding. To have clinical value, we believe the stratification of the population should be done based on the imagery rating of a smaller number of words. This will be possible by selecting only a subgroup of the words we have used,

more specifically those words that lie at the extremes of the continuum. Furthermore, to evaluate possible clinical insights and applications, it would be useful to use this methodology with children. Indeed, conducting assessments at various ages during childhood could allow us to define the ontogeny of the imagery capacity across development and thus might be helpful in trying to identify atypical developmental trajectories. Finally, our research could be tested at the neurophysiological level in order to both identify brain neural networks that render the mental imagination of one class of words differently than another and to determine how they vary in different clinical groups.

CONCLUSION

We used Paivio's imagery scale to investigate whether autistic traits correlate with the capacity to imagine different kinds of words. The outcome is even more intriguing than we anticipated since it indicates that the ratings assigned by people to certain world classes can predict that person's inclination to manifest autistic traits, including whether they fall above or below the diagnostic threshold.

People with more autistic traits have a higher capacity than typical matching controls to imagine theoretical, emotional and proprioceptive words. This may support the claim that people with high functioning autism compensate for their difficulties in understanding their internal states by using specific cognitive strategies related to imagery, more specifically by using associations to words referring to external sensory information. This finding certainly invites further investigation since it could lead to important insights for the development of psychological treatments. Furthermore, our results also suggest something more specific, i.e., that the reason people with high functioning autism show increased skills for theoretical tasks is not due to a highly developed capacity to recall verbal definitions or to build meaningful links among words; instead, these increased skills result from a capacity to form perceptual images of theoretical concepts.

AUTHOR CONTRIBUTIONS

ACKNOWLEDGMENTS

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Electrophysiological Correlates of Emotional Source Memory in High-Trait-Anxiety Individuals

Lixia Cui[1], Guangyuan Shi[1,2], Fan He[3], Qin Zhang[1], Tian P. S. Oei[4,5,6] and Chunyan Guo[1]*

[1] Beijing Key Laboratory of Learning and Cognition and Department of Psychology, Capital Normal University, Beijing, China,
[2] Psychological Health Education and Consultation Center, Dalian University of Technology, Dalian, China, [3] Guanghua
School of Management, Peking University, Beijing, China, [4] School of Psychology, University of Queensland, Brisbane, QLD,
Australia, [5] James Cook University, Singapore, Singapore, [6] Asia University, Taichung, Taiwan

The interaction between recognition memory and emotion has become a research hotspot in recent years. Dual process theory posits that familiarity and recollection are two separate processes contributing to recognition memory, but further experimental evidence is needed. The present study explored the emotional context effects on successful and unsuccessful source retrieval amongst 15 high-trait-anxiety college students by using event-related potentials (ERPs) measurement. During study, a happy, fearful, or neutral face picture first was displayed, then a Chinese word was superimposed centrally on the picture and subjects were asked to remember the word and the corresponding type of picture. During the test participants were instructed to press one of four buttons to indicate whether the displayed word was an old or new word. And then, for the old word, indicate whether it had been shown with a fearful, happy, or neutral face during the study. ERPs were generally more positive for remembered words than for new words and the ERP difference was termed as an old/new effect. It was found that, for successful source retrieval (it meant both the item and the source were remembered accurately) between 500 and 700 ms (corresponding to a late positive component, LPC), there were significant old/new effects in all contexts. However, for unsuccessful source retrieval (it meant the correct recognition of old items matched with incorrect source attribution), there were no significant old/new effects in happy and neutral contexts, though significant old/new effects were observed in the fearful context. Between 700 and 1200 ms (corresponding to a late slow wave, LSW), there were significant old/new effects for successful source retrieval in happy and neutral contexts. However, in the fearful context, the old/new effects were reversed, ERPs were more negative for successful source retrieval compared to correct rejections. Moreover, there were significant emotion effects for successful source retrieval at this time window. Further analysis showed ERPs of old items were more negative in fearful context than in neutral context. The results showed that early unsuccessful fearful source retrieval processes (related to familiarity) were enhanced, but late successful fearful source retrieval processes during source retrieval monitoring (related to recollection) were weakened. This provided preliminary evidence for the dual processing theory.

Keywords: anxiety, source memory, old/new effect, emotion effect

INTRODUCTION

Episodic memory, referring to memory for an event or episode that occurs at a certain time and a certain place, includes two elements: item memory and source memory (Slotnick et al., 2003). Item memory refers to the recognition or recall of previously presented information itself, whereas source memory refers to the recollection or recall of the context from which the fact or information is acquired (Johnson et al., 1993). According to dual-process theories, when both item and source are remembered accurately, it is inferred that the memory decision is based on recollection. When the correct recognition of old items matches with incorrect source attribution, dual-process theories posit that the memory decision is based on familiarity. Familiarity and recollection are distinct cognitive processes. Familiarity relies on automatic processes and recollection relies on intentional processes.

The past studies have shown that the background emotional valence affects the retrieval of source memory, and we can speculate that both early item retrieval and late sources retrieval are affected by it (Jaeger et al., 2009). Some studies demonstrated that event-related potentials (ERPs) which were related to emotion-laden pictorial contexts as elicited during object recognition differed in two ways (Jaeger and Rugg, 2012). First, there was a relatively early-onset (circa 300–500 ms) positivity for objects encoded in emotional rather than in neutral contexts. Secondly, there was a positively inclined shift in the ERPs for emotionally encoded objects, which showed a relatively late onset (circa 700 ms). This was frontally distributed, and it persisted for several 100 ms. Findings from Smith et al. (2004) were replicated in Jaeger et al. (2009), by which the latter study team contrasted ERPs that had been studied in association with emotionally negative to neutral contexts during item recognition after the shorter study-test delay (10 min).

Past studies employing normal controls have demonstrated the effects of emotional contexts on memory retrieval (Smith et al., 2004; Jaeger et al., 2009; Jaeger and Rugg, 2012), but whether the emotion effects on successful retrieval are different from unsuccessful source retrieval has not been explored. One study showed that the emotion effects on information retrieval were different at different stages amongst high-trait anxiety individuals (Williams et al., 1988). One of the most elaborate theories for explaining selective information processing in anxiety was developed by Williams et al. (1988). This theory proposed that there should be two different stages of processing (i.e., automatic and strategic) related to the two distinct pathways of information integration and elaboration. At the integration stage of processing, if a stimulus is evaluated as threatening, people with high-trait-anxiety are likely to allocate cognitive resources to this new threatening information, thus, establishing a preference for processing this stimulus. In contrast, at the elaborative stage, there might not be extra resources allocated for cognitive processing, or cognitive resources for processing threatening stimuli may be removed altogether. This way, anxiety will either not be related to an enhanced recall of threatening stimuli (as when additional resources are unavailable) or be related to a worst memory of the threatening stimuli (as when baseline cognitive resources for stimuli processing are unavailable). The two processes are independent, meaning that a bias in one process is not associated with a bias in the other. Studying ERP differences produced in response to successful or unsuccessful source retrieval using different emotional contexts in high-trait-anxiety individuals would contribute to a deeper understanding of the relation between familiarity and recollection.

In the present study, we explored the cognitive and neural mechanisms of source retrieval under different emotional contexts in high-trait-anxiety individuals by using ERPs measurements and a source memory multiple-task paradigm. There were four responses in the test phase: (1) old item–happy context, (2) old item – fearful context, (3) old item – neutral context, and (4) new item. In the test-phase, trials for old items would be assigned to the condition of correct source retrieval (w/source) if the item was endorsed as an old item with the correct emotional context judgment, and if the item was endorsed as an old item but with the incorrect emotional context judgment these trials would be assigned to the condition of false source retrieval (w/o source). Using this paradigm we were able to compare how retrieval processing was moderated by the emotional context when the source retrieval was successful or unsuccessful. Based on the Dual-process theories (Williams et al., 1988), we hypothesized that the effects of emotional context on information retrieval differed depending on successful or unsuccessful source retrieval at different stages in high-trait-anxiety individuals.

METHODS

Participants

Initially, 99 participants were recruited through advertising from several universities in Beijing. They also completed the State-trait Anxiety Inventory (STAI) and the top 30% of the STAI was selected for the study. Sixteen right-handed young adults were employed as subjects and remunerated at the rate of ¥20/hr. All study participants reported good health with no history of neurological or psychiatric illnesses. One participant with less than 16 artifact-free trials in at least one relevant condition was excluded from the analysis, leaving a final sample of fifteen participants (mean age was 21.81, $SD = 1.59$). Of the 15 subjects contributing data, 8 were women. The mean trait anxiety score for this group was 59.06 ± 3.88. Each participant signed an informed consent. This study was approved by the Institutional Review Board of the Capital Normal University.

MATERIALS

State-Trait Anxiety Inventory (STAI)

The State-trait Anxiety Inventory (Speilberger et al., 1983) was utilized as the measure of anxiety symptoms. For the 20 trait items in the STAI, the students were asked to circle the number that best described how they generally felt with a four-point scale ranging from: 1 = almost never to 4 = almost always). All anxiety-absent (positively worded) items were reverse scored

(i.e., reversed score = 5-original score). The internal consistency reliability (Cronbach's α) of the Chinese versions of STAI was 0.88 and the Chinese undergraduates norm score of trait anxiety is 43.31 ± 9.20 (Li and Qian, 1995).

Stimuli

In total, 1056 Chinese words were selected from Modern Chinese Frequency Dictionary and the average frequency of all these words is 25.0 occurrences/million (range = 4–82 occurrences/million) (Beijing Language and Culture University, 1986), of which 576 words were presented as old words both in the study and the test phase. Only 384 words were presented as new words in the test phase and 96 words were presented as filters in the study phase. The 1056 Chinese words were also rated on a nine-point scale by 50 college students in two dimensions: emotional valence and arousal. The results showed that the average emotional valence score of every word was 4.0 ± 0.56 and the average arousal score of every word was 4.0 ± 0.22.

A total of 120 face pictures were drawn from the native Chinese Facial Affective Picture System (Wang and Luo, 2005), including 40 pictures of happy, fearful, and neutral face emotions, respectively. Pictures were presented within a white box to clearly demarcate their separation from the background. Eight pictures for each emotion were selected for the filters and practice. The rest of 96 pictures were presented as the context for target words, and each picture was repeated 6 times. The valence means of 32 pictures (16 male faces, 16 female faces) for each emotion was for happy, $M = 6.69 \pm 0.33$; for neutral, $M = 4.89 \pm 0.30$; for fearful, $M = 2.67 \pm 0.41$. The results of one-way ANOVA with repeated measures showed that valence means differed significantly among the three emotions, $F(2,62) = 978.42$, $p < 0.001$. The arousal means of each emotion picture was as follows: for happy, 6.15 ± 0.92; for neutral, 3.74 ± 0.51; for fearful, 5.93 ± 1.05. The results of one-way ANOVAs of arousal for three emotion pictures showed a main effect of condition ($p < 0.001$). A Tukey HSD test revealed that the arousal level of fearful or happy emotion pictures was significantly higher than that of the neutral emotion pictures ($p < 0.05$). No significant difference was revealed between conditions pertaining to the arousal of fearful and happy emotions. All the pictures were similar in size, context, spatial frequency, contrast grade, brightness, and other physical properties. The Chinese words and the emotion pictures were randomly matched in each block. See experimental stimulus samples in **Figure 1**.

Procedure

The experiment was conducted in a soundproof room. Subjects were seated in a quiet room with their eyes approximately100 cm from a 17-in screen. All face pictures were presented in the center of the screen. The viewing angle was $8.02 \times 9.19°$.

Using a study-test paradigm, the research was divided into 16 blocks. Each block comprised a study phase, a distraction phase, and a test phase. In the experiment, subjects were instructed to watch the center of the screen, and to relax and control their blinking.

The study phase included 42 trials, in which the first three and the last three trials were fillers. The other 36 trials, which were made up of 12 face pictures each for the three emotional contexts, and arranged pseudo-randomly with no more than three pictures from the same valence category presented consecutively. In one trial (see **Figure 2**), before presentation of the face picture, a fixation cross appeared at the central location during the inter stimulus interval (ISI) ranging from 800 to 1000 ms. Then the face pictures context was initially presented alone on the screen for 1500 ms. During this time subjects made a judgment on whether the face picture showed a fearful, happy, or neutral face. The responding fingers were balanced across participants. After presenting the context, the Chinese word was superimposed centrally on the face picture. Subjects were required to remember the word and the corresponding type of face picture (i.e., fearful/happy/neutral). The word and face picture were presented together for 2000 ms, after which the fixation cross appeared on screen, before the next face picture was presented. The emotion pictures were balanced for gender, and repeated for the same number of times. The Chinese words were not emotionally laden and not repeated in the study phase.

The test phase followed the study phase after a delay of around 1 min, during which a serial subtraction task was used to minimize rehearsal effects. In the test phase of the item memory task, each block consisted of 36 studied words, 6 filler items, and 24 new words, each of which was presented for 1500 ms with an ISI ranging from 1400 to 1800 ms. Each participant was instructed to press one of four buttons on the response box to indicate whether it was an old or new word. And then, for those that were old words, the participants were instructed to indicate whether it had been shown with a fearful, happy or neutral face (See **Figure 1**). The responding fingers were balanced across participants. To avoid key confusion, the buttons of emotion pictures in study phase corresponded with those in the test phase.

ERP Recording and Analysis

Electroencephalographic recordings were obtained from 62 scalp sites using Ag/AgCl electrodes embedded in an elastic cap at locations from the extended International 10–20 System. These electrodes were referenced to the right mastoid during recording and re-referenced to the average of the right and left mastoid offline. Two additional channels were used for monitoring horizontal and vertical electrooculographic (EOG) recordings. Impedance was reduced below 5 KΩ. EEG signals were filtered with a band-pass of 0.05–40 Hz and sampled at a rate of 500 Hz. Each epoch lasted 1600 ms, including 200 ms prior to stimulus onset. Trials with a voltage, relative to the 200-ms baseline, exceeding ± 75 μV at any electrode were excluded from analysis, as were trials with artifacts in the EOG channels. ERPs were quantified by measuring mean amplitudes in three latency intervals (300–500, 500–700, and 700–1200 ms for the test phase), relative to the mean amplitude of the pre-stimulus baseline ($-200–0$ ms). These intervals were selected based on visual inspection of grand-average ERPs, given that similar intervals have been used in prior studies of related ERP phenomena. Although initial analyses focused on three midline locations (Fz/Cz//Pz), topographic analyses confirmed that these midline locations captured the most important effects. ERPs were averaged for test phase data, when words were presented with

FIGURE 1 | Experimental stimulus sample.

FIGURE 2 | Experimental paradigm. During the study, a happy, fearful, or neutral face picture first was displayed, then a Chinese word was superimposed centrally on the picture and participants were asked to remember the word and the corresponding type of picture. During the test participants were instructed to press one of four buttons to indicate whether the displayed word was an old or new word. And then, for the old word, participants were instructed to indicate whether it had been shown with a fearful, happy, or neutral face.

a blank background. In the test-phase, trials for old items were classified as hit $_{\text{item w/source}}$ if the item was endorsed as an old item with the correct source judgment, and as hit $_{\text{item w/o source}}$ if the item was endorsed as an old item but with the incorrect source judgment. The hit $_{\text{item w/source}}$ and hit $_{\text{item w/o source}}$ both were tested for three different emotional contexts. Meanwhile, new trials were classified as correct rejections, if they were correctly endorsed as new, and as false alarms, if incorrectly endorsed as

old. The hit $_{item\ w/source}$ and hit $_{item\ w/o\ source}$ both have three types as for different emotion.

For each dependent variable, an ANOVA with repeated measures was performed. All ANOVAs were two-tailed with a level of significance set to $\alpha = 0.05$ and supplemented with pairwise comparisons or simple effect comparisons when appropriate. For all effects with two or more degrees of freedom in the numerator, we adjusted when appropriate for violations of sphericity, which are inherent in ANOVAs, according to the Greenhouse and Geisser (1959) formula. Midline ERP measurements were evaluated using a condition-by-electrode-location ANOVA for each latency interval. Main effects of electrode location are not reported.

RESULTS

Behavioral Results

Given the four-key response requirements in the source test, we analyzed two different hits in three different emotion contexts. One hit was correct item and source (hit $_{item\ w/source}$). The other was when the source judgment was incorrect (hit $_{item\ w/o\ source}$). The mean accuracy and reaction times (RTs) for hit $_{item\ w/source}$ and hit $_{item\ w/o\ source}$ in fearful, happy, and neutral contexts, as well as data for correctly rejected new items, are shown in **Table 1**.

Hit Rates

One-way repeated-measures ANOVAs were conducted on hit rates of the three conditions (hit $_{item\ w/source}$, hit $_{item\ w/o\ source}$, correct rejections) separately for three different emotion face contexts. A main effect of condition was observed for all of the three different emotion face contexts ($ps < 0.001$). Tukey HSD tests revealed that both hit $_{item\ w/source}$ rates and hit $_{item\ w/source}$ rates were lower than correct rejection rates, meanwhile hit $_{item\ w/source}$ rates were higher than hit $_{item\ w/o\ source}$ rates ($ps < 0.05$), regardless of the emotional context (See **Table 1**).

One-way repeated-measures ANOVAs were conducted on hit $_{item\ w/source}$ rates with three different emotional contexts and no main effect of emotional context was observed ($p > 0.05$). But the results of one-way repeated ANOVAs conducted on hit $_{item\ w/o\ source}$ rates with three different emotion contexts showed a main effect of emotional context, $F(2,28) = 6.946$, $p < 0.01$, $\eta^2 = 0.19$. A Tukey HSD test revealed that hit $_{item\ w/o\ source}$ rates, either in fearful or in happy context, were higher than hit $_{item\ w/o\ source}$ rates in neutral context ($ps < 0.05$) (See **Table 1**).

RTs

One-way repeated ANOVAs were conducted on RTs with three conditions (hit $_{item\ w/source}$, hit $_{item\ w/o\ source}$, correct rejections) separately for three different emotional contexts. A main effect of condition was observed for all the three emotional contexts ($ps < 0.001$). Tukey HSD tests revealed that both hit $_{item\ w/source}$ RTs and hit $_{item\ w/source}$ RTs were longer than correct rejections RTs regardless of the emotional context. On the other hand, hit $_{item\ w/source}$ RTs were shorter than hit $_{item\ w/o\ source}$ RTs in happy and neutral contexts ($ps < 0.05$), while there was no significant

difference between hit $_{item\ w/source}$ RTs and hit $_{item\ w/o\ source}$ RTs in fearful context ($p > 0.05$).

One-way repeated-measures ANOVAs were conducted on RTs for hit $_{item\ w/source}$ with three different emotional contexts and a main effect of emotion context was observed, $F(2,28) = 8.262$, $p < 0.01$, $\eta^2 = 0.41$. A Tukey HSD test revealed that RTs for hit $_{item\ w/source}$, either in neutral or happy context, were significantly faster than RTs for hit $_{item\ w/source}$ in fearful context ($ps < 0.05$). No significant difference was revealed between RTs for hit $_{item\ w/source}$ in neutral and happy context. One-way repeated ANOVAs conducted on RTs for hit $_{item\ w/o\ source}$ with three different emotional contexts showed a main effect of emotional context, $F(2,28) = 3.732$, $p < 0.05$, $\eta^2 = 0.26$. A Tukey HSD test revealed that RTs were significantly slower for hit $_{item\ w/o\ source}$ in fearful context than in happy context ($p < 0.05$). No significant difference was found between RTs in fearful and neutral context (see **Table 1**).

Event-Related Potential Data

The mean (range) number of trials contributing to the average ERPs for each response type were for correct rejections, 265 (126–370); for fear/hit $_{item\ w/source}$, 93 (51–130); for fear/hit $_{item\ w/o\ source}$, 51 (20–94); for happy/hit $_{item\ w/source}$, 100(55–138); for happy/hit $_{item\ w/o\ source}$, 51(26-91); for neutral/hit $_{item\ w/source}$, 94(43–130); and for neutral/hit $_{item\ w/o\ source}$, 39(20,71).

Test-phase ERPs were analyzed separately for each condition. Clear differences were observed beginning about 300 ms after stimulus onset and lasted for 900 ms. ERPs were generally more positive for remembered words than for new words. This ERP difference is termed as an old/new effect and the old/new effect as a measure of cognitive and neural mechanisms of retrieval has been widely used (Friedman and Johnson, 2000). **Figure 2** shows ERPs from the three chief conditions in the test phase. Two different old/new effects were computed. The first was based on correct source recognition, such that hit $_{item\ w/source}$ trials were compared to correct rejections. The second old/new effect was based on recognizing the item as old but with the wrong context; hit $_{item\ w/o\ source}$ trials were compared to correct rejections. We are most interested in the difference of these two old/new effects and the different emotion effects on them. Thus, first: two different old/new effects would be contrasted separately for three different emotion face pictures that followed. These repeated-measures ANOVAs with two factors, condition (correct rejections/hit $_{item\ w/source}$/hit $_{item\ w/o\ source}$) and electrode location (Fz/Cz/Pz), were conducted on mean amplitude data for three time intervals, 300–500 ms (corresponding to a negative-going wave), i.e., N400 ms, 500–700 ms (corresponding to a late positive component, i.e., LPC), and 700–1200 ms (corresponding to a late slow wave, i.e., LSW). These time window regions were selected based on the timing of memory effects in previous studies (Rugg and Allan, 2000; Maratos and Rugg, 2001; Smith et al., 2004) and visual inspection of the present data. Secondly, another repeated-measures ANOVA with two factors, emotion condition (i.e., fearful/happy/neutral) and electrode location (Fz/Cz/Pz), was conducted to compare emotion effects separately in conditions of hit $_{item\ w/source}$ and hit $_{item\ w/o\ source}$.

TABLE 1 | Means (and SEs) for the Accuracies and Reaction Times (RTs) for each condition.

		Old			New
		Fearful context	Happy context	Neutral context	(Correct rejection)
Accuracy (SE)	hit item w/source	0.52 (0.14)	0.58 (0.13)	0.55 (0.12)	0.78 (0.20)
	hit item w/o source	0.31 (0.14)	0.30 (0.10)	0.23 (0.09)	
Reaction time in ms (SE)	hit item w/source	1013.70 (121.32)	957.39 (113.52)	973.15 (118.53)	847.41 (74.47)
	hit item w/o source	1075.94 (170.58)	1044.18 (164.24)	1074.57 (176.43)	

In the test phase, new trials were classified as correct rejections if correctly endorsed as new; old trials were classified as hit item w/source if the item was endorsed as an old item with the correct source judgment, as hit item w/o source if the item was endorsed as an old item but with the incorrect source judgment. The hit item w/source and hit item w/o source both have three types for different emotions.

Old/New effects

In fearful context The results of the ANOVA with two factors, condition (correct rejections/hit item w/source/hit itemw/osource) and electrode location (Fz//Cz//Pz) in the test phase of the 300–500 ms revealed a main effect of condition, $F_{(2,13)} = 39.120$, $p < 0.001$, $\eta^2 = 0.33$ and significant interaction effects between condition and electrode location, $F_{(4,56)} = 4.269$, $p = 0.03$, $\eta^2 = 0.37$. *Post hoc* comparisons (Bonferroni) showed the N400s were more positive both for fearful hit item w/source and fearful hit item w/o source compared to correct rejections ($ps < 0.001$) and there was no significant difference between hit item w/source and hit item w/o source. ($ps > 0.05$).

ANOVA of the 500–700 ms latency region revealed a main effect of condition, $F_{(2,13)} = 8.978$, $p < 0.05$, $\eta^2 = 0.42$. *Post hoc* comparisons (Bonferroni) showed the LPCs were more positive for both fearful hit item w/source and fearful hit item w/o source compared to correct rejections ($ps < 0.001$) and there was no significant difference between hit item w/source and hit item w/o source ($ps > 0.05$; see **Figure 3**).

For the 700–1200 ms latency region, ANOVA of the data revealed an interaction between condition and electrode location, $F_{(4,56)} = 12.476$, $p < 0.001$, $\eta^2 = 0.27$. *Post hoc* comparisons (Bonferroni) showed that for the hit item w/source old/new effect was reversed and the LSW amplitudes were larger for correct rejections than for fearful hit item w/source at Pz ($p < 0.05$). The hit item w/o source old/new effect was not significant ($ps > 0.05$) and there was no significant difference between hit item w/source and hit item w/o source ($ps > 0.05$) (see **Figure 3**).

In a happy context The results of the ANOVA with two factors, condition (correct rejections/hit item w/source/hit item w/o source) and electrode location (Fz/Cz/Pz) in the test phase of the 300–500 ms revealed a main effect of condition, $F_{(2,13)} = 59.12$, $p < 0.001$, $\eta^2 = 0.27$ and significant interaction effects between condition and electrode location, $F_{(4,56)} = 4.269$, $p < 0.05$, $\eta^2 = 0.29$. *Post hoc* comparisons (Bonferroni) showed the N400s were more positive for both fearful hit item w/source and fearful hit item w/o source compared to correct rejections ($ps < 0.001$) and there was no significant difference between hit item w/source/and hit item w/o source ($ps > 0.05$).

ANOVA of the 500–700 ms region revealed a main effect of condition, $F_{(2,13)} = 10.376$, $p < 0.001$, $\eta^2 = 0.30$ and significant interaction between condition and electrode location, $F_{(4,56)} = 3.778$, $p < 0.05$, $\eta^2 = 0.36$. *Post hoc* comparisons

(Bonferroni) showed that the LPCs were more positive for happy hit item w/source compared to correct rejections ($ps < 0.001$), but there were no significant difference between hit item w/o source and correct rejections ($ps > 0.05$) and no significant differences between hit item w/source/and hit item w/o source ($ps > 0.05$) (see **Figure 3**).

ANOVA of the 700–1200 ms revealed a significant interaction between condition and electrode location, $F_{(4,56)} = 10.900$, $p < 0.001$, $\eta^2 = 0.36$. *Post hoc* comparisons (Bonferroni) showed the LSWs were more positive for happy hit item w/source compared to correct rejections at Fz ($p = 0.037$), but neither did for hit item w/o source ($ps > 0.05$) and there was no significant difference between hit item w/source/ and hit item w/o source ($ps > 0.05$) (see **Figure 3**).

In a neutral context The results of the ANOVA with two factors, condition (correct rejections/hit item w/source/hit item w/o source) and electrode location (Fz/Cz/Pz) in the test phase of the 300–500 ms revealed a main effect of condition, $F_{(2,13)} = 19.12$, $p < 0.001$, $\eta^2 = 0.26$ and significant interaction effects between condition and electrode location, $F_{(4,56)} = 4.269$, $p = 0.03$, $\eta^2 = 0.17$. *Post hoc* comparisons (Bonferroni) showed the N400s were more positive for both fearful hit item w/source and fearful hit item w/o source compared to correct rejections ($ps < 0.001$) and there was no significant difference between hit item w/source/and hit item w/o source ($ps > 0.05$) (see **Figure 3**).

ANOVA of the 500–700 ms revealed a main effect of condition, $F_{(2,13)} = 13.059$, $p = 0.003$, $\eta^2 = 0.36$ and a significant interaction between condition and electrode location $F_{(4,56)} = 14.23$, $p = 0.016$, $\eta^2 = 0.17$. *Post hoc* comparisons (Bonferroni) showed that the LPCs were more positive for happy hit item w/source compared to correct rejections in all electrode locations, Fz ($p = 0.04$), Cz ($p = 0.021$), Pz ($p = 0.013$), but there were no significant differences between hit item w/o source and correct rejections ($ps > 0.05$) and no significant differences between hit item w/source and hit item w/o source ($ps > 0.05$) (see **Figure 3**).

For the 700–1200 ms, ANOVA of the data revealed an interaction between condition and electrode location, $F_{(4,56)} = 14.740$, $p < 0.001$, $\eta^2 = 0.19$. Further analysis showed the LSW amplitudes were larger for neutral/hit item w/source than for correct rejections at Fz ($p = 0.004$), but neither did for hit item w/o source ($ps > 0.05$) and there
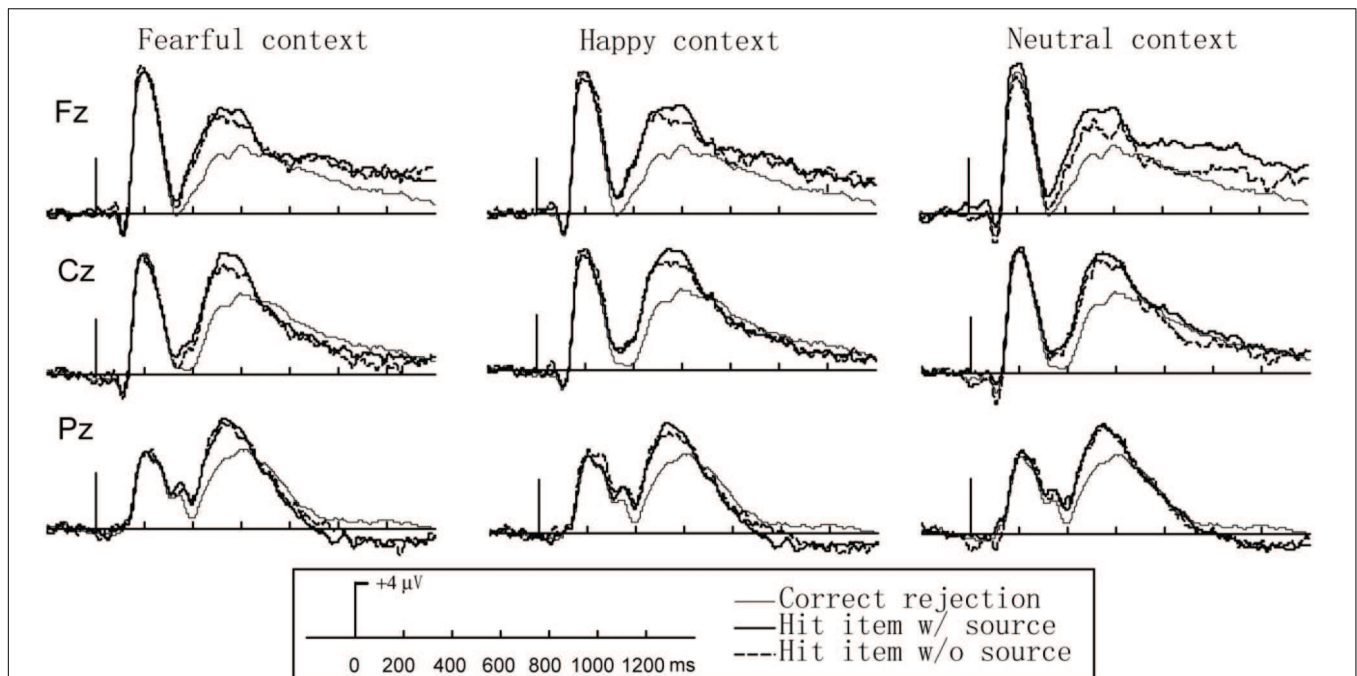
FIGURE 3 | Event-related potential (ERP) waveforms for hit item w/source, hit item w/o source, and correct rejection in the source test in different emotional valence contexts (Hit trials are correct responses to old items, and correct rejection trials are correct responses to new items).

was no significant difference between hit item w/source/and hit item w/o source (ps > 0.05) (see **Figure 3**).

Emotion Effects

To compare the effects of emotion on the ERPs elicited by hit item w/source in three different emotional contexts, repeated-measures ANOVA with two factors, i.e., emotional context (fear/happy/neutral) and electrode location (Fz/Cz/Pz) was conducted on mean amplitude data for three time intervals, 300–500, 500–700, and 700–1200 ms. The repeated-measures ANOVA results showed no significant difference on mean amplitude data for two time intervals, 300–500 and 500–700 ms. The ANOVA results of the 700–1200 ms revealed a main effect of condition $F_{(2,28)} = 4.086$, $p = 0.028$, $\eta^2 = 0.19$. *Post hoc* comparisons (Bonferroni) showed that the LSWs were more negative for fearful hit item w/source as compared to neutral hit item w/source and no significant difference between neutral and positive context or between negative and positive context (ps > 0.05).

Similarly, the repeated-measures ANOVA of hit item w/o source with two factors, i.e., emotion context (fear/happy/neutral) and electrode location (Fz/Cz//Pz), showed no significant difference on mean amplitude data for three time intervals, 300–500, 500–700, and 700–1200 ms (ps > 0.05) (see **Figure 4**).

DISCUSSION

By using a source memory multiple-task paradigm this study explored the differences between successful source retrieval, unsuccessful source retrieval, and different emotional context

effects on them. During the test phase, correct rejections need only item retrieval, but successful or unsuccessful source retrieval needs not only item retrieval but also source retrieval. So compared with correct rejections, successful and unsuccessful source retrieval were difficult. Our behavioral data suggested that hits of successful and unsuccessful source retrievals were lower and their RTs were longer than that of correct rejections. This was consistent with a previous study demonstrating that source retrieval was later than item retrieval (Guo et al., 2006). And compared with successful source retrieval, the hit of unsuccessful source retrieval was lower and the RTs of unsuccessful source retrieval were longer. This was consistent with previous findings. Results from this study suggest that RT could be extended either by unsuccessful source retrieval or uncertain source retrieval (Cansino et al., 2002). However, only in the fearful context, hit item w/o source RTs were not observed to differ significantly from hit item w/source RTs. There is a possibility that highly anxious individuals experience some form of interference from fearful stimuli even when correct judgments have been made.

As for emotional effects, hit item w/source rates did not show significant differences among different emotional contexts. On the other hand, hit item w/source RTs were significantly longer in fearful than in neutral and happy contexts. Hit item w/o source rates in happy and fearful contexts were higher than that in the neutral context. For hit itemw/o source RTs, there was no significant difference between fearful and neutral contexts. However, hit itemw/o source RTs were significantly longer in the fearful than in the happy context. The higher hit item w/o source rates in emotional contexts suggested that emotional contexts may facilitate the unsuccessful source retrieval in highly anxious

FIGURE 4 | Event-related potential waveforms for fear hit item w/source, **happy hit** item w/source, **and neutral hit** item w/source **in the source test.**
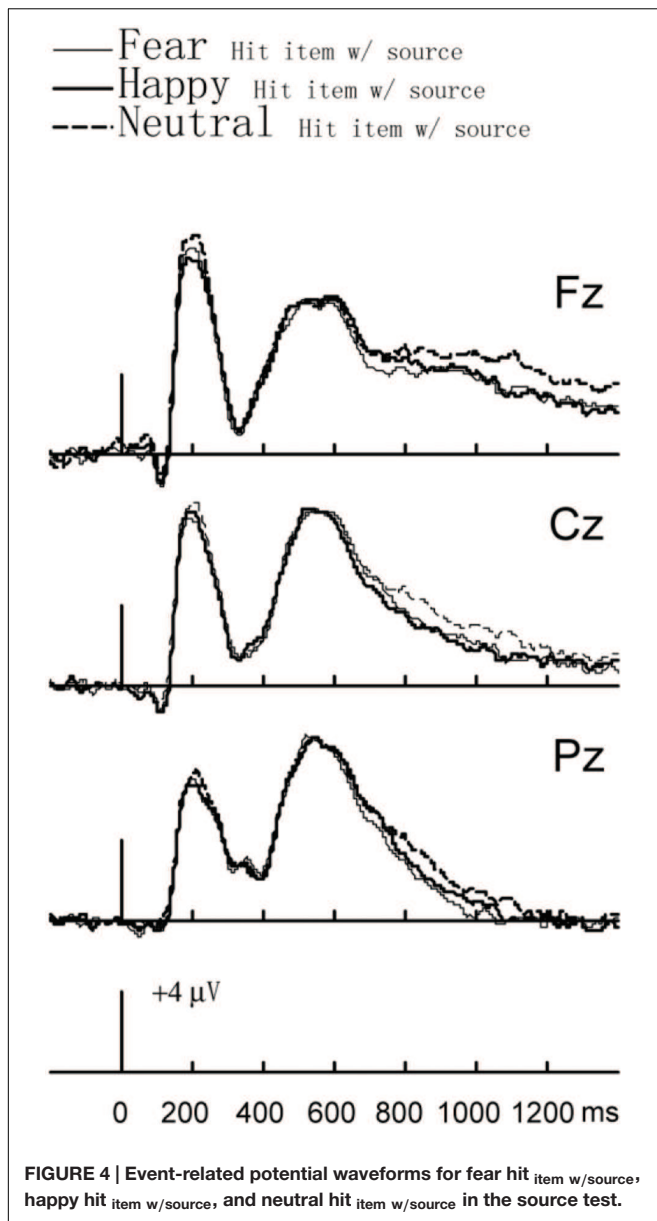
individuals. The longer hit item w/source RTs in fearful context suggested that highly anxious individuals may spend more time making judgments in fearful contexts during successful source retrieval.

Consistent with many prior reports, ERPs of successful and unsuccessful source retrieval were more positive than new items in the three different emotion contexts between 300 and 500 ms after stimulus onset (old/new effect; Mecklinger, 2000; Curran and Cleary, 2003; Speer and Curran, 2007). In addition, there was no difference between the old/new effects of hit item w/source and hit item w/o source conditions tested at this window in the three different emotional contexts. This suggested that N400 was related to early item retrieval and independent of source retrieval. Moreover, the current study indicated that item retrieval during 300–500 ms was not influenced by emotional contexts. It seemed

that item familiarity had not been modulated by the nature of the emotional context.

In the 500–700 ms (LPC), hit item$_{w/source}$ old/new effects existed in all electrode locations in the three emotional contexts. One effect relevant to the present study is a positivity toward a left parietal maximum, i.e., the so-called left parietal old/new effect. This effect goes into onset around 400 ms post-stimulus, has a duration of around 500 ms, and is thought be a correlate of episodic retrieval or "recollection" (Smith, 1993; Rugg et al., 1996). A second relevant effect is the "right frontal old/new effect." As implied by name, this is maximal over the right frontal scalp and goes into onset around 500–600 ms post stimulus, persisting for a second or more. The effect has been proposed as a neural correlate of post retrieval monitoring (Wilding and Rugg, 1996; Rugg et al., 1998). Some studies also found that brain regions associated with recollection were distributed closer to the frontal-central area (Duarte et al., 2004; MacKenzie and Donaldson, 2007; Speer and Curran, 2007). These showed that the distribution of the source memory covers a wide range of brain regions, including frontal, frontal-central area, and parietal area. They might have different functions in the retrieval on source memory. Supporting this, results in this study revealed non-significant emotion effects for hit item w/source condition when tested among the three emotion contexts at this window. All these results seemed to show that successful source retrieval (recollection) had not been modulated by the emotional context during 500–700 ms in the high-trait-anxiety individuals.

The ERPs for hit item w/o source in the fearful context were more positive than that for correct rejections during 500–700 ms time window. No such difference was revealed in the happy and neutral context. Thus, the higher positivity for fearful hit item w/o source compared with correct rejections may suggest that the high-trait-anxiety participants might have an enhanced memory bias for fearful source information related to source familiarity. According to dual process theory familiarity relies on automatic processes. This is consistent with the theory of selective information processing by Williams et al. (1988), which posited that highly anxious individuals display a memory bias for negative stimuli at the integration (automatic) stage of processing.

In the 700–1200 ms time window (LSW), hit item w/source old/new effects were observed at F$_Z$ electrode site and ERPs of hit item w/source in happy and neutral contexts were more positive than that of correct rejections. However, ERPs for hit item w/source in electrode P$_Z$ in the fearful context were more negative than that for correct rejections. Additionally, emotion effect analyses showed that at the 700–1200 ms time windows, ERPs of hit item w/source in the fearful context were more negative than that of hit item w/source in the neutral context. This result, together with the result of reversed hit item w/source old/new effects in the fearful context in the 700–1200 ms time windows, implied that the high-trait-anxiety participants minimized an explicit recollection of fearful information during source retrieval monitoring. Our findings were consistent with prior studies, one of which revealed that the slow waves at the left parietal area for anxious individuals were smaller for negative stimuli compared to other types of stimuli (Inaba and Ohira, 2009). A possibility

was the result of problems in attention among high-trait- anxiety participants (Williams et al., 1997). It has been suggested that anxious individuals avoid the elaborative processing of negative stimuli (Mogg et al., 1989; Holmes et al., 2008). For example, Mogg et al. (1989) reported greater interference in a Stroop task and lower accuracy for negative items in a subsequent recognition memory task among high-anxiety individuals. These findings were inferred to be due to selective attention and an avoidance of elaborative encoding of negative items. Recently, Holmes et al. (2008) reported that when looking at a fearful face, the high-trait-anxiety group showed increased visual P1 and less significantly enhanced fronto-central positivity and EPN as compared with the low-trait-anxiety group. Considering all these results above, anxiety may favor attention processing mechanisms at early stages over the effort- and time-consuming elaborative processing mechanisms, due to the major role that anxiety plays in the detection and avoidance of negative or dangerous encounters in one's surroundings (Mogg and Bradley, 1998).

However, one limitation of the present study was that only the high trait-anxiety-group was used and, thus, it was unable to say whether the findings were actually driven by trait anxiety. A normal control or low trait anxiety group would be needed for such a purpose. Another limitation was that the sample size was rather low. Although we had sufficient power to detect the influences of fearful context based p-values and effect sizes provided in the results section, future studies with larger sample size are still needed to help support the conclusion made in the present study.

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CONCLUSION

This study provided preliminary behavioral and electrophysiological evidence of the effects of emotion context on source memory processing mechanisms in high-trait-anxiety participants. Study results showed that early unsuccessful fearful source retrieval processes (related to source familiarity) were enhanced, but late successful fearful source retrieval processes during source retrieval monitoring (related to source recollection) were weakened in high anxiety individuals. However, in happy and neutral contexts, results differed. This study provided preliminary evidence for the dual processing theory.

AUTHOR CONTRIBUTIONS

LC and GS the main writers and contributors of the paper and contributed equally to this work. CG the director of the research. GS completed most parts of the experiment and data analysis. FH finished part of the data analysis. GS and ZQ revised the paper. TO finished the English editing.

FUNDING

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Emotion Regulation Therapy: A Mechanism-Targeted Treatment for Disorders of Distress

Megan E. Renna[1,2], Jean M. Quintero[1,2], David M. Fresco[3,4] and Douglas S. Mennin[1,2]*

[1] The Graduate Center, City University of New York, New York, NY, USA, [2] Hunter College, City University of New York, New York, NY, USA, [3] Psychology Department, Kent State University, Kent, OH, USA, [4] Case Western Reserve University School of Medicine, Cleveland, OH, USA

"Distress disorders," which include generalized anxiety disorder and major depression are often highly comorbid with each other and appear to be characterized by common temperamental features that reflect heightened sensitivity to underlying motivational systems related to threat/safety and reward/loss. Further, individuals with distress disorders tend to utilize self-referential processes (e.g., worry, rumination, self-criticism) in a maladaptive attempt to respond to motivationally relevant distress, often resulting in suboptimal contextual learning. Despite the success of cognitive behavioral therapies for emotional disorders, a sizable subgroup of patients with distress disorders fail to evidence adequate treatment response. Emotion Regulation Therapy (ERT) is a theoretically derived, evidence based, treatment that integrates principles (e.g., skills training, exposure) from traditional and contemporary therapies with findings from basic and translational affective science to offer a framework for improving intervention by focusing on the motivational responses and corresponding regulatory characteristics of individuals with high levels of chronic distress. Open and randomized controlled trials have demonstrated preliminary support for the utility of ERT as reflected by strong effect sizes comparable to and exceeding established intervention approaches. In addition, pilot findings support the role of underlying proposed mechanisms in this efficacious response. This article presents the functional model associated with ERT and describes the proposed mechanisms of the treatment. Additionally, a clinical case is presented, allowing the reader to gain a greater applied understanding of the different components of the ERT model and treatment.

Keywords: emotion regulation, mindfulness, treatment, generalized anxiety disorder, depression

INTRODUCTION

Generalized anxiety disorder (GAD) and major depressive disorder (MDD) are often referred to as "distress disorders," in part because of the profound misery and suffering they confer and that they are especially treatment refractory. Indeed, reviews of lifetime prevalence rates of comorbidity estimated three of out of every five individuals diagnosed with GAD also meet diagnostic criteria for comorbid depression (Tyrer and Baldwin, 2006; Fisher, 2007), while prospective longitudinal estimates range from these disorders being 48–72% comorbid (Moffitt et al., 2007). These disorders, particularly when they co-occur, often fail to make sufficient treatment gains thereby prolonging

their deficits in life functioning and satisfaction. For example, only 50–60% of GAD patients treated with traditional cognitive behavioral therapy (CBT) achieved clinically meaningful change—lower than the success rate for other mood and anxiety disorders (Borkovec and Ruscio, 2001). Similarly, the most efficacious psychological treatments for MDD are at best only modestly superior to non-directive supportive therapy (Cuijpers et al., 2008). Also, when GAD is comorbid with MDD, patients demonstrate suboptimal durability of their depression treatment gains (Newman et al., 2010). Finally, in the National Institute of Mental Health (NIMH)-funded, Sequenced Treatment Alternatives to Relieve Depression Study, the subgroup of patients who evidenced the weakest treatment gains reflected a clinical presentation of mixed anxiety-depressive disorder (e.g., MDD + apprehensive anxious symptoms) was most treatment refractory (Farabaugh et al., 2010).

The term distress disorders was derived primarily from actuarial studies of diagnostic comorbidity and the surface characteristics of various mood and anxiety disorders (e.g., Watson, 2005; Krueger and Markon, 2006). However, grouping these conditions under this heading may in fact reveal a set of shared neurobehavioral characteristics that contribute to the clinical severity and challenges of achieving an optimal treatment response. Additionally, the term distress disorders signifies that although nosological systems such as the Diagnostic and Statistical Manual for Mental Disorders (DSM; American Psychiatric Association, 2013) and the International Classification of Diseases (ICD; World Health Organization, 1992) may be descriptive in terms of the surface characteristics of disorders such as GAD and MDD, they are largely agnostic to the known or hypothesized etiological factors. In particular, patients with distress disorders, especially GAD and MDD are characterized by intense emotional experiences resulting in an inordinately cautious manner that favors protection over promotion (Woody and Rachman, 1994; Chorpita et al., 1998; Klenk et al., 2011). In addition, individuals with distress disorders frequently engage in one or more forms of negative self-referential processing (NSRP; e.g., Northoff, 2007) such as worry, rumination, and self-criticism as a way of relating to the arising of intensive emotional and motivational experiences (Mennin and Fresco, 2013). This profile or endophenotype represents the starting point of our Emotion Regulation Therapy (ERT; Mennin and Fresco, 2013) approach, a theoretically derived, mechanism focused treatment developed to better understand and reduce the suffering caused by distress disorders such as GAD and ruminative depression.

In particular, the ERT model melds principles from traditional and contemporary cognitive behavioral treatments (e.g., skills training and exposure) with basic and translational findings from affect science to identify targets of treatment in terms of core disruptions of normative motivational, emotional, and cognitive systems. The ERT model also aligns well with the Research Domain Criteria (RDoC) initiative (Cuthbert and Insel, 2010), proposed by the NIMH as an alternate system of nosology which seeks to identify mechanisms that explain processes from normative to dysfunctional variants in hopes that new forms of intervention can be developed to normalize the underlying biobehavioral dysfunction and ideally improve treatment efficacy for otherwise treatment refractory disorders. Specifically, several domains of the RDoC System overlap well with the mechanisms underlying the ERT model (i.e., sustained thr eat and loss in the negative valence system, reward learning in the positive valence system, and cognitive control within the cognitive systems domain). The ERT model also offers clinicians familiar with principles of cognitive-behavioral therapy, functional analysis, and emotion-focused therapies a means of deriving a case formulation approach to assessing hypothesized deficits in their clients, teaching emotion regulation skills that assist clients in noticing and responding to emotional cues in their lives, and helping to build lives that reflect a balance of seeking reward in the face of challenges and risks. The goals of this paper are to (1) introduce an emotion regulation model of distress disorders, (2) describe ERT components using a case vignette, (3) review the empirical evidence for clinical efficacy and purported mechanisms, and (4) briefly discuss future directions for improving understanding and treatment of distress disorders utilizing ERT.

EMOTION REGULATION PERSPECTIVE ON DISTRESS DISORDERS

Normative and Disordered Emotional Functioning

One of the most basic goals of all organisms is to bring balance with respect to engaging reward and minimizing loss while seeking safety and avoiding threat (Dollard and Miller, 1950). This balance is achieved by the fine tuning of a *reward system* which mobilizes behavioral approach toward rewarding or appetitive stimuli while minimizing loss and a *security system* which instigates avoidance of novel, potentially threatening, or painful stimuli or end states as well as engagement of safety stimuli that protect an individual from such perceived threats and can reinstate a state of quiescence and calm. The security and reward systems are relatively independent and can be activated alone or in unison in response to a prompt (Stein and Paulus, 2009). In essence, normative functioning represents a constant state of engaging and resolving situations that provoke conflicts of motivational systems in service of taking effective behavioral action. Correspondingly, engaging behavioral actions to achieve or restore motivational balance likely consists of responding in a manner reflecting a contextually and situationally appropriate balance of reward/loss and safety/threat systems while also informing one's actions by higher order values-based decision-making (e.g., Wilson and Murrell, 2004). Attaining goals that reflect motivational salience and one's personal values provides feedback relating our behavioral effort to an outcome.

Emotions are an important part of our motivational systems serving as cues and signals guiding us to flexibly respond to events in our lives in accordance with both personal goals/values

and changing contexts (Frijda, 1986). In some instances, the optimal tuning in a given situation results in the accentuation (i.e., up-regulation) of the emotional salience of the situation; in other instances, toning down (i.e., dampening) the emotional aspects of the situation is warranted (Ochsner et al., 2004). A functional systems approach to emotion regulation argues that these systems work together to maintain dynamic homeostasis between bodily systems and internal and external stimuli in a context-appropriate manner.

Individuals with distress disorders frequently experience conflicting pulls from reward/loss and safety/threat systems and lack the means to effectively resolve these motivation conflicts. Klenk et al. (2011) lends support to this view of motivational conflict, especially with respect to GAD and MDD, by drawing from regulatory focus theory (RFT; Higgins, 1997), a normative model of promotion (i.e., reward/loss) and prevention (i.e., safety/threat) motivations where these two systems are conceptualized as separate and mutually inhibitory of one another. In accounting for GAD, especially when it co-occurs with MDD, Klenk et al. (2011) postulate primary failure in the prevention system (i.e., hyperactivation) that in turn can lead to failure (e.g., hypoactivation) in the promotion system. One possibility is that salience in one or both of these motivational systems may increase levels of subjective intensity and corresponding distress. Although more rigorous experimental and biobehavioral research is needed, preliminary findings support a role for both motivational dysfunction (i.e., Campbell-Sills et al., 2004) and subjective intensity (i.e., Mennin et al., 2007) in the distress disorders.

Rather than processing emotion information and utilizing its motivational value, individuals with distress disorders often fail to enhance or diminish emotional experiences in a manner appropriate to a particular environmental context. Emotion regulation deficits commonly occur in GAD (Mennin et al., 2007; Etkin et al., 2010; Etkin and Schatzberg, 2011), and MDD (Johnstone et al., 2007). These deficits are seen at all levels of cognitive elaboration of emotional cues (i.e., levels of verbal linguistic processing of the emotional information).

At a less elaborative level, individuals with distress disorders exhibit attentional rigidity in processing both interoceptive and exteroceptive emotional stimuli (Mogg and Bradley, 2005; Clasen et al., 2013). For example, GAD with and without MDD is characterized by a failure to spontaneously regulate emotional conflict by shifting attention in response to a motivationally salient emotional stimulus in conflict adaptation task (Etkin et al., 2010; Etkin and Schatzberg, 2011). Individuals with distress disorders also struggle to implement more verbally elaborative strategies. Aldao and Mennin (2012) found that when trying to implement emotion regulation strategies such as cognitive reappraisal and emotional acceptance, GAD participants showed a paradoxical pattern of increased heart rate variability during a post-evocative film recovery period compared to control participants who demonstrated the expected pattern of decreased heart rate variability during this period. A similar paradoxical pattern was found by Johnstone et al. (2007) when comparing the neural activation during a similar

reappraisal task in individuals with MDD as compared to healthy control participants. Specifically, those with MDD showed a positive association between ventromedial prefrontal cortex and amygdala activation during reappraisal compared to control participants who showed an inverse relationship between activation in the ventrolateral prefrontal cortex and the amygdala that was mediated by the ventromedial PFC prefrontal cortex. Further, pupil dilation findings demonstrated that depressed patients who expend more effort to reappraise negative stimuli had greater activation in the amygdala, insula, and thalamus, whereas control individuals demonstrated decreased activation in those areas. Rather than effectively engaging adaptive emotion regulation strategies, individuals with distress disorders alternatively utilize perseverative strategies that may be employed to compensate for a negative emotional state, chiefly by enveloping it in elaborative negative self-referential processing (Borkovec et al., 2004; Nolen-Hoeksema et al., 2008; Mennin and Fresco, 2013).

Negative Self-Referential Processing and the Challenge of Distress Disorders

The ability to reflect on one's self may represent the most core human form of mentation (e.g., Raichle et al., 2001). Self-referential processing is often a useful means of resolving situations associated with a pronounced discrepancy between a current emotional/motivational state and a representation of the future (i.e., planning), past (i.e., failures/losses), or an idealized self (i.e., self-analysis; Borkovec et al., 2004; Carver and Scheier, 2004). Reflecting on the past, future, and one's sense of self can help mentally prepare for action toward desired goals and avoid undesired ones. This same ability, however, may be associated with dysfunction (Olatunji et al., 2013). NSRPs are common processes in many forms of psychopathology, including GAD and MDD, and includes repetitive or perseverative thought (Watkins, 2008) such as rumination (e.g., repetitive thinking about past mistakes aimed at reducing distress related to perceived losses; Nolen-Hoeksema et al., 2008) and worry (e.g., repetitive thinking about future events aimed at reducing distress that arises from conflicting emotional and motivational states; Borkovec et al., 2004; Mennin and Fresco, 2013). Despite the slightly different focus of these two forms of perseveration, the functional utility of worry and/or rumination are likely similar in that they offer a potential escape from a wide array of considerably aversive potential threats and losses. In addition, self-criticism (e.g., evaluation of the emotional self characterized by unworthiness, inferiority, failure, guilt, and chronic fear of disapproval and rejection; Blatt, 1995) can be seen as another form of NSRP that also can be seen as a desperate means of coping or compensating with intense emotional experiences.

In essence, individuals with distress disorders may be more prone to utilize NSRPs to escape or dampen emotionality at the cost of accurately gleaning the motivational message that is being conveyed, undermining immediate behavioral action in response to one's emotions, and ultimately, losing sight of the enriching and fulfilling aspects of life. This false sense of short-term security comes with a price of minimizing attention to

potentially rewarding experiences (Bogdan and Pizzagalli, 2006; Whitmer and Gotlib, 2012); thus perpetuating the diminished quality of life commonly reported by individuals with distress disorders. There is, therefore, a strong need within the field for the development of treatments that specifically aim to reduce NSRPs in an effort to ameliorate symptoms and promote more adaptive emotion regulation.

One hypothesis regarding the treatment refractory nature of these disorders is that individuals with distress disorders who are most difficult to treat are highly characterized by NSRPs. Specifically, pre-treatment levels of rumination predict an inferior acute treatment response in MDD and dysthymic disorder (e.g., Ciesla and Roberts, 2002; Schmaling et al., 2002; Jones et al., 2008). Similarly, higher levels of residual depression symptoms and rumination are associated with a greater likelihood of relapse following acute treatment for MDD with CBT (Watkins et al., 2011) and MBCT (Michalak et al., 2008; Farb et al., 2011; Bieling et al., 2012). Like rumination, self-criticism has also shown deleterious effects on treatment efficacy both in terms of acute treatment gains and in long-term treatment gains (Blatt et al., 2010). Finally, deliberate efforts to target forms of NSRP (e.g., worry and rumination) improve treatment durability (van Aalderen et al., 2011; Watkins et al., 2011; Wells et al., 2012), providing evidence for the utility of developing and honing treatments that are specifically aimed at reducing levels of NSRP among individuals with distress disorders.

Narrow and Rigid Contextual Learning

Adaptation refers to the process by which an organism becomes better suited to prospering in their habitats (Dobzhansky, 1970). Identifying and emitting the contextually appropriate behavioral response may be the difference between life and death and between love and loss. Adaptive and flexible behavioral responses are dependent upon the ability to increase awareness of cues and contingencies in the environment and respond in ways to promote survival and success. Adaptive motivational responses and regulatory capacities provide a foundation for behavioral flexibility in that they help us attain maximal emotional clarity (e.g., Gohm and Clore, 2002) and subsequently implement effective and goal-relevant responses for optimal behavioral outcomes.

Optimal reward learning requires us to take behavioral actions that are informed by the assignment of value to possibly rewarding stimuli and subsequent predictions about when and where we might encounter these stimuli (O'Doherty, 2004). Bogdan and Pizzagalli (2006) examined factors such as reward sensitivity (increased likelihood of responding to "rich" rewarding stimuli based upon past learning history) as evidence of the influence of emotion and accurate cue detection on reward learning and behavior. Similarly important is our ability to reliably detect and respond to cues that signal a clear and present danger (LeDoux, 1996) and, subsequently, learn to accurately detect safety cues and differentiate these signals from threat so that we do not expend valuable resources (e.g., time and energy) in attempts to escape from 'non-threats.' Contemporary models

of threat and safety learning are predicated on principles of Pavlovian conditioning and the knowledge that successful fear extinction represents new, inhibitory learning (Bouton et al., 2001).

Emotion regulation plays an important role in inhibitory learning via selection of optimal responses that promote abolishment of a conditioned emotional response. With respect to threat and safety learning, adaptively attending to motivational and emotional signals can facilitate inhibitory learning. By contrast, one factor important to achieving durable inhibitory learning is the degree of stimulus generalization that an individual displays in relation to the acquisition of a conditioned stimulus (CS; Lissek, 2012). In particular, individuals prone to anxiety disorders are less successful in discriminating the properties of stimuli that share characteristics with a training CS, thereby resulting in stimulus overgeneralization and experiencing fear elicitation to a broader array of stimuli. Similarly, for most organisms, signals or cues in the environment of unambiguous safety from fear leads to new inhibitory learning that helps abolish the conditioned emotional response. Individuals with distress disorders often exhibit impoverished and inflexible repertoires of behavior in response to the situations that typically function to promote escape, avoidance, or inactivity as a means of attempting to manage emotional/motivational signals (e.g., Ferster, 1973). These behavioral patterns negatively impact reward learning. For example, depressed individuals exhibit suboptimal responsivity to future opportunities for reward even after cued to the availability of these reward (Bogdan and Pizzagalli, 2006). Bar (2009) proposed a model of optimal functioning characterized by broad and contextual associative processing of historical and environmental factors to accurately imagine future events and outcomes. Depressive rumination is one strategy common to distress disorders that narrows associative processing and in turn, decreases the likelihood of new reward-based learning and obfuscates focusing on purposeful action (Bar, 2009). Whitmer and Gotlib (2012) found that instructing depressed individuals to ruminate interfered with learning the probability that a particular stimulus would be associated with punishment.

Similarly, individuals prone to anxiety disorders are less likely to achieve a durable and broad-based abolishment of a conditioned fear response because of deficits in detecting cues of unambiguous safety. Instead, their search for safety is often characterized by hypervigilance and overactivity, thereby resulting in an inferior and less durable acquisition of inhibitory learning (Woody and Rachman, 1994; Lohr et al., 2007). Further, resorting to worry to regulate perceived threat experiences has been shown to encourage avoidance of emotional processing (Borkovec et al., 2004; Newman and Llera, 2011) and results in increased threat conditionability, greater stimulus generalization, and diminished ability to discriminate stimuli and learning contingencies (Otto et al., 2007; Salters-Pedneault et al., 2008; Lissek, 2012). Finally, GAD is associated with restrictions in valued actions and goals (Michelson et al., 2011). ERT was therefore developed in an effort to promote contextual engagement while reducing NSRPs for individuals with distress disorders.

FIGURE 1 | Conceptual model of target mechanisms, change principles, and therapeutic processes in Emotion Regulation Therapy.
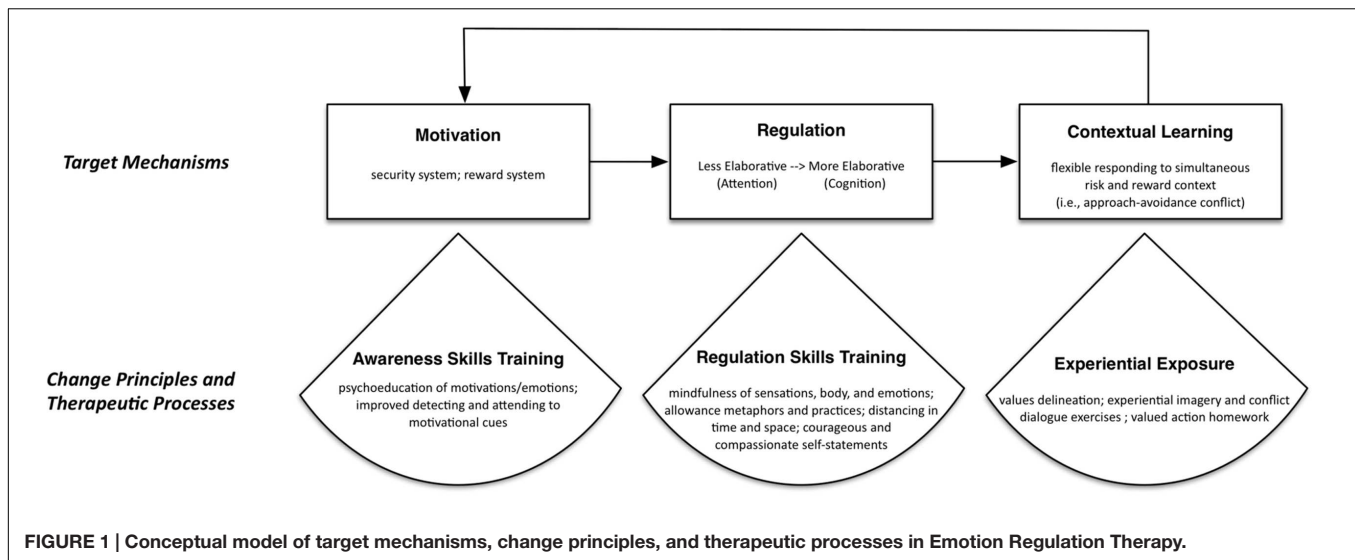
EMOTION REGULATION THERAPY

In its current form, ERT is a manualized intervention consisting of 16 weekly sessions (a prior version of the treatment utilized a 20 weekly sessions format; e.g., Mennin et al., 2015) that specifically target motivational mechanisms, regulatory mechanisms including self-referential (i.e., worry, rumination, and self-criticism) and behavioral (i.e., avoidance, reassurance-seeking, and compulsive behaviors) responses, and contextual learning consequences that are hypothesized to comprise the distress disorders (see **Figure 1** for a summary of the relationship between this model and ERT components). ERT is divided into two sequential phases, with the first phase of treatment focusing on the cultivation of mindful emotion regulation skills with the goal of promoting intentional and flexible responding to intense emotional experiences, including emotions of anxiety, anger, and sadness. These skills consist of practices designed to cultivate attention regulation followed by meta-cognitive regulation. All these skills are aimed at helping clients develop alternatives to the reactive cognitive responses such as worry, rumination, and self-criticism that have characterized their lives. Instead of reactively responding to challenging emotional situations, clients are taught to approach their lives "counteractively" by utilizing these skills in the moment when they first notice the arising of emotional and motivational cues. In the second phase of ERT, the focus shifts to promoting behavioral "proactivity." This contextual engagement is cultivated through assisting clients to identify what is meaningful in their lives and how anxiety and depression hold them back from this. Subsequently, clients are encouraged to proactively take actions reflective of this personal meaning and value (Hayes et al., 2012). Through the utilization of imaginal exposures and dialog tasks (described below), clients commit to taking meaningful actions between sessions that help cultivate an enriching and valued life.

There is no single assessment device, but from initial intake and throughout each component of the treatment, therapists render a clinical impression for the degree to which: clients endorse intense emotions as well as a narrowing of their focus on security to the exclusion of reward (i.e., motivational mechanisms); engage in rigid and reactive responses in service of escaping or avoiding intense emotions (i.e., regulatory mechanisms); and in turn, diminish their pursuit of potentially rewarding or enhancing experiences (i.e., contextual learning consequences). In addition to monitoring these aspects of the ERT model and purported mechanisms, therapists also track and revise their impressions regarding the degree to which clients demonstrate mindful awareness of emotions and motivations, demonstrate a capacity to regulate their emotions, and articulate and take actions reflective of meaningful reward and value. Finally, clients complete a brief standardized self-report battery prior to each session to capture a dynamic assessment of changes in worry, rumination, anxiety, depression, attention regulation, decentering, and reappraisal throughout treatment.

Introduction to Case: Lores

Lores is a 28-year-old Hispanic woman who has a master's degree and works as a financial consultant. She is currently single and describes numerous difficulties associated with past relationships, including fears of infidelity and constantly needing reassurance and support from romantic partners about relationship status and in making everyday decisions. Due to these worries, she avoids dating and experiences great discomfort from the idea of pursuing romantic relationships. Lores has been experiencing anxiety and worry, "for as long as [she] can remember" and has difficulty identifying a time when she was not plagued by chronic and debilitating worry. Additionally, she expresses anxiety with respect to her career path as well as efforts to balance her anxieties regarding fear of failures in work endeavors with her strong desire to succeed in the finance field. She is currently studying for the Certified Financial Analyst (CFA) exam, and feels so much apprehension at the prospect of failing that she is considering not taking it at all. Two years prior, Lores attempted to take the exam and spent 6 months studying. However, on the day of the exam, Lores felt overwhelmed by her worries regarding failure that she

did not show up for the test. Currently, when she sits down to study, Lores experiences so much difficulty concentrating, due to rumination about this past failure or worry about failing again, that she often ends up not being able to study at all and eventually gives up. Additionally, Lores often has difficulty sleeping and chronic muscle tension, which causes her physical discomfort throughout the day. Finally, she has concerns about her family and worries whether she can adequately care for her parents given her mother's emotional difficulties and her father's physical disability that prevents him from working. This role reversal confers a significant economic, cognitive, and emotional burden on Lores that contributes to an overall reduction in her quality of life.

Although Lores has struggled with these symptoms for many years; over the past 2 years, she has increasingly felt down and depressed and often finds herself ruminating about past relationships and difficulties throughout her education and career, culminating in the failure to take the CFA exam. She often feels hopeless that things will never change and experiences excessive guilt, especially with respect to whether she has harmed her potential career advancement, and in turn the impact it might have on her ability to care for her parents. These thoughts often make her feel worthless and incapable of success and happiness – which in turn, makes her even more hesitant to pursue her CFA or pursue romantic relationships. In all, these symptoms of generalized anxiety and co-occurring depression cause significant impairment in Lores' everyday life. Recently, Lores has begun to isolate herself from her friends given her upset and has missed several days of work because of the fatigue and sadness that she often experiences.

Phase I: Mindful Awareness and Emotion Regulation Skills
Psychoeducation
The first component of Phase I emphasizes psychoeducation surrounding the challenges of distress associated with generalized anxiety and depression. At the outset, normative functioning related to the three target mechanisms in ERT is contrasted with the characteristics of chronic anxiety and recurring depression. Clients are encouraged to provide personally relevant examples that depict their struggles as a way for them to begin to see both past and current patterns through the lenses of ERT. At this introductory stage of therapy, clients are encouraged to adopt an open perspective and to start noticing the way they are swayed by emotions and motivations. Clients also learn about the role of reactive self-referential responses and contextualize these cognitive processes as poor ways of managing intense emotions such as sadness, anxiety, or fear and the motivational impetuses they engender. Throughout this early part of ERT, Lores learns that she often utilizes NSRPs such as rumination and self-criticism but also that her guilt and shame also are likely indicators of underlying anxiety and sadness.

Relatedly, Lores and her clinician discuss how her emotions may send her motivational messages that compel her to feel pulled toward security and/or reward. In introducing the motivational model, security is described as the ways in which

an individual feels pulled toward emotional safety, often resulting in avoidance, escape, or a lack of action altogether. In contrast, the reward system is described as drawing a person toward approaching things, with an emphasis on thriving rather than simply surviving. In reflecting on a moment when Lores was perseverating about her upcoming CFA exam, she and her clinician specifically identify that her strong pulls toward security are compelling her to avoid the exam altogether. However, through psychoeducation, they are able to establish that Lores also has reward motivations that encourage her to take the exam and feel efficacious about achieving her goals of becoming a CPA.

Cue Detection and Self-Monitoring
An integral component of ERT involves the utilization of cue detection, referred to in ERT as "Catch Yourself Reacting" (CYR), as a means of gaining awareness of one's emotional experience and its different components. This exercise is similar to self-monitoring, chain analysis (e.g., Linehan, 1993), or functional analysis (e.g., Ferster, 1973). Clients complete CYR forms in moments when they notice intense or difficult emotions. CYR forms help clients identify triggers of emotional responses in specific moments, emotions, motivational impetuses, "reactive" self-referential responses (i.e., worry, rumination, and self-criticism), and "reactive" behavioral responses (i.e., physical avoidance, compulsive behaviors, "emotional" eating or drinking). In the latter sessions of Phase I, clients also identify mindful emotion regulation skills that they deployed in the moment and alternative or "counteractive" behavioral responses that they imagined or engaged that would be more functional for achieving their goals. Clients are instructed to complete CYR forms several times each week as a way of promoting cue detection outside of session. Each subsequent ERT session typically begins with a review of an emotionally poignant moment that prompted the completion of a CYR. When a client does not complete their CYR forms over the past week, or when a particular CYR event did not resolve favorably, therapists lead clients in a practice referred to as a "Do-Over," which involves a vivid reimagining of the event and their emotional responding to the event, and results in the completion of a CYR in the moment within the therapy room. An example of a Do-Over conducted with Lores occurred regarding an instance when she became anxious about reaching out to her friends to invite them to dinner. This imagery exercise encouraged Lores to imagine the exact moment when she noticed her anxiety and subsequent strong pulls toward security. In doing so, Lores was better able to identify how anxiety led her to become worried and self-critical, and that these NSRPs resulted in her experiencing feelings of guilt, shame, loneliness, and sadness.

Mindful Emotion Regulation Skills
The emotion regulation skills utilized in ERT are based upon mindfulness meditation practice and implementation. Clients receive recordings of guided meditations that reflect the ERT skills described below. Their individual therapist records these meditation exercises so that clients can practice these "off-line" meditation practices at a set time each day to build the particular skill. Each skill also has a briefer "on-the-spot" practice that can

be completed in the moment when the client is experiencing an intense or stressful event. In the final session of Phase I, clients are presented with the complete ERT Toolbox, which outlines four main regulatory skills and associated practices. Clients also review the other components of the treatment covered thus far and clinicians underscore the necessity in implementing ERT skills as a way to get in touch with their experience from a different motivational configuration in service of responding to their emotions in a counteractive, rather than reactive, manner.

At the outset of Phase I, Lores learns attention regulation practices intended to cultivate one's capacity for *orienting* to their emotional experiences and *allowing* or sustaining their attention on the emotional experiences. These two skills are designed to help Lores identify and maintain awareness of her emotions and the ensuing motivational pulls that underlie the arising of her emotions. In orienting, Lores is taught to attend to her breath and body, noticing feelings of tension versus relaxation so that she can reliably attend to visceral sensations as well as her own emotional experience (e.g., Kabat-Zinn, 1990; Borkovec et al., 2002; Segal et al., 2002; Marra, 2004; Teasdale and Segal, 2007; Roemer et al., 2009). In allowing, Lores is taught that rather than suppressing her intense emotions, she can welcome them as part of her unfolding experience (see Hayes et al., 2012). The allowing practices (Segal et al., 2002; Ricard, 2006) assist clients to maintain attention on whatever arises without relying on internal (e.g., one's breath) or external (e.g., sounds, etc.) cues as an anchor for the practice. Lores experiences difficulty allowing intense emotions such as anxiety and sadness through the formal on-line skill, but is able to cultivate allowing through using the on-the-spot version of the skill, where she tells herself to pause or allow in emotionally intense situations as a way to invite in all the emotions that she is experiencing rather than suppressing or avoiding them.

After gaining competency in the attention regulation skills of orienting and allowing, clients like Lores are taught metacognitive regulation skills intended to help not only detect emotions and underlying motivational pulls but also create a healthy distance in order to generate emotional clarity rather than being reactive and automatically pulled to action. The first of these skills, is decentering (Safran and Segal, 1990; Fresco et al., 2007; Bernstein et al., 2015) or *distancing* as it is described to clients. Decentering helps clients gain temporal distance and perspective from emotionally evocative stimuli (e.g., viewing inner experiences as temporary; Kabat-Zinn, 1994) as well as spatial distance (e.g., viewing inner experiences as physical objects that are separate from oneself; Kalisch et al., 2005; Hayes et al., 2012). For Lores, the thought of registering for the CFA exam brought on overwhelming and smothering feelings of anxiety. Decentering allowed Lores to view this state of anxiety as a temporary product of her mind that was not all defining of her and consuming.

The other metacognitive regulation skill in ERT is cognitive reappraisal (e.g., Gross, 2002) or *reframing* as it is described to clients. Reframing refers to the ability to change one's evaluation of an event so as to alter its emotional significance. Within the context of ERT, reframing is approached in terms of meditation practice (Salzberg, 1995) intended to help clients develop courageous and compassionate self-statements, where clients are taught to re-evaluate a situation in a manner that appreciates and validates the presence of emotional pain and provides compassion for such experiences (Leary et al., 2007). Through the utilization of this skill, Lores learns to approach her emotional experience with compassion toward herself rather than being overcome by self-criticism through envisioning compassionate statements that she receives from other people and translating them to be offered to herself. Through the cultivation of reframing, Lores is eventually able to generate courageous statements that tell her that she is stronger than her anxiety and depressed mood. In moments where Lores experiences self-criticism, she calls to mind this courageous reframe by keeping a business card with this statement in her bag or pocket that she is able to read as a reminder to utilize this skill.

Taking Action

A final concept taught to clients in Phase I of ERT is Taking Counteraction, which is congruent with Linehan's (1993) notion of opposite action, as a way of restoring motivational balance and with an "outside-in" approach discussed in behavioral activation treatments (e.g., Jacobson et al., 2001; Martell et al., 2001). Taking counteraction involves encouraging clients to envision how their thoughts and actions would look if they were to act in a manner opposite to their current feelings and motivational pulls. For instance, Lores is asked to envision registering for her CFA exam and the strong pulls toward security that is prohibiting her from taking this action, and then to imagine what it would feel like with a different motivational configuration. The goal of this exercise is to allow Lores to get in touch with her reward motivation surrounding taking the exam and her desire to advance in her career, thus leading to greater balance between security and reward. In doing so, Lores may imagine or enact behavioral responses that reflect a more optimal balance of security and reward. Subsequently, Lores is encouraged to utilize her mindful emotion regulation skills to become comfortable with these behavioral responses and potentially how she feels about taking such an action.

Phase II: Experiential Exposure to Promote New Contextual Learning

Whereas the first half of ERT represents the movement from being "reactive" to "counteractive" in response to emotional states, the second half invites clients to become "proactive" in service of broadening one's behavioral repertoires. In this way, taking a proactive stance involves exposure to meaningfully rewarding, but often anxiety-inducing experiences. Exposure exercises are typically understood as a way to *reduce* emotion (especially fear) (e.g., Foa and Kozak, 1986). However, recent empirical and theoretical advances have advocated for a broader focus than simple emotion reduction. Indeed, modern learning theory suggests that exposure is effective, not because previously associated emotional meanings are unlearned or erased, but because new emotional meanings are strengthened (Bouton et al., 2001; Craske et al., 2008). Informed by important basic findings about the nature of classical extinction and inhibitory learning (e.g., Bouton et al., 2001), implementations of exposure

therapy have moved beyond sustained fear reduction and habituation accounts of extinction to promote superior inhibitory learning and extinction retrieval (e.g., Craske and Vervliet, 2013). Recent innovative treatments for depression have also benefited from these basic and translational findings and, subsequently, utilized exposure to deliberately provoke and activate historical negative content such as loss, so that this material can be explored alongside information that is dissonant and serve to facilitate broad-based change in maladaptive cognitive–affective– behavioral–somatic patterns (e.g., Hayes et al., 2007).

Emotion Regulation Therapy is consistent with these theoretical accounts of inhibitory learning and uses various experiential techniques (i.e., imaginal exposure and experiential dialog) to prepare clients for real-world exposure. Specifically, ERT delineates three main exposure components to promote proactive living: (1) imagery related to taking proaction; (2) experiential dialog tasks to explore perceived internal conflicts related to motivational impetuses that may prevent proactions (e.g., Greenberg, 2002); and (3) planned between-session exercises wherein clients engage proactions in their everyday life. Finally, experiential engagement continues into the concluding sessions, wherein treatment gains are consolidated and the client prepares for the end of treatment. Clients and therapists discuss how their acquired ERT skills can continue to be utilized in service of responding to difficult events that might arise after the conclusion of treatment. In doing this, potentially stressful and painful life circumstances are explored in experiential exposure exercises that center on hypothetical situations related to core themes that may appear in the future.

Values Identification and Proaction

By the beginning of Phase II, Lores has acquired skills that assist her in taking a more forward looking or "proactive" orientation toward life rather than responding reactively through worry and rumination as a result of her intense emotions. The goal of this part of the treatment involves the client's ability to use mindful emotion regulation skills that facilitate taking proactions that reflect a meaningful and rewarding life path. Identifying meaningful proactions are accomplished by working with clients to delineate personal values, which represent a person's highest priorities and most cherished principles (Hayes et al., 1999, 2011; Wilson and Murrell, 2004). Taking proactions from a valued perspective involves intentionality and "top-down" processing of personal meaning and goal setting. However, the motivational configuration of the individual at any given point in time may introduce conflicts and pull the individual in a value incongruent direction. Therefore, ERT expands values-based processing to address more than just "top-down" decisions related to the person's values. It strives to strike a balance with "bottom-up" influences of security and reward motivational impetuses.

Clients complete exercises to help elucidate their values (e.g., Hayes et al., 2012). In identifying these values, clients are presented with different life domains (i.e., family, interpersonal relationships, community, self-care) and they are asked to identify how important the particular domain is to them on a 0–10 scale and how consistently they are living by this value on the same scale. Value domains that contain a large discrepancy

between its importance and how consistently the client is living by the value are optimal candidates for Phase II exercises (i.e., client indicates that the value is very important to them but they are not living consistently with said value; Hayes et al., 2012).

Imaginal Exposure

To assist clients in adopting a proactive orientation toward life, Phase II consists of a series of imaginal exposures centered on envisioning taking proactions. Specifically, imaginal exposure tasks that focus on engaging in specific proactions are conducted (1) to provide the client with an experientially rich rehearsal of the steps that might be necessary to take a proaction, and (2) to confront the emotional challenges that are likely to come up as the client imagines engagement of this proaction. In this imagery exposure task (called the "Do It" in session), therapists help clients imagine each step involved in engaging this action, while noticing changes in motivational impetuses and encouraging utilization of skills to address arising difficulties and obstacles. To begin this exercise, clients first imagine a safe space where they do not feel a strong need for security. Throughout the exercise, it is typical for clients to feel pulled toward wanting more security as they envision taking the proaction and begin to get in touch with the anxiety that may be associated with this action. This strong pull toward security and any associated discomfort sets the stage for the conflict dialog task (described below).

In the case of Lores, continued career growth is an important theme for her. However, she experiences a motivational conflict in deciding whether or not she should register for the upcoming CFA exam – considered a marker of success in her line of work – that she has spent a substantial amount of time preparing over the past several months. Due to this conflict, she experiences strong rumination over what she considers her past failure in not following through in taking the exam 2 years prior. Imaginal exposures with Lores involve guiding her step by step through the actions required to register to take the test, most notably actually registering for the exam, while assessing changes in her security and reward motivations. In an effort to deepen her experience throughout the exercise, the therapist assists Lores in envisioning steps that will highlight her pull toward security-based motivation that prohibit her from engaging in the action due to her increasing anxiety, including logging on to her computer and researching the deadlines to register for the exam and information required to register. Similarly, the therapist attempts to engage Lores's motivation toward reward by having her describe what it might feel like successfully register for and complete the CFA exam including not only a sense of relief but also potential feelings of accomplishment and agency.

Exploring Conflict Themes in Obstacles to Proaction

The second experiential exposure component involves addressing perceived obstacles (e.g., Hayes et al., 2012), which reflect the client's internal struggle that may be holding her or him back from engaging proaction. In ERT, obstacles are approached via "conflict themes" including primarily: (1) a motivational conflict (e.g., security motivations that are blocking or interrupting reward efforts); and, (2) self-critical reactive responses to

emotions (i.e., judgmental negative beliefs about one's emotional responses and associated motivations). These conflict themes are addressed within session using an experiential dialog task (Greenberg, 2002; Elliott et al., 2004). In ERT, the motivational conflict is addressed by encouraging clients to engage in a dialog between the parts of themselves that represent the conflict: the part that is strongly motivated to obtain security, and the part that is motivated toward a more unified motivational stance conducive to action. Throughout the dialog, clients physically move between two different chairs within the therapy room, and, with the therapist's coaching, alternate speaking from the security side of themselves that is currently holding them back and the proactive side of them, who want to engage in the action and see the importance in doing so. Ultimately, the goal of this task involves reaching a compromise between the two sides and ideally allowing the client to become more proactive in taking an action. This dialog task serves two main purposes. First, it represents an exposure to conflict themes, which can cultivate a greater sense of emotional tolerance. Secondly, the task aims at generating new perspectives (i.e., new meaning) on the obstacles that hinder proactive engagement. Clients are invited to use this greater emotional tolerance and these new perspectives to reflect on their stated values and bring about a greater commitment to taking action to cultivate them.

Through completion of this task, Lores is able to realize that although she is pulled strongly by security, she recognizes the importance of attain her CFA certification and the potential promotion that may accompany it. Within this exercise, Lores is able to engage her sense of reward in her work and infuse her proactive reward voice with an impetus to engage despite her fears. In this sense, Lores' voices that encourage security versus proactive engagement are able to reach an agreement, and she is able to move forward, despite the anxiety that she feels over the uncertainty associated with taking the exam and the possibility of change in her life.

Between-Session Proactions

In an effort to promote a proactive approach toward life not only within session, but between sessions as well, clients and therapists work together at the end of each ERT session to identify an action that they can take during the week to move them closer toward their value in any given domain. Ideally, optimal candidates for planned actions are centered on the imaginal exposure and conflict dialog task that they completed during session. However, in the event that these tasks presented emotions that were too intense for the individual to confront and they are unwilling or unable to complete the action presented throughout the session, a smaller, more manageable action is chosen with guidance from the therapist.

Similar to the CYR form that is used to promote self-monitoring and counteraction in the first half of ERT, clients are encouraged to complete a See Yourself Acting (SYA) form during the second half that facilitates planned proactions that take place between sessions. The SYA form is comprised of two parts, and is specifically designed to assist the client in working through the different emotions, reactive responses, and levels of security

and reward that are present prior to completing the action in the first part. Further, after completing the action, clients complete a second column of the form, which fosters the processing of the experience, including the outcome of attempting to take the action and any emotions and reactive responses that actually came up while completing it as well as their actual levels of security and reward that were present. Ideally, clients complete the first part of the SYA form in session with the client as a way to troubleshoot potential internal (i.e., emotional and motivational) and external (i.e., logistical) obstacles that may be presented in their attempt to complete the action. Clients then complete the second part of the form after attempting to engage the action between sessions, and bring the completed form back with them to the next session to discuss the outcome with their clinician.

Lores has many potential candidate planned proactions. Given the strong pulls toward both security and reward in regards to her job and taking the CFA exam, an optimal planned action between sessions would be for her to officially register for her exam. Given that she sees great importance in furthering herself at work (i.e., reward), but also experiences anxiety associated with taking the exam and potential failure (i.e., security), this action represents an appropriate balance between the two motivational systems that will assist her in living a more proactive manner. A potentially less anxiety-provoking action could be researching information on registering for the CFA exam or going to the bookstore and purchase a prep book to aid in her studying. In thinking about the significant burden that she endures as the caretaker and provider of her family, an additional proaction that may be explored in these sessions may involve self-care, and establishing activities that will provide her with a sense of joy and release that she would not typically pursue. The ultimate goal of this exercise with Lores is to have her gain self-efficacy through her ability and determination to complete these actions outside of session, and complete larger actions over time in an effort to ultimately live consistently with her expressed values.

Termination and Consolidating Treatment Gains

The final sessions of Phase II (sessions 14–16) focus on the termination of the therapeutic relationship and assisting the client in becoming more independent in her or his ability to take larger steps toward a proactive life following the end of ERT. For Lores, these final sessions will specifically focus on goal-setting in further envisioning her life if she could overcome anxiety and a strong pull toward security as well as ways to reduce her tendency to ruminate and the mood variations that she is prone to experiencing. During these final meetings, Lores and her clinician strategize about the skills that she can use when her emotions become intense. At this point, clients and therapists reflect together on the progress that has been made throughout the course of ERT in reviewing the ERT Toolbox and identifying points throughout the treatment where they have noticed change within themselves in an effort to further establish self-efficacy. Finally, ERT therapists and clients say their goodbyes, with the goal of the client continuing to utilize their ERT skills following the termination of treatment.

EVIDENCE IN SUPPORT OF ERT

To date, ERT has been administered in university-based clinics and counseling centers serving both community members and students. ERT is delivered by doctoral students in clinical psychology who have been trained and supervised by the third and fourth authors. Adherence to the manual has been high in all trials in terms of both frequency (ranging from 73 to 100%) and skillfulness (ranging from 80 to 100%) of the delivery of intervention components (discussed below). A 20-session version of ERT has established preliminary efficacy through an initial open trial (OT) of adults ($N = 20$; $M_{age} = 32.25$, $SD = 10.96$) diagnosed with GAD with and without co-occurring major depression (Mennin et al., 2015) and in a randomized control trial (RCT) of adults ($N = 63$; $M_{age} = 38.30$, $SD = 14.46$) examining symptom changes throughout ERT in comparison to a minimal attentional control condition (Mennin et al., under review). ERT was well tolerated by clients, as evidenced by low rates of attrition in the course of treatment. In terms of clinical outcomes, patients in this initial OT evidenced reductions in both clinician-assessed and self-reported measures of GAD severity, worry, trait anxiety, depression symptoms, and corresponding improvements in quality of life, with within subject effect sizes well exceeding conventions for large effects (Cohen's $d = 1.5$–4.5). These gains were maintained for 9 months following the end of treatment (Mennin et al., 2015). The patients in the RCT who received immediate ERT, as compared to a modified attention control condition, evidenced significantly greater reductions in GAD severity, worry, trait anxious, and depression symptoms, and corresponding improvements in functionality and quality of life, with between subject effect sizes in the medium to large range ($d = 0.50$–2.0). Similar to the OT findings, these gains were maintained for 9 months following the end of treatment (Mennin et al., in preparation). A sizable subgroup of GAD patients with comorbid MDD were enrolled and treated. Within-subject effect sizes in both clinician-assessed and self-report measures of GAD severity, worry, trait anxious, and depression symptom, and corresponding improvements in functionality and quality of life were comparable to the overall trial findings between individuals in the immediate or delayed treatment conditions, thereby suggesting that MDD comorbidity did not interfere with treatment efficacy ($d = 1.5$–4.0). Furthermore, depression-related outcomes such as rumination and anhedonia were reduced considerably ($d = 1.5$–2.0).

These findings offer substantial preliminary evidence for the effectiveness of the treatment, but these samples were relatively limited to a largely homogeneous sample of Caucasian, middle-aged participants with middle- to upper-class socioeconomic backgrounds. Thus, the current 16-session version of ERT has recently been tested in an OT format with an ethnically diverse and disadvantaged sample of young adults ($N = 32$; $M_{age} = 22.25$, $SD = 2.48$) diagnosed with a primary diagnosis of any anxiety or mood disorder including GAD (Renna et al., in preparation). This sample is relatively diverse, with many participants from various cultural and socioeconomic backgrounds throughout a large, urban commuter college campus who were seeking treatment in the college-counseling center for mood and anxiety issues. Specifically in regards to race, this sample consisted of individuals of whom 43.8% of the sample self-identified as Caucasian, 6.3% as African American, 21.9% as Asian American or Pacific Islanders, 9.4% as mixed race, and 3.1% as other. 15.6% of the sample also self-identified their ethnicity as Hispanic/Latino. Preliminary results demonstrate a comparably severe sample to the previous trials and similarly strong ameliorative changes from pre-to-post treatment in worry, rumination, generalized anxiety, anhedonic depression, clinician rated severity of GAD and MDD, social disability, and quality of life (all p-values < 0.05; d's $= 1.3$–4.1). These gains were maintained at a 3 and 9-month follow-up (all p-values < 0.05; d's $= 1.6$–4.7). Although findings from this study offers evidence for ERT reducing symptoms associated with anxiety and depressive disorders in a diverse young adult sample population, future work that includes a waitlist control is still needed to make any conclusions about efficacy in this young adult population.

We have also examined whether these treatment outcomes are the result of changes in the outlined target mechanisms by assessing changes in performance on lab-based computerized behavioral tasks across three time points within the previous 20-session version of ERT: pre-treatment, mid-treatment, and post-treatment. One promising preliminary finding is related to emotional conflict adaptation (Etkin et al., 2010; Etkin and Schatzberg, 2011) wherein clients were administered a conflict adaptation task and evidenced pre- to mid-treatment improvements in their ability to shift their attention in the face of emotional conflict (pre to mid $d = 0.74$) to levels comparable to healthy controls (Etkin et al., 2010). Indeed, a baseline comparison between the clinical group and healthy controls demonstrated a significant between-subjects effect of Group (patient versus control) for conflict adaptation ($p = 0.006$, $\eta_p^2 = 0.12$). Further, these pre- to mid-treatment changes were associated with gains in patients' ability for greater mindful observing which in turn was associated with reductions in social disability throughout the follow-up period (Renna et al., in preparation). The Emotional Interference Task (EIT; Buodo et al., 2002) was also completed by a subset of ERT participants to assess changes in attentional flexibility throughout treatment. Particularly, participants were instructed to respond to a tone as quickly as possible following viewing of neutral and negative images. Findings from this task demonstrate that clients increased their ability to sustain attention despite emotional distraction from pre- to mid-treatment, when attention skills are targeted, after viewing both neutral ($p = 0.032$; $d = 1.331$) and negative ($p = 0.031$; $d = 1.341$) images. Further, this change in attentional flexibility from pre to mid treatment significantly predicted reductions in anxiety and worry at post-treatment as well as decreases in social disability and emotional reactivity (Renna et al., in preparation). This subset of individuals' performance on the EIT was also compared to a healthy control group at pre-treatment. Results demonstrated a significant difference between participants in the GAD and control group for negative images ($p = 0.046$, hedge's $g = 0.545$) and neutral images ($p = 0.047$, hedge's $g = 0.544$).

We also developed an Approach-Avoidance variant of the Implicit Association Task (AAIAT) and administered this task to a subset of patients to examine changes in implicit associations related to security- and reward-related processing throughout ERT. Specifically, patients demonstrated changes in the motivational salience of approach versus avoidance words from mid to post-treatment ($p = 0.019$; $d = 1.076$) when motivational change is directly engaged. Further, these mid-to-post changes were strongly associated with changes in emotional clarity, negative emotionality, and quality of life (Quintero et al., in preparation). We have also assessed heart rate variability (HRV), an index of parasympathetic flexibility (Porges, 2001; Thayer et al., 2012), during a fearful film throughout treatment. At pre-treatment, clients displayed a flattened response throughout the experimental period (suggesting reduced cardiac flexibility) and across this period demonstrated lower levels of HRV compared to a normal control comparison group. At mid-treatment, clients displayed a quadratic pattern of vagal withdrawal (i.e., reactivity) and vagal rebound in comparison to pre-treatment ($d = 0.81$), reflecting a more normative response to these changing emotional contexts. Clients who showed the greatest increases in parasympathetic flexibility from pre- to mid-treatment showed the greatest pre- to post-treatment gains in diagnostic severity, anxiety, and mood symptoms. Despite these promising mechanistic findings, the exclusion of a control treatment diminishes the ability to attribute treatment change to specific components of ERT. Despite this limitation, taken together, these preliminary data are supportive of our hypotheses that ERT may, in part, exert its therapeutic impact through normalization of emotion regulatory mechanisms.

CONCLUSION AND FUTURE DIRECTIONS

Distress disorders are highly comorbid with each other and may be commonly characterized by temperamental features that reflect heightened sensitivity to underlying motivational systems related to threat/safety and reward/loss. Further, individuals with distress disorders tend to perseverate in a maladaptive attempt to respond to motivationally relevant distress and often utilize these self-referential processes (e.g., worry, rumination, and self-criticism) resulting in suboptimal contextual learning. Despite the success of cognitive behavioral therapies (CBT) for emotional disorders, a sizable subgroup of patients with distress disorders fail to evidence adequate treatment response. ERT is a theoretically derived, evidence based, treatment that integrates principles from traditional and contemporary therapies with findings from basic and translational affective science to offer a framework for improving intervention by focusing on the motivational responses and corresponding regulatory characteristics of individuals with high levels of chronic distress. Open and randomized controlled trials have demonstrated preliminary support for the utility of ERT as reflected by strong effect sizes comparable to and exceeding established intervention approaches. In addition, pilot findings

support the role of underlying proposed mechanisms in this efficacious response.

Ongoing trials are examining more nuanced demographic information of this sample of participants, such as primary language, personal and family income, sexual orientation, and parental education level. Additionally, a current trial of ERT is testing its transdiagnostic efficacy by requiring inclusionary criteria of high emotionality and inordinate negative self-referential processing but can be diagnostically heterogenous (American Psychiatric Association, 2013). Data on skills usage and mindfulness practice from past and current trials of ERT are also currently being analyzed to assess whether or not the use of these skills following the acute period of ERT is associated with maintenance of symptom improvement and mechanistic gains throughout the 3- and 9-month follow-up periods. An additional empirical question that we seek to examine in ERT is a question of dosing, i.e., what is the minimum number of sessions of ERT needed to promote symptom improvement, increased quality of life, and reduced social disability? With this aim in mind, a current trial of ERT is underway that examines the effectiveness of traditional 16-session ERT versus a more abbreviated 8-session version. The 8-session version of the treatment has been established in an effort to maintain treatment fidelity from previous versions of ERT, while potentially providing the treatment to a larger number of individuals, thereby reducing patient burden. The establishment of the effectiveness of 8-session ERT permits us to disseminate the treatment to a wider and more diverse group of individuals, and therefore, further advance the general understanding of the treatment. Accordingly, other investigators have recently begun to examine this briefer version of ERT with caregivers of those with cancer who are highly ruminative or worried given that this population has demonstrated a poor response to psychosocial treatments including CBT (Mennin and Fresco, 2014).

Although ERT has established preliminary efficacy as an intervention to treat generalized anxiety and co-occurring depression, due to its multiple mechanisms and treatment components, it is difficult to identify which aspects of the intervention are promoting symptom reduction and mechanistic change. We recently argued that all cognitive behavioral treatments share common core emotion-related principles (Mennin et al., 2013). Indeed, there have been a number of recent treatments that target emotions more directly and have improved our ability to treat anxiety and mood disorders including dialectical behavior therapy (Linehan, 1993), acceptance and commitment therapy (Hayes et al., 1999), mindfulness-based cognitive therapy (Segal et al., 2002), behavioral activation (Jacobson et al., 2001), acceptance-based behavioral therapy (Roemer et al., 2008), the unified protocol (Ellard et al., 2010), STAIR narrative therapy (Cloitre et al., 2002), and rumination-focused cognitive- behavioral therapy (Watkins et al., 2011). Although ERT utilizes similar treatment components and techniques to these approaches, ERT derives from a separate conceptual model. In particular, ERT represents an intervention that incorporates common underlying mechanisms of traditional and third-wave CBTs that reflect both basic research and affect science. It will be important to determine whether the underlying

mechanisms delineated in this paper and/or other mechanisms underlie the efficacy of ERT as well as these approaches. We also plan to use a dismantling approach to identify the way that specific skills in ERT may contribute to improvements in the purported mechanisms by examining whether briefer and more targeted intervention components can more precisely and specifically target the purported mechanisms of action. This work will allow us to better hone the treatment in identifying the way in which specific ERT skills, in isolation, promote changes in each purported mechanism. Additionally, future research may benefit from utilizing a control treatment to isolate gains made throughout treatment that may specifically be attributed to components of ERT. Finally, current research on ERT is examining neural underpinnings of the purported mechanisms associated with the treatment. Building upon the preliminary findings from the behaviorally based tasks, participants in our current trials are completing a number of computer-based tasks while undergoing functional magnetic resonance imaging (fMRI) at different points throughout treatment.

Although these findings offer support for the utility of ERT, clinical research must continue to delineate the longer-term impact of the treatment on individual's symptoms and overall well being going forward. Further, ERT should continue to be honed in an effort to reach a wider group of individuals through greater efforts for treatment personalization including addressing specific contextual challenges of diverse groups in terms of race, culture, and socioeconomic status. Despite the need for these future steps, ERT demonstrates a novel approach for treating distress disorders in an effort to promote stronger long-term ameliorative changes for the individuals suffering from these conditions.

ETHICS STATEMENT

This study was approved by the Ethics Commitee of Hunter College Human Research Protection Program (HRPP). All subjects in studies referenced were given full study consent prior to any research procedures.

AUTHOR CONTRIBUTIONS

All authors listed, have made substantial, direct and intellectual contribution to the work, and approved it for publication.

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Emotion Regulation in Schema Therapy and Dialectical Behavior Therapy

Eva Fassbinder[1]*, Ulrich Schweiger[1], Desiree Martius[2], Odette Brand-de Wilde[2] and Arnoud Arntz[3]

[1] Department of Psychiatry and Psychotherapy, University of Luebeck, Luebeck, Germany, [2] De Viersprong, Netherlands Institute of Personality Disorders, Halsteren, Netherlands, [3] Department of Clinical Psychology, University of Amsterdam, Amsterdam, Netherlands

Schema therapy (ST) and dialectical behavior therapy (DBT) have both shown to be effective treatment methods especially for borderline personality disorder. Both, ST and DBT, have their roots in cognitive behavioral therapy and aim at helping patient to deal with emotional dysregulation. However, there are major differences in the terminology, explanatory models and techniques used in the both methods. This article gives an overview of the major therapeutic techniques used in ST and DBT with respect to emotion regulation and systematically puts them in the context of James Gross' process model of emotion regulation. Similarities and differences of the two methods are highlighted and illustrated with a case example. A core difference of the two approaches is that DBT directly focusses on the acquisition of emotion regulation skills, whereas ST does seldom address emotion regulation directly. All DBT-modules (mindfulness, distress tolerance, emotion regulation, interpersonal effectiveness) are intended to improve emotion regulation skills and patients are encouraged to train these skills on a regular basis. DBT assumes that improved skills and skills use will result in better emotion regulation. In ST problems in emotion regulation are seen as a consequence of adverse early experiences (e.g., lack of safe attachment, childhood abuse or emotional neglect). These negative experiences have led to unprocessed psychological traumas and fear of emotions and result in attempts to avoid emotions and dysfunctional meta-cognitive schemas about the meaning of emotions. ST assumes that when these underlying problems are addressed, emotion regulation improves. Major ST techniques for trauma processing, emotional avoidance and dysregulation are limited reparenting, empathic confrontation and experiential techniques like chair dialogs and imagery rescripting.

Keywords: emotion regulation, emotional avoidance, Schema therapy, dialectical behavior therapy, experiential techniques, skills

INTRODUCTION

Dialectical behavior therapy (DBT) and Schema therapy (ST) have both shown to be effective treatment methods especially for borderline personality disorder (BPD) (Zanarini, 2009; Stoffers et al., 2012), a disorder that is specially associated with emotional dysregulation. Although both, ST and DBT, have a cognitive-behavioral background, there are major differences in how both methods

deal with emotions and emotion dysregulation. This paper provides an overview of background and theory of both treatment approaches, a model how both methods conceptualize emotion dysregulation and the major therapeutic techniques with respect to emotion regulation. Further it is discussed how DBT and ST concepts and techniques map onto the process model of emotion regulation from James Gross (Gross, 2015). Similarities and differences of the two methods are highlighted and illustrated with a case example.

BACKGROUND AND THEORY

Dialectical Behavior Therapy (DBT)– Background and Theory

Development of Dialectical Behavior Therapy and the Dialectic of Acceptance and Change

DBT was developed in the late 1980s by Linehan (1993a,b), originally for chronically (para)suicidal patients, then extended to patients with BPD. To that time, these patients had been considered as "untreatable." A focus on problem solving or cognitive restructuring, according to standard cognitive behavioral therapy (CBT), had been experienced as potentially invalidating by the patients and had led to frustration, angry reactions, resistance and treatment drop outs. On the other side, focusing on acceptance and validation has also been perceived as problematic by patients since their problems and behaviors did not change. This led to one of the most important features of DBT, the *"dialectic" of acceptance and change*. This means, that therapists, on the one hand accept patient as they are and provide validation for their thoughts, emotions and behaviors, while on the other hand therapists acknowledge the need for change and foster the learning of new skills to deal with problems and to reach personal goals (Linehan and Wilks, 2015). This dialectic stance has been inspired by principles of dialectic philosophy (e.g., everything is transient and finite, everything is composed of contradictions, passage of quantitative into qualitative changes, change results from a helical cycle of thesis, antithesis and synthesis).

DBT is currently the most extensively studied and used approach to treat BPD (Stoffers et al., 2012). In addition, DBT has been adapted and successfully tested for BPD with several comorbidities and other psychiatric conditions in which problems in emotion regulation lead to psychopathology such as substance misuse (Linehan et al., 1999, 2002; Dimeff and Linehan, 2008), eating disorder (Safer et al., 2001; Telch et al., 2001; Kröger et al., 2010), post-traumatic stress disorder (Steil et al., 2011; Harned et al., 2012, 2014; Bohus et al., 2013), or depression (Lynch et al., 2007).

Skill Acquisition and the four Modules in DBT

DBT conceives emotion regulation skills deficits as the core of BPD. Thus, the main focus of the treatment is the acquisition of a functional emotion regulation. With its CBT background, DBT draws from a broad spectrum of cognitive and behavioral treatment techniques to induce the development of skills in emotion regulation. Skill training is embedded in four modules:

- *Mindfulness* is central to all skills in DBT. The mindfulness skills derive from traditional Buddhist meditation practice, though they do not involve any religious concepts. In DBT it means the practice of being fully aware and present in the present moment, experiencing one's emotions, thoughts or body sensations without judging and without reacting to them. The mindfulness skills are divided into "what skills" (observing, describing and participating) and "how-skills" (non-judgmentally, one-mindfully and effectively). An important concept of this module is "wise mind," which allows to base decision making on a balance between intuition and facts. The implicit goal is to provide the experience that emotions and cognitions are internal events that are a patterned response to external and internal stimuli. Mindfulness allows watching cognitions and emotions from an observer perspective as separate both from the external world and the self.

- *Emotion regulation* compromises detailed psychoeducation on emotions in general and a broad spectrum of specific emotions to foster an in depth understanding of emotions and emotion regulation. It teaches skills in problem solving, checking reality and taking opposite action to behavioral tendencies associated with specific emotions as well as skills reducing emotional vulnerability. The module intends to give the patient a fresh look on emotions and to decrease emotional and experiential avoidance. A critical feature is to enable the patient to make an active choice between acting with an emotion or opposite to it.

- *Interpersonal effectiveness* teaches how to obtain objectives skillfully and how to act effectively with respect to objectives, relationship and self-respect. The implicit objective is to reduce interpersonal avoidance which is the key to change experiential and emotional avoidance and to increase interpersonal behavior that has a high probability of being positively reinforced.

- *Distress tolerance* focusses on teaching crisis survival skills. It fosters acceptance in situations that cannot be otherwise changed or avoided without making things worse. There is an emphasis on self-soothing, improving the moment and adaptive distraction. Important concepts are "radical acceptance" and "willingness." The module intends to decrease self-destructive ways of emotional avoidance like self-injury, substance abuse or distraction with risk taking behavior.

Major Components of DBT

In standard DBT there are four *major components*: skills training group, individual psychotherapy, telephone coaching, and consultation team.

- *DBT skills training group* is usually carried out in a group format with approximately eight patients and two skills trainers. The group follows a manualized protocol (Linehan, 2015a,b). In the original format group members meet once a week for approximately two and a half hours, yet there are varying adaptations to heterogeneous settings. The skills training group focusses on psychoeducation and training of behavioral skills in the four DBT modules mindfulness, interpersonal effectiveness, emotion regulation and distress

tolerance. Homework assignments for patients are given every session and aim at practicing the learnt skills in everyday live.

- *DBT individual psychotherapy* is carried out by an individual therapist on a weekly basis with 50 min sessions. The individual therapist is the primary treatment provider and responsible for treatment planning, crisis management and decisions about individual modifications of treatment. The individual therapist supports the patient in the implementation of the skills, he has acquired in the skills training group, helps with trouble shooting and removing obstacles to change and ensures generalization of change. The individual therapy follows a hierarchy with four stages and structured target levels for each stage. The idea is to optimize the change process and to begin the change process with reducing life-threatening and therapy interfering behavior and then proceed to support skills acquisition, treatment of comorbid conditions, finding solutions for problems in living and creating a life worth living. Basic treatment strategies comprise specific dialectical strategies, validation, behavior analysis, didactic strategies and problem solving, commitment strategies, contingency management, observing-limits procedures, skills training, exposure-based procedures, cognitive modification and stylistic strategies like reciprocal communication and case management strategies.

- *DBT telephone coaching:* In crisis situation patients can call their individual therapist outside the sessions and receive support in applying suitable skills. It was designed to help generalize skills into the patient's daily life.

- *DBT therapist consultation team:* Communication between the providers of individual therapy and skills training is very important to support each other in providing the treatment. In standard DBT the therapists meet weekly and review which skills are currently the focus of the group sessions and discuss any problems the patients have in applying the skills. The meetings safeguard that the therapists share a common language and a common knowledge about the skills communicated to the patients. Further they support each other to provide DBT.

Schema Therapy (ST)–Background and Theory

Development of ST

Schema therapy also derives from CBT and was originally developed by Young et al. (2003) for patients, which did not respond to standard CBT. These patients often had a comorbid personality disorder (PD) and showed complex, rigid, and chronic psychological problems in emotion regulation and in interpersonal relationships, which in most cases could be followed back into their childhood. These problems also impaired the psychotherapeutic process as those patients had difficulties in forming a collaborative relationship with the therapist and could not be reached with standard CBT techniques due to (anticipated) intensive emotional reactions and coping strategies such as avoidance or surrender. In the process of finding ways to address the needs of these patients, Young integrated ideas and techniques from other theoretical orientations into a classical

CBT frame (especially attachment theory, Gestalt therapy). A strong emphasis was placed on the biographical aspects for the development of maladaptive psychological patterns through traumatization in childhood and frustration of basic childhood needs. The therapeutic relationship was conceptualized as *"limited reparenting"* meaning that the therapist creates an active, caring, parent-like relationship with the patient (Young et al., 2003).

ST was developed as a transdiagnostic approach, but also provides disorder specific models for most PDs (see overview in Arntz and Jacob, 2012). Several studies have shown that treatment based on that model is very effective for patients with BPD (Giesen-Bloo et al., 2006; Farrell et al., 2009; Nadort et al., 2009; Dickhaut and Arntz, 2013), but also for other PDs (Bamelis et al., 2013). Good results are also reported for depression, post-traumatic stress disorder, eating disorders, and complex obsessive compulsive disorders (Cockram et al., 2010; Simpson et al., 2010; Malogiannis et al., 2014; Renner et al., 2016; Thiel et al., 2016).

Central Concepts in ST: Schemas, Coping Strategies and Modes

ST is based on the idea that aversive experiences and frustration of basic childhood needs (e.g., safety, love, attention, acceptance, or autonomy) lead in interaction with biological and cultural factors to the development of *maladaptive schemas*. Schemas are defined as organized patterns of information processing compromising thoughts, emotions, memories, and attention preferences (Young et al., 2003). Schemas have a strong impact on how individuals view themselves, their relationships to others and the world. Young described 18 maladaptive schemas, e.g., shame/defectiveness, social isolation, mistrust, or unrelenting standards (Young et al., 2003). If a maladaptive schema gets activated, associated painful emotions arise. In order to deal with these intensive emotions, *coping strategies* (surrender, avoidance, overcompensation) are developed that attenuate aversive emotions but impair adaptive interpersonal and self-regulatory behavior.

While working with BPD patients Young discovered that the schema model was not optimal to explain and work with the quick mood and behavior changes of these patients. Thus, he extended the schema theory with the mode model approach, first for BPD later for narcissistic patients (Young et al., 2003). Since then, the mode model has be elaborated and empirically tested with specific mode models for most PDs (Lobbestael et al., 2008, 2010; Bamelis et al., 2011). A mode is a combination of activated schemas and coping strategies and describes the current emotional-cognitive-behavioral state. A mode can change quickly, while a schema is rigid and enduring (schema = trait, mode = state; Young et al., 2003). It is therefore a convenient concept in clinical practice as it helps patients and therapists understand the sometimes quick emotional changes.

Modes can be divided into 4 broad categories:

(a) *Dysfunctional child modes* are activated when patients experience intense aversive emotions, e.g., fear or abandonment, helplessness, sadness (vulnerable child modes), anger, or impulsivity (angry/impulsive child

modes). Child modes develop when major needs, particularly attachment needs, were frustrated in childhood.

(b) *Dysfunctional parent modes (punitive or demanding)* are associated with self-devaluation, feelings of self-hatred, guilt, shame, or extremely high standards. They reflect internalized negative beliefs about the self, which the patient has acquired in childhood due to the behavior and reactions of significant others (e.g., parents, teachers, peers).

(c) *Dysfunctional coping modes* describe the excessive use of the coping strategies surrender (Compliant surrender mode), avoidance (e.g., Detached protector mode or Self-soother mode), or overcompensation (e.g., Self-Aggrandizer mode or Bully-and-Attack-mode) in order to reduce the emotional pain of child and parent modes. These modes are usually acquired early in childhood to protect the child from further harm and are therefore considered as "survival strategies."

(d) The *healthy modes* of the *healthy adult mode* and the *happy child mode* represent functional states. In the healthy adult mode, people can deal with emotions, solve problems and create healthy relationships. They are aware of their needs, possibilities and limitations and act in accordance with their values, needs and goals. The happy child mode is associated with joy, fun, play, and spontaneity. The healthy modes are usually weak at the beginning of therapy.

For a detailed description of all modes see Arntz and Jacob (2012).

Therapy Goals and Treatment Strategies in ST

The major goal in ST is helping patients to understand their emotional core needs and learn ways of getting needs met in an adaptive manner or to help them deal with the frustration if needs cannot be satisfied. This requires breaking through long-standing emotional, cognitive and behavioral patterns, meaning change of dysfunctional schemas, coping strategies and modes. According to the mode model there are specific goals connected with every mode guiding the treatment: Child modes are supported and comforted. Dysfunctional parent modes are reduced, therapists even "combat" the punitive parent mode. Dysfunctional coping modes should be reduced and replaced by healthier, more flexible strategies. However, as these modes have served as "protective shield" for vulnerable child modes for such a long time, therapists have to proceed particularly careful. Only if the patient feels safe enough in the therapeutic relationship, the adaptive function of the coping modes has been validated enough and their advantages as well as disadvantages have been reviewed cautiously, the patient will be able to reduce his "protective shield" and learn healthier strategies to deal with emotions and relationships. A last important goal is to strengthen the healthy modes. To achieve these goals, *mode-specific cognitive, experiential, and behavioral interventions* are used, with a strong emphasis on experiential techniques like chair dialogs and imagery rescripting. *"Limited reparenting"* (behaving like a "good parent" toward the patient, within the boundaries of the therapy relationship) is central to ST and underlies all therapeutic techniques. "Limited reparenting" serves as an antidote to traumatic experiences and leads to corrective emotional experiences. "Limited reparenting" provides empathy, warmth, protection and care for the patient. However, it may also be necessary to set limits to the patient and to empathically confront him with the consequences of his behavior and the need to change.

DBT AND ST MODELS OF EMOTION AND EMOTION DYSREGULATION

How DBT Conceptualizes Emotion Dysregulation

DBT explains BPD and its symptoms as the consequence of a severe disorder in the emotion regulation system. The genesis of these emotion regulation skills deficits is explained by the interplay of biological factors, learning history and social context (biopsychosocial model). Symptoms such as self-injury, binge eating, alcohol abuse, dissociation, or impulsive behaviors are regarded as coping strategies for intense emotions. Thus, a primary goal of DBT is to teach patients skill to tolerate and regulate intensive emotions.

DBT provides intensive psychoeducation on emotions and the (evolutionary) adaptive value of emotions. Emotions are considered as complex, brief, involuntary, patterned, full-system responses to internal and external stimuli (Ekman and Davidson, 1994). The DBT model of emotion and emotion regulation contains six interacting subsystems (Linehan, 2015b):

(a) Emotional vulnerability factors
(b) Internal and external events that serve as emotional cues (e.g., prompting events)
(c) Appraisal and interpretations of cues
(d) Emotional response tendencies (including physiological, cognitive, experiential responses and action urges)
(e) Non-verbal and verbal expressive responses and actions
(f) After-effects of the initial emotion, including secondary emotions and after-effects of problem behavior like social isolation or problematic peer relationships.

All DBT-modules (mindfulness, distress tolerance, emotion regulation, interpersonal effectiveness) are intended to improve understanding of own and other's emotions and learning emotion regulation skills. Patients are encouraged to train these skills on a regular basis. DBT assumes that expert knowledge on emotions, improved skills and skills use will result in better emotion regulation.

Although, this model was originally developed for patients with BPD, DBT has been applied in many other psychiatric conditions with data suggesting effectiveness (see above). Thus, it can be seen and used as a transdiagnostic model for optimization of emotion regulation skills in other clinical populations as well as in healthy individuals.

How ST Conceptualizes Emotion Dysregulation

In ST problems in emotion regulation are mainly seen as a consequence of adverse early experiences (e.g., lack of safe

attachment, childhood abuse or emotional neglect). Negative experiences in childhood have led to fear of emotions and result in attempts to avoid emotions and (intimate) relationships. Dysfunctional schemas about the self and relationships to other as well as about the meaning of emotions prevail (e.g., "Emotions always hurt" or "to show emotions is a weakness"). ST assumes that when these underlying problems are addressed, emotion regulation improves. Thus, emotion regulation is not directly addressed as in DBT and there is no explicit model of emotion and emotion dysregulation as in DBT. However, emotion dysregulation can be explained by the mode model.

In ST emotion regulation skills improve by experiencing safe attachment and validation of needs and emotions through the specific features of the therapeutic relationship (esp. "limited reparenting" and "empathic confrontation") and being safely guided through emotional processes with experiential techniques (e.g., processing of traumatic experience with imagery rescripting). Further, experiential avoidance mainly displayed by the coping modes is challenged as it blocks access and fulfillment of the patient's needs leading to enduring aversive emotions. ST assumes that by using these strategies the patient's fear of emotions reduces, while willingness to overcome experiential avoidance increases.

Gross' Process Model of Emotion Regulation and its Connection to DBT and ST

Gross' modal model of emotion regulation is the currently prevailing generic model to describe the emotion generating process (Gross, 2015). It compromises a *situation—attention—appraisal—response—sequence*: Briefly, the emotion sequence begins with a psychologically relevant *situation*, which can emerge from the external environment (e.g., being criticized by the boss) or from internal triggers like thoughts, body sensations, or other emotions (e.g., having a thought like "I am a loser"). Such a situation draws the individual's *attention* (e.g., attention focus on angry eyes of the boss) and gives rise to an *appraisal* (e.g., "I am going to get fired"). It follows a response including biological/experiential (e.g., heart beating faster, flushing, feeling ashamed or anxious) and behavioral changes (e.g., looking down, apologizing for mistake). This response often changes the situation (e.g., boss feels sorry after apology and says "Well, besides that one mistake, I am very glad that we have you in the team") and gives rise to a new sequence.

According to the "process model of emotion regulation" (Gross, 2015) emotions can be influenced by targeting any component of the situation—attention—appraisal—response—sequence:

- *Situation Selection* by avoiding or approaching situations (e.g., going to a party with nice people to make it more likely to have a feeling of joy or avoiding a critical person to avoid shame)
- *Situation Modification* refers to staying in the situation but adding new behavioral elements (e.g., by asking my friend to give me a hug)

- *Attentional Deployment* refers to selecting a new attentional focus within a situation (e.g., by talking to someone the feeling of shame gets stronger, if one focusses on own performance and mistakes like stuttering instead of shifting the attention focus to the conversation partner)
- *Cognitive Change* refers to modifying the appraisal of the situation or getting a critical distance to cognitions (e.g., saying: "The thought 'I am a loser' is a thought not the truth")
- *Response Modulation* refers to directly influencing experiential, behavioral or physiological components of the emotional response [e.g., taking a deep breath to relax and calm down body sensations (modulation of biological response) or going to an exam although one is afraid to fail (modulation of action response)].

Table 1 gives an overview of the five categories of emotion regulation strategies from the Gross' process model and how DBT and ST concepts and techniques map onto the process model. This results in a theoretical framework that allows the discussion of similarities and differences of these two psychotherapeutic methods with respect to emotion regulation. It is important to note that in this table the primary association between related DBT or ST technique and category of emotion regulation strategies is mentioned, although many techniques address several categories of emotion regulation strategies. In the following we describe the concepts and techniques first for DBT and then for ST and make the connection to every category of the process model of emotion regulation.

STRATEGIES AND TECHNIQUES TO REGULATE EMOTIONS

Concepts and Techniques for Emotion Regulation in DBT

DBT is a treatment model developed for a clinical population. The process model of emotion regulation is a generic model developed in basic sciences two decades later (Neacsiu et al., 2015). Yet there is apparently a strong similarity between the conceptualizations of emotion regulation in the process model and DBT. DBT offers specific behavioral and cognitive strategies for the regulation of emotions in each category defined by the process model (**Table 1**). The DBT part of **Table 1** was strongly inspired by Neacsiu et al. (2015), who already mapped the DBT model onto the process model of emotion regulation. DBT skills are taken from the recent DBT manual (Linehan, 2015a,b). As can be seen in the table the category of response modulation has been divided into *biological/experiential response* and *expression/action response*. Furthermore, we added *managing emotional after-effects of the initial emotion*, especially addressing secondary emotions, and *managing emotional vulnerability factors* to response modulation. In the following the main skills for each category are described. Of particular note is that especially mindfulness skills are essential for every category, since skills of each category afford mindful observing, describing and participating in the present moment effectively and without judgment.

TABLE 1 | Categories of emotion regulation strategies from the Gross' process model, related DBT, and ST concepts and techniques.

Categories of Gross' Process Model	DBT concept of emotion regulation difficulties	Related DBT techniques and skills	ST concept of emotion regulation difficulties	Related ST techniques
Situation Selection	Interpersonal skills deficit Experiential Avoidance Deficit of reinforcement	Planned Activities: Accumulate Positive Emotions, Action to Build Mastery Interpersonal effectiveness	Schema avoidance Schema surrender Schema overcompensation Experiential Avoidance	Psychoeducation in terms of mode model to foster understanding and overcome schema coping/experiential avoidance Empathic confrontation of dysfunctional situation selection that repeats history (e.g., dysfunctional partner choice) Cognitive techniques (e.g., schema or mode diary's identifying triggers, situations and unhealthy coping). Behavioral techniques (e.g., role plays of present situations, planning of healthy steps, stopping unhealthy choices)
Situation Modification	Problem solving skills deficits Interpersonal skills deficit	Problem solving Interpersonal effectiveness skills	Dysfunctional modes vs. Healthy adult mode	Becoming aware of emotional needs and helping patient "modify" situation so that needs are better met. Behavioral techniques (e.g., role plays of present situations, problem solving) Imagery Rescripting and PsychoDrama (Modification of context and situation)
Attentional Deployment	Mindfulness skills deficits	Mindfulness	Schema or mode maintenance (as attention is focused on information that confirms schema/mode)	Attention shift to different modes (e.g., with chair dialog or cognitive techniques), esp. to healthy adult mode
Appraisal	Dialectical dilemmas, Experiential avoidance due to meta-belief on emotions	Dialectic thinking, Validation, Check the facts Reality Acceptance Managing dialectic dilemmas, Walking the middle path	Distortion of information by early maladaptive schemas, Dysfunctional modes vs. healthy adult mode	Identification and re-appraisal of schemas through cognitive techniques (e.g., schema or mode diaries, socratic dialoq, schema-dialog) and experiential techniques (e.g., chair work and imagery rescripting; including trauma reprocessing) Change of meaning of early experiences that underlie dysfunctional schemas
Response Modulation	High emotional reactivity and sensitivity, Emotion regulation skills deficits, Interpersonal skills deficits, Mindfulness skills deficit	**Biological/experiential response Modulation:** Change physiology (TIP skills) Self-soothing Half-Smile/Willing hand **Expression/action response modulation:** Opposite action Interpersonal effectiveness Exposure Behavioral techniques **Managing emotional-after effects:** Psychoeducation on emotions Mindfulness and Acceptance skills (Identify and Label emotions, Observe and Describe Emotions, Exposure) **Managing emotional vulnerability factors:** Change Biological Sensitivity (PLEASE-Skills)	Dysfunctional modes vs. healthy adult mode	Limited Reparenting (modeling and shaping of emotional response in direct contact) Helping to express emotions and needs Modeling of healthy ways to deal with emotions by therapist Empathic confrontation to block problematic emotional reactions and promote functional reactions Emotional exposure Imagery rescripting (processing of traumatic experiences, altering of emotional response) Behavioral techniques including alternative behavioral responses and healthy self-soothing, relaxing strategies.

Situation Selection

Psychopathology related to this area arises when patient avoid situations that are important for their goals and values or if patients approach situations where they are more likely to have unpleasant emotions. Situational avoidance may result in a deficit of reinforcement and pleasant emotions. From the DBT

perspective the difficulties in this area mainly arise from skills deficits resulting in experiential avoidance (e.g., the patient does not go to a date with a friend caring for her to avoid feelings of shame or anxiety). The alternative possibility is that patients with deficits in social cognitions or interpersonal effectiveness skills deficit do not avoid aversive situations that may be avoided without a penalty (e.g., the patient meets with an invalidating friend).

The skill "*Accumulating Positive Emotions*" teaches patients that by approaching pleasant situations or situations that are meaningful in the light of their values and goals, they can increase positive emotions and reinforcement in their daily life in the short (e.g., by creating more pleasant events) and in the long run by living a life fitting their own values. "*Building Mastery*" aims at engaging in activities that foster the sense of competence, self-control, and self-efficacy. These two skills have an important overlap with behavioral activation treatment for depression (Kanter et al., 2009) and are in line with the strong emphasis on values in acceptance and commitment therapy (ACT) (Hayes et al., 2012). Moreover, *interpersonal effectiveness skills* are trained with the patients, where they learn to anticipate the consequences of interpersonal situations (e.g., "if I go dancing, when I feel lonely and have drunken alcohol and flirt with a drunken, older man, there is a high probability that he will try to have sex with me") and learn to take functional decisions, which situations to approach and which to avoid. Moreover, they learn how to build and maintain functional relationships and end destructing ones.

Situation Modification

Successful modification of situations especially affords problem solving strategies and interpersonal effectiveness skills. Patients are taught steps of standard *problem solving* (D'Zurilla and Nezu, 1999) to find and execute effective and doable solutions and to reduce distress in problematic situations. Within *interpersonal effectiveness* patients learn how to reach their goal in a specific situation without hurting others or damaging their own self-respect.

Attentional Deployment

Psychopathology in this area arises if the control of attention is inflexible and not directed to the situational context. Some patients avoid the perception of the situational context by distraction or dissociation because of fears of interpersonal rejection. Others focus their attention inwards on physical symptoms of anxiety or on internal cognitive processes like worry or rumination or try to suppress unwanted thoughts or emotions. *Mindfulness exercises* in DBT help to keep the focus of attention in the presence and to avoid inflexible attachment to internal events like thoughts and emotions.

Appraisal

Problems in this category are consequences of dysfunctional information processing. DBT assumes that patients have insufficient skills in dialectic thinking, that they do not consider sufficiently the opposing forces that make up inner and outer realities. Patients fluctuate between invalidation of their internal experience on the one side and states of cognitive fusion,

when they treat interpretations, assumptions and thoughts and emotions as facts in the outer world on the other side (e.g., "If I am angry, he must have done something wrong").

One core technique to teach dialectic thinking is *validation*. Using validation strategies, the therapist communicates to the patient that her behavior makes sense and has a connection to her present context and past learning history. This applies quite particularly when the behavior on the surface appears "dysfunctional." Uncovering the validity within problem behavior is a crucial prerequisite for changing exactly this behavior. The repeated use of validation strategies by the therapist will finally result in patients using validation as a skill. The skill "*Check the facts*" is the dialectic counterpart. It is intended to help patients to view thoughts as thoughts and emotions as emotions and to disentangle thoughts and emotions from actual facts. With this skill patients learn to consider actual facts for their decisions. DBT uses *mindfulness skills* with their focus on the present context as an antidote to worry, rumination and threat monitoring.

DBT conceptualizes problems in the appraisal category as caused by dialectical dilemmas: Patients often show patterns of dichotomous thinking are stuck in polarities, unable to move to a synthesis and are unable to anticipate or accept change. The skill "*Walking the Middle Path*" from the module interpersonal effectiveness teaches patients to find a synthesis between opposites: e.g., to base decisions on facts while concurrently experiencing intense emotions, to have a strong desire for change while concurrently dealing in an accepting way with the present moment. Further psychopathology in this category arises from meta-beliefs patients have on emotions (e.g., "Emotions are bad and destructive" or "Emotions should always be trusted"). These meta-beliefs, in DBT called "*Myths about emotions*," are challenged and psychoeducation is provided.

Response Modulation

DBT explains problems in this area with high emotional reactivity and sensitivity as well as skills deficits in emotion regulation, interpersonal effectiveness, distress tolerance and mindfulness. In DBT it is very important to separate the *biological/experiential response* including the action tendency, the urge to act with the emotion, from the behavior response itself. One major DBT-skill "*opposite action*" aims acting opposite of the emotion-driven behavior (e.g., to approach a dog although you have dog fear and the emotion of fear tells you to avoid dogs). This skill is indicated when the emotion driven behavior is not in accordance with the facts or the values of the patient. Moreover, *managing emotional after effects* and *vulnerability factors* are important subcategories in DBT.

- **Biological/experiential response**
  For BPD patients emotions often come with a high intensity of aversive physical sensations causing a high distress and a strong action urge, DBT provides a set of *distress tolerance skills*. These skills aim to calm down the high physiological arousal and to block acting on maladaptive urges. For example, the "*TIP skills*" (abbreviation for: *T*ip your face into ice cold water, *I*ntense Exercise, *P*aced Breathing, and *P*aired Muscle

Relaxation) teaches patients how to down-regulate their physiological response through temperature change, exercise, breathing, or muscle relaxation. For the down-regulation of distress there are many other strategies in the DBT manual including *self-soothing with the five senses*, *distracting* (e.g., with activities) or changing the body posture to a more accepting posture (e.g., *half smiling and willing hands*). Half smiling was developed in line with research showing that facial expression influence emotions (Ekman, 1993). Patients are supported to develop a "*distress tolerance skill chain*" for high distress situations and perform a sequence of distress tolerance skills (e.g., 1. Ice cold water, 2. run steps three times up and down 3. Bite into chili pepper). It is very important to acknowledge the dialectic that DBT aims at mindfully accepting arousal and emotions without judgment while at the same time acting to reduce arousal. These skills serve as crisis strategies in high distress situations to block dysfunctional action urges like self-injury, rage attacks, or alcohol consumption, which lead to a further complication of the situation.

- **Expression/action response**
  Every emotion comes with an action urge. Many times acting on the urge is effective. If the behavior does not fit the facts or the values of the patient, there is the possibility to modify the behavioral response. An important option for emotion regulation is "*opposite action*" where one explicitly does the opposite of the emotion-driven behavior. This skill of course includes *exposure* to unpleasant emotions and follows similar principles as exposure-based treatments for anxiety disorders (e.g., approaching the feared stimulus). These principles are transferred to other emotions such as shame, disgust, anger, guilt, or sadness. "Opposite action" is also an important part in the treatment of depression, as proposed by Behavioral Activation (Kanter et al., 2009): Patients are motivated to engage in activities and to act opposite to the depression urge of social withdrawal, inactivity and avoidance. Changing action tendencies includes changing the overt action (e.g., being kind to a person one is angry with) but also body language, facial expression, or tone of voice. To address all these components patients are also trained in *interpersonal effectiveness*. It is important to distinguish opposite action from thought or emotion suppression or submissive interpersonal behavior: Opposite action does not intend to suppress an emotion, but to be mindfully aware and accepting of an emotion and its action urge, but to be able to decide to act differently. Opposite action does not intend to "give in" in contentious issues, it opens up new possibilities for solving interpersonal conflict.

- **Emotional after-effects**
  Emotions do not only influence concurrent behavior, cognition and emotion but also future behaviors, cognitions and emotions. Therefore, emotional after-effects of events are an important topic for emotion regulation. After effects may give rise to specific changes in attention, physiology, behavior, and appraisal. Humans avoid or perform specific behaviors because they anticipate specific emotional states. Much of emotional distress is caused by secondary emotions

due to judgments about the primary emotion (e.g., evaluation of anxiety as "stupid" leads to intensive shame as secondary emotion. The evaluation of anger as meaning "you are an aggressive person" leads to guilt when the primary emotion of anger occurs). Mindful awareness of these emotion cycles helps to interrupt them and to apply change strategies if necessary. In the first step DBT provides *psychoeducation on emotions* in general and on specific emotions such as anger, disgust, guilt, joy, love, shame, fear, envy, jealousy, or sadness. For each emotion the adaptive value, typical prompting events (cues), interpretations/appraisals, biological/experiential changes, expression/behavior changes, after-effects, and secondary emotions are explained and words how to describe the emotion are provided. This helps patients to "*identify and label emotions*." Moreover, patients learn to *observe and describe* emotions in a non-judgmental way. A very important aspect is *mindfulness and acceptance* in *exposure to emotional experience,* especially to the primary emotions. This means "experiencing emotions without judging them or trying to inhibit them, distract from them or to hold on them" (Linehan, 2015b).

- **Emotional vulnerability**
  DBT aims at fostering resilience by addressing emotional vulnerability factors. PLEASE is an acronym for treating *P*hysical *Il*lness, balanced *E*ating, avoiding mood-*A*ltering substances, balancing *S*leep, and getting, adequate *E*xercise.

Concepts and Techniques for Emotion Regulation in ST

Although, emotion-oriented interventions and systematic emotional work are central to ST, it is important to keep in mind that in ST regulation of emotions is not in the foreground of ST theory. ST intends to change dysfunctional schemas on the self, on relationships to others and on the world as a whole (as well as on the meaning of emotions), which underlie today's problems. These dysfunctional schemas were developed early in childhood through adverse experiences and gave rise to coping strategies such as avoidance, surrender or overcompensation to deal with (expected) threat or gratification. These coping strategies have often become very rigid and block access to the underlying schemas. Thus, the schemas cannot be changed and the disorder is maintained. ST of course aims to break through these rigid coping mechanisms to reach the dysfunctional schemas, however the ultimate aim is to change the underlying schemas.

Painful emotions and difficulties in regulating them are seen as a consequence of these underlying dysfunctional schemas. For instance, if one's need for emotional intimacy cannot be met because the representation of other people includes that other people will take advantage of you, if they see this "weak" need, or will punish you for having this need, it is understandable that dysfunctional emotion regulation results (e.g., by keeping out of intimate relationships). If corrective experiences in treatment lead to a change of the schema representation of other people, then the problem is resolved. If the representation of emotion entails that emotions constitute a threat, the patient will feel unsafe with emotion, and use avoidance or overcompensation

to prevent that emotions are triggered. The aim of ST then is to help the patient feel safer with emotions. Thus, the way patients view, experience and regulate emotions changes substantially through the course of treatment without emotion regulation being directly addressed.

To give a better overview on how emotions are worked with in ST we decided to present ST techniques with special regard to emotions first in line with the basic ST literature (Young et al., 2003; Arntz and Jacob, 2012) by dividing them in therapy relationship, experiential, cognitive, and behavioral techniques. Afterwards we explain how these concepts and techniques can be mapped to the process model of emotion regulation (see also **Table 1**).

ST Techniques to Work with Emotions

Therapy relationship techniques

The therapy relationship is an important vehicle for corrective emotional and interpersonal experiences. The major techniques are "*limited reparenting*" and "*empathetic confrontation.*" With the central attitude of "*limited reparenting*" the therapist provides a good-parent-like relationship characterized by warmth, empathy, support, careful self-disclosure, and safe attachment. He helps the patient to become aware of his emotions and needs, gives support in expressing emotions and needs, validates them and—within certain boundaries—fulfills the needs. Especially important is the fulfillment of needs that were frustrated in childhood. "Limited reparenting" is specifically designed to serve as an antidote to the patient's maladaptive schemas. The therapist directly models and shapes the emotional response of the patient providing external emotion regulation like parents do for their children (e.g., if a patient feels anxious in a vulnerable child mode the therapist provides safety). Moreover, the therapist models healthy ways of intrinsic emotion regulation by showing how he deals with his own emotions and needs. "Limited reparenting" also means to help patients to experience emotions in a safe way without being overwhelmed by emotional distress. Thus, the therapist sets up emotional work in small steps and actively guides through the process.

With "*empathetic confrontation*" the therapist challenges experiential avoidance mainly displayed by the coping modes. He emphasizes the adaptive value of the coping mode, and at the same time makes clear that the coping mode blocks access and fulfillment of the patient's needs leading to enduring aversive emotions. Also he promotes functional emotional reactions. ST assumes that by using these strategies the patient's fear of emotions reduces, while willingness to overcome the coping modes increases and by this the pathway to heal dysfunctional schemas opens. In a way, ST-therapy relationship-strategies resemble the way how emotion regulation develops in children. In childhood extrinsic emotion regulation by caregivers is initially dominant (Gross, 2013; e.g., a sad child is soothed by its mother, who plays with the teddy bear for the child). By experiencing adaptive extrinsic emotion regulation by caregivers and getting models for intrinsic and extrinsic emotion regulation, children can learn intrinsic emotion regulation (e.g., the sad child soothes itself by playing with its teddy bear) and also extrinsic emotion regulation for others (e.g., the child

soothes another sad child in kindergarten by playing with the teddy bear).

Cognitive techniques

Cognitive techniques compromise a range of techniques similar to the techniques also used in CBT. In regard to emotion regulation strategies patients receive intensive *psychoeducation on schemas, schema coping, modes, needs, emotions as well as on normal development of children*. Within the mode model the therapist illustrates, why and how coping modes developed and validates their function, which is mainly to shelter the child modes from more emotional pain. He explains what children need to develop a healthy way to deal with emotions and points out the differences to the patient's history (e.g., "when a child is angry, it is not okay to tell him, that it is egoistic and to withdraw affection. Every child would feel guilty then. The parent needs to talk to the child, to find out why it is angry and help the child to calm down."). The therapist fosters *mode awareness*, in which emotions play an important role (e.g., "if I feel guilty I need to look if this feeling is connected to my punitive parent mode"). He explains the mode-specific goals of ST (e.g., fighting the punitive parent and soothing the child modes) and promotes mode change, best in the healthy adult mode. He helps with the *identification and re-appraisal of schemas and mode-related cognitive distortions* (e.g., identify "I am worthless" as a cognition of the punitive parent mode, restructuring from healthy adult mode). Other important cognitive techniques compromise *reviewing pros and cons* (e.g., of coping modes to overcome experiential avoidance) or *focusing long-term consequences* (e.g., "If I stay in the detached protector, it is not possible to get close to others and I will go on feeling lonely and depressive.") or *writing diaries or flashcards* to promote mode awareness and mode change.

Experiential techniques

Experiential techniques including emotional processing of aversive childhood memories are extensively used and are central to ST, which is a main difference to standard CBT. The main focus of ST is on changing dysfunctional schemas and the meaning of emotions and needs through emotional restructuring. As such ST does not place a strong emphasis on typical CBT exposure techniques aiming at habituation and extinction. An emotion is processed until the respective emotion (i.e., sadness, loneliness) and the connected need (e.g., need for attachment) and if necessary its biographical background becomes clear, than the emotion can be restructured. The main experiential techniques are so-called "*chair dialogues,*" *imagery exercises,* most often *imagery rescripting,* and *historical role play*.

In *chair dialogs* different chairs are used for different perspectives or emotions. In ST, most often different modes are placed on different chairs and dialogs between them are performed. The patient changes the seats and expresses on every chair the perspective and emotions of the related mode. When another mode pops up, the therapist usually asks the patient to change the seat to the chair that symbolizes the popped-up mode (e.g., 'I hear you have a strong feeling of loneliness. I think this is connected to your vulnerable child mode. Would you please take

a seat on the vulnerable-child-chair and tell me how little Tanja feels?'). The therapist helps the patient to express his feelings and needs and to detect and experience different mode perspectives. The therapist might also model to express those perspectives, emotions and needs the patient finds hard to express. These exercises clarify ambivalent emotions and inner conflicts, which is an important diagnostic step to the solution of an emotional problem. Moreover, chair dialogs can be used to restructure modes and emotions leading to new emotional experiences and changes in the dysfunctional schemas, meaning of needs, and emotions. To achieve this, the therapist or the healthy adult mode addresses every mode by adapting his tone of voice, the content of what he says to the mode and his actions following the mode-specific goals of ST (e.g., comfort the vulnerable child mode, fighting the punitive parent mode). Thus, the patient experiences in a highly emotional way, that his needs and emotions are important and that self-devaluation can be reduced.

Imagery exercises can also be used for diagnostic reasons to clarify the biographical origin of dysfunctional schemas and emotional problems as well as related behavior patterns (*diagnostic imagery*). Most often diagnostic imagery exercises start from a current situation associated with strong emotions. The patient is asked to image that situation with eyes closed, the therapist focusses especially on the emotions and where in the body the patient can feel the emotion. When the emotion is clear enough, the therapist asks the patient to wipe away the image of the current situation and just stay with the emotion (affect bridge) and go back to his childhood and see if an image that is associated to that emotion pops up. The childhood image is then again explored with emphasis on emotions and needs. *Imagery Rescripting* (Arntz and Weertman, 1999) is considered to be the most powerful technique to change schemas and the meaning of adverse childhood events and emotions. The patient is asked to image a stressful (childhood) memory related to his maladaptive schemas (e.g., emotional abuse). Such a situation can be found through affective bridges as explained above or can be directly taken from the reports of the patient. When the patient clearly feels the related emotions and needs, the "rescripting part" is started by introducing a helping figure in the image, which modifies the situation to a more pleasant ending for the child, meaning that the child's needs are fulfilled. This helping figure can be the patient himself in his healthy adult mode, if he is already strong enough. For patients with PD this is often not the case in the beginning of therapy. Thus, the therapist or another helpful person (even a fantasy figure) can be introduced as helping figure. In the "rescripting part" the needs of the child are fulfilled, meaning that the perpetrator is stopped and the child is protected and cared for. Aversive emotions such as anxiety, shame or guilt are reduced, while experiencing safety, secure attachment, warmth, love, joy, and other pleasant emotions are promoted. By this, the original meaning of the trauma is changed. For some patients rescripting works better in the form of a role play, for instance if imagery constitutes a problem. Note that from an ST-perspective it is not necessary that the patient relieves the whole trauma, since habituation is not the primary goal.

Historical role-play (Arntz and Weertman, 1999) is a form of drama therapy, where therapist and patient play a traumatic biographical memory together as a role play. The patient switches roles by playing his own role (most often as a child) in the first round and the role of the perpetrator (most often a parent) in the second. This helps the patient to see another perspective on the events and to change the meaning of the situation. If a patient e.g., feels unlovable, since his father did not show any interest and was annoyed by the child, the patient can see by overtaking the perspective of the parent, that the father was overwhelmed with work and had never learnt how to show feelings. By this he can understand that it is not him being unlovable, but the circumstances of the situation that made his father act like that.

Behavioral techniques

Behavioral techniques mainly aim at breaking through rigid behavior patterns connected with the coping modes. After many years of dysfunctional coping this behavior has often become habitual and patients lack other skills to deal with emotions and needs. Thus, they need support to learn new strategies. ST compromise a range of techniques similar to the techniques also used in CBT such as *behavioral experiments, role play, homework, planning of activities, problem solving,* or *skill training.* If pathological choices (e.g., of abusive partners, of abusive work situations) remain the therapist will also address this on a behavioral level (help patients make healthy choices what to avoid and what to approach). Often it is very hard or even impossible for patients to change their behavior in the beginning of therapy due to maladaptive schemas, thus these strategies have a stronger emphasis later in the course of therapy, and are often prepared by experiential techniques.

Connection of ST Techniques to the James Gross' Process Model

In the following we map the ST concepts and techniques on the James Gross' process model of emotion regulation by going through each category of emotion regulation strategies (see also **Table 1**).

Situation selection

Schema therapy explains why patients avoid situations that might be useful for them and do not leave situations that are harmful using the concepts of schema avoidance, schema surrender, and schema overcompensation. It is assumed that dysfunctional child, parent and coping modes are responsible for problematic avoidance behavior or inaction. ST uses psychoeducation about the mode model to help to understand and overcome problematic schematic coping and experiential avoidance. Empathetic confrontation is used to confront patients with dysfunctional *situation selection* that repeats history and by this maintains schemas (e.g., dysfunctional partner choice). Behavioral techniques like role plays of the present situation and actively changing what situations to select may be used to foster transfer of behavior from the therapy session into the life of the patient.

Situation modification

Similarly, ST assumes that problem solving skills that are necessary to improve situations may be blocked by schema

avoidance, schema surrender or schema overcompensation. ST supports the patient to develop awareness of their modes and individual needs and helps patients to modify situations so that needs are better fulfilled. Behavioral techniques help with testing and transfer of problem solving skills. Cognitive techniques help to identify problematic situations, situational triggers and alternative ways to get needs met. Imagery rescripting and historical role play may in particular modify the internal context in problematic situations.

Attentional deployment

Dysfunctional schemas and modes are maintained, since attention is focused on information that confirms the dysfunctional schema or mode. This problem of attention that is inflexible and not directed to the situational context is addressed by ST using the attention shift that is associated with mode work through cognitive and experiential techniques. Chair dialogs for example require the patient to shift their attention to varying aspects of internal and interpersonal situations and facilitate the experience of the emotional changes associated with shifting attentional deployment.

Appraisal

One core assumption of ST is that information processing and decision making is influenced by early maladaptive schemas and that psychopathology is related to a dominance of dysfunctional modes to the detriment of the healthy adult mode. Consequently, when dealing with emotion regulation, appraisal is a core area for ST. Identification and re-appraisal of schemas through cognitive and experiential techniques are central for ST. ST assumes that mode awareness and cognitive flexibility that is developed during therapy allows the patient to switch from dysfunctional modes to the healthy adult mode and by this eliminate problematic appraisal processes. All experiential techniques promote *change of appraisal* especially through changing the meaning of emotions and early experiences that underlie schema.

Response modulation

ST assumes that psychopathology in this category is related to dysfunctional modes in particular dysfunctional child and parent modes and coping modes. The therapy relationship techniques, especially limited reparenting, aim to model and shape emotional responses in direct contact with the patient. Empathic confrontation is used to block problematic emotional reactions and promote healthy emotional reactions. Emotional exposure in experiential techniques is set up in small steps with shelter by the therapist and plays an important role of response modulation. In imagery rescripting traumatic experiences are processed and through the new script where the patient's needs get fulfilled the emotional response is directly altered. Behavioral techniques support the transfer of new responses into the everyday life of the patient.

Similarities and Differences between DBT and ST

Both treatments share a CBT background and help patients to deal with emotional dysregulation. Both explain development of emotional dysregulation with invalidating aversive experiences in childhood in interplay with biological factors even if later in the therapy process the biographical aspects play a more distinct role in ST. In both methods the therapeutic relationship is marked by validation, acceptance and warmth for patients and both treatments address experiential avoidance. However, there are major differences in the terminology, explanatory models and techniques used in both methods. **Table 2** summarizes the main features, similarities and differences.

APPLICATION

In this passage we will describe a case example of a woman with BPD and present the main strategies regulating emotions first from a DBT and then from a ST perspective.

Case Example

Mona, a 23-year old, overweight woman, comes to psychotherapy and reports: "I just cannot deal with my emotions, my moods shift so rapidly, no one is able to follow. I do not even understand myself. I guess, that is why I just cannot have a normal relationship. With my last boyfriend I had so many fights. I always thought he would leave me for another woman. I just could not trust him. I had so many rage attacks and threw things at him. And then he really left me. He said, he just could not stand it anymore....Well, and since then, I just do not want anyone close to me anymore, besides my little sister. It just does not work with me." Asked directly for her symptoms, she reports cutting with razorblades about once a week ("That happens often when I am in an emotional chaos....I do not care about the scars. I am ugly anyway"), daily binge eating in the evening and about three times a week smoking cannabis ("This just helps to calm down, when I feel lonely, sad or guilty"), suicidal ideas ("I often think, my life is a mess anyway and only pain. If I was dead, this all would stop and I would have peace and silence. I would not feel guilty and ashamed anymore. Nobody would miss me. I tried it four times with pills, but it did not work."), social withdrawal and inactivity ("Most of the day I lie in bed. I really do nothing. I am a loser"). She also suffers from disturbing intrusive memories and nightmares, where she relieves physical and emotional abuse from her father and stepmother, but also from the death of her older sister. The sister died 19-year-old of a heroin overdose, when Mona was 15 years. Mona feels guilty that she did not help her. With regard to her biography she reports further: "My father drank a lot of alcohol. He was very impulsive, violent-tempered, often shouted at us and beat us. We all had panic, when he came home. My real mother was caring and warm-hearted, but she was also afraid of him and could not protect us. She died from cancer, when I was seven. My stepmother was also addicted to alcohol. She was very moody, sometimes she was nice, but then, and you could never tell when and why, she got angry, insulted and beat us. My elder sister was the only one, who was there for me. But when she began to take drugs, she became very unreliable and I was totally lost. For my younger sister I was the 'mom,' since nobody was there. She is still living with my parents. I cannot forgive myself that I left her there."

TABLE 2 | Main features, similarities, and differences of DBT and ST.

	DBT	ST
Explanatory model	Emotion dysregulation as central problem, Biosocial theory to explain emotion dysregulation, Focus on connection between emotion regulation and dysfunctional behaviors	Case conceptualization using the mode concept; frustration of basic needs in childhood leads to the development of maladaptive schemas and modes, problems in emotion regulation and interpersonal relationships follow. Emotion dysregulation is not seen as the central problem
Integration of childhood experiences	No explicit focus except for psychoeducation and validation of emotional dysregulation	Full integration: Maladaptive schemas, today's problematic behaviors, fear of emotions and relationships are associated with biographical experiences; psychoeducation regarding basic needs of children
Trained skills	Primary aim is skill acquisition in the area of emotion regulation. Skills are trained in the four DBT-modules emotion regulation, distress tolerance, mindfulness and interpersonal effectiveness	Skills for emotion regulation are not directly trained. Fostering meta-understanding of the current mode, skills for using the healthy adult mode, awareness of one's own needs and ways to meet them
General therapeutic strategies	Validation strategies, explicit techniques in DBT (V1–V6) Dialectical strategies (balance between acceptance and change, pro-contra lists) Commitment strategies Skills training Extensive use of cognitive and behavioral techniques, no special focus on experiential techniques	Special focus on therapy relationship: Limited reparenting and empathic confrontation also contain validation strategies with a special focus on validation of traumatic childhood experiences as well as validation of emotions and needs, but not as explicitly as in the DBT protocol Empathic confrontation contains validation (esp. of needs and relationship to childhood experiences) of current dysfunctional mode-driven behavior and confrontation with problematic consequences and the need for change Skills are not trained directly Special focus on experiential techniques (esp. imagery rescripting and chair-dialogs) and therapy relation techniques Mode-specific use of cognitive and behavioral techniques
Analysis of problem behavior	Chain analysis according to the DBT model for each type of problem behavior; hierarchy of problem behaviors; focus on obvious and threatening problem behaviors such as suicide attempts, self-harm and impulsive behavior, focus on emotions and triggers as well as on consequences of behavior, no focus on needs	Analysis with cognitive or experiential techniques according to the mode model, mostly for problematic situations which lead to emotional suffering and frustration of needs; no specific hierarchy, focus both on obvious problem behaviors, but also on "hidden" problem behaviors such as avoidance or surrender, focus on emotional needs and modes
Structure of the individual therapy session	Fixed structure with a "crisp beginning" involving a diary card, processing of topics according to the DBT goal hierarchy, focus on emotions	No fixed structure specification, flexible hierarchy depending on the dominating mode and frustrated needs
Group therapy and structure of the group session	Group therapy is essential ingredient of DBT. Structure: Homework and goal-related opening and closing round, teaching of skills from the DBT modules with a fixed manual; preferred use of cognitive and behavioral therapeutic techniques	Group therapy is not mandatory, but has shown to be helpful in BPD patients. Structure: Begin with safety imagery, topics are covered depending on the dominating mode; designed as "group family" to create corrective experiences; preferred use of experiential and limited reparenting techniques
Dealing with self-injury	Fixed procedures according to protocol based strategies, top priority in goal hierarchy; self-injuries are usually discussed with behavioral analysis before other issues are addressed	No fixed structure specification, and need not be treated with first priority (only if highly threatening); therapeutic intervention is directed at the trigger mode
Dealing with emotional problems	Comprehensive psychoeducation in the modules for emotion regulation; mindfulness and acceptance of emotions; teaching and training of specific emotion regulation skills, decision on whether one should act according to or opposite to the emotion; emotion processing with the help of emotion protocols (more cognitive approach)	Promotion of safe experiencing of emotions; explaining aversive emotions and problems in emotion regulation within the mode model, especially in the beginning extrinsic emotion regulation through therapist according to the mode-specific goals, focus on needs (e.g. "What do I need when I'm sad?"); focus on experiential interventions, mainly imagery rescripting and chair dialogs, aims at developing corrective experiences
Development of the working alliance	Therapist as a "coach" of the patient; therapeutic team at eye level with patient, dialectical formation of working alliance with warmth, empathy, acceptance and validation on the one side and pushing for change on the other	Therapist acts to a limited extent as a good parent with "limited reparenting," i.e., meeting needs of patient that were frustrated in childhood; use of the working alliance for changing modes and to experience emotions and relationships in a safe way
Mindfulness training	Central role; non-judgmental attitude is promoted	Not included in ST
Skills training in distress tolerance	High priority; psychoeducation, development of a skills chain for stress regulation to prevent problem behaviors, reality accepting skills to ease emotional pain	Limited use, mainly for emergency situations in the beginning of therapy

DBT Perspective

DBT Case Concept

After a thorough assessment of Mona's presenting problems and her biography, the therapist educates Mona about BPD as a disorder of the emotion regulation system by using the biopsychosocial model: The precipitation factors were a history of invalidation, physical and emotional abuse by her parents in combination with a high emotional sensitivity. Mona has skills deficits in emotion regulation, in particular in dealing with grief and sadness (death of mother and sister, breaking up of partner), mistrust (expectations to be betrayed), anger (rage attacks), guilt (own behavior toward elder sister before her death, insufficient present support for her younger sister), and shame (own body, being mentally ill, abusing substances, disturbed eating behavior, inactivity). Both the externalizing behavior and internalizing problem behaviors (suicide attempts, self-injury, binge eating, drug use, social withdrawal, and inactivity) serve the avoidance or attenuation of aversive emotions and the associated physical symptoms of tension and pain. The patient also has skills deficits in the areas of self-management, mindfulness and metacognition, interpersonal behavior, and stress-tolerance. The therapist explains that DBT will focus on the acquisition of functional emotion regulation skills in the four modules, so that Mona can gain more control on her behaviors and in her life in general. The therapist uses a broad range of validation strategies to communicate acceptance and emphasize the understandability of Mona's behaviors and emotions. At the same time he motivates her to learn new strategies and pushes for change (dialectical balance of acceptance and change strategies).

The therapist sets up an intensive psychotherapy program with the following elements: individual therapy including telephone coaching, skills training group, case management by social worker, occupational therapy, and exercise therapy (Nordic walking).

Target Hierarchy of Problem Behavior and Goals for Therapy

The therapist explains the DBT hierarchy of problem behaviors and Mona agrees with him on the following target hierarchy:

(1) Suicidal behavior with intoxications
(2) Severe self-injury with razor blades
(3) Drug consumption
(4) Binge eating
(5) Social withdrawal,
(6) Physical inactivity,
(7) Economics.

They agree on the following goals and agreements for therapy:

- Regular attendance at therapy including all elements of the treatment program
- Practice of emotion regulation skills, especially learning new ways to tolerate and deal with grief, guilt, and shame
- Practice of distress-tolerance skills to prevent dysfunctional behavior
- Practice mindfulness and interpersonal effectiveness skills
- Preparation of a non-suicide decision

- Self-injuries must be medically cared of and be examined by a behavioral analysis
- Daily use of the DBT Diary Card to track problem behaviors as well as skill use, discussion at the beginning of each individual session
- Abstinence of drugs
- Practice of structured eating
- Developing a daily movement program
- Developing a perspective for education and work rehabilitation.

Understanding Problem Behavior and Learning New Skills

With behavioral analyses and chain analyses Mona learns to understand her own behavior, what it is caused by, why it is maintained and what consequences follow. **Figure 1** shows a chain analysis of a serious self-injury (problem-behavior) after Mona saw her ex-boyfriend with another women (prompting event). Mona and the therapist work out emotional vulnerability factors, the emotions, thoughts, body reactions, and behaviors that follow the prompting event and end in the problematic behavior. Further they look at short-term and long-term consequences of the problem behavior.

After conducting the chain analysis they look for new skillful behavior to replace the problem behavior: The therapist explains that, when Mona is under such high tension, that she can't think clearly, she first needs to use her distress tolerance skill chain. She found out, that the best skill in such situations is to tip her head into a bucket full of ice-cold water or to do exercise (e.g., 20 sit-ups). When she has calmed down she needs to have a look at her emotions, accepting and without judgment. The therapist's validation strategies are very important for Mona to stop devaluation of her thoughts, behaviors and emotions. In the skill training group she learns to identify, describe and observe her emotions mindfully and about primary and secondary emotions. She also learns that she has a choice to act with or opposite to an emotion. Thus, she and her therapist go in many situations through each emotion involved and work out, if it is a primary or secondary emotion, if Mona wants to act with or opposite to it and how this behavior would look like. In the situation from the example chain analysis Mona and the therapist work out that sadness is the primary emotion, while guilt, self-hatred and shame are secondary emotions and result from judgments of the situation. With help of the therapist Mona decides that it would be good to act opposite to guilt, self-hatred and shame. Her action-urge from sadness is to withdraw from social contacts and to go in her bed. She anticipates that in a future situation this would end with her using drugs or binge eating. Thus, she decides to act opposite to this urge as well and plans to contact her friend Sarah in a future situation and ask her, if she can come around. Her new behavior plan is to self-validate herself, stop to blame and hurt herself, and on the contrary call her friend Sarah. The new skills are practiced intensively over and over again in individual therapy, group therapy and as homework.

Although, she does not like the skill of "radical acceptance" in the beginning, Mona finds out that this skill is especially
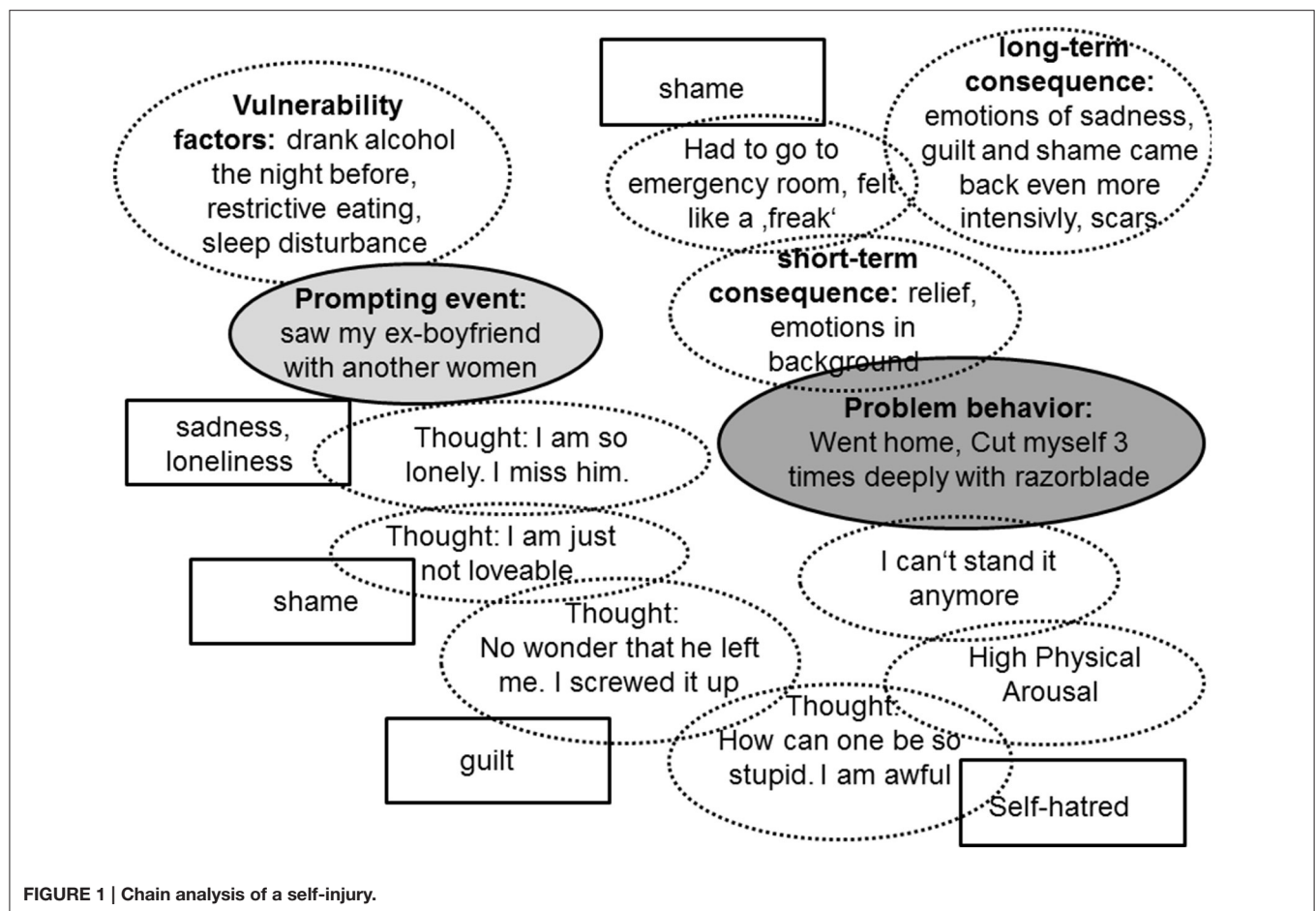
FIGURE 1 | Chain analysis of a self-injury.

important for her in situations she cannot change, e.g., in dealing with the loss of her mother and sister.

ST Perspective
Case Conceptualization and Psychoeducation with the Mode Model

After investigating Mona's current problems and her biography, the therapist develops an individual case conceptualization according to the mode model in interaction with Mona (see **Figure 2**). As usual in individual ST, Mona chose individual names for her modes: Mona's fears of being abandoned, feelings of mistrust, loneliness, sadness and anxiety are conceptualized in the vulnerable child mode ("little Mona"), her rage attacks and fights with the partner in the angry child mode ("angry Mona"). These modes developed since basic childhood needs have been frustrated and Mona has two times experienced a loss of her most important attachment figure. Self-devaluation, shame, guilt, and self-hatred refer to the punitive parent mode ("the punisher"), which developed probably due to experiences of aggression and insults from her father and stepmother. Early in life Mona developed "the shield," her detached protector mode, as a survival strategy to protect herself from further emotional pain. In this mode she avoids getting close to others and distracts from intensive emotions or calms them down by self-injury, substance

abuse, binge eating, social withdrawal, and sleeping. Her frequent mood-shifts and identity disturbances can be explained with rapid mode shifts. Mona's therapy attendance and her care for her sister are conceptualized in her healthy adult mode ("grown-up Mona"). The biographical context is brought into the case conceptualization with arrows (see **Figure 1**). The therapist helps Mona to foster her mode awareness and educates her about the general and mode-specific goals of ST. All of Mona's problems and symptoms are conceptualized and treated in terms of the modes involved.

Bypassing the Detached Protector Mode

First the therapist works on Mona's detached protector mode, since it is very strong and rigid and blocks access to the child and parent modes. He starts by reviewing the pro and cons of this mode (see **Table 3**). Later the therapist proposes a chair dialog to better understand the "Shield." He asks Mona to take place in a chair for the "Shield" and to answer to all his questions out of the "Shield's" view. He says: "Hello Shield. You're extremely important for Mona. I'd like to better understand you. Can you tell me, why you are here today?" He asks for the development of the mode (e.g., "Do you know, when you first came in Mona's life? Why did Mona need you?"). He validates Mona: "Oh yes, Mona told me, that she was often punished very harshly by her

FIGURE 2 | Mona's mode model.
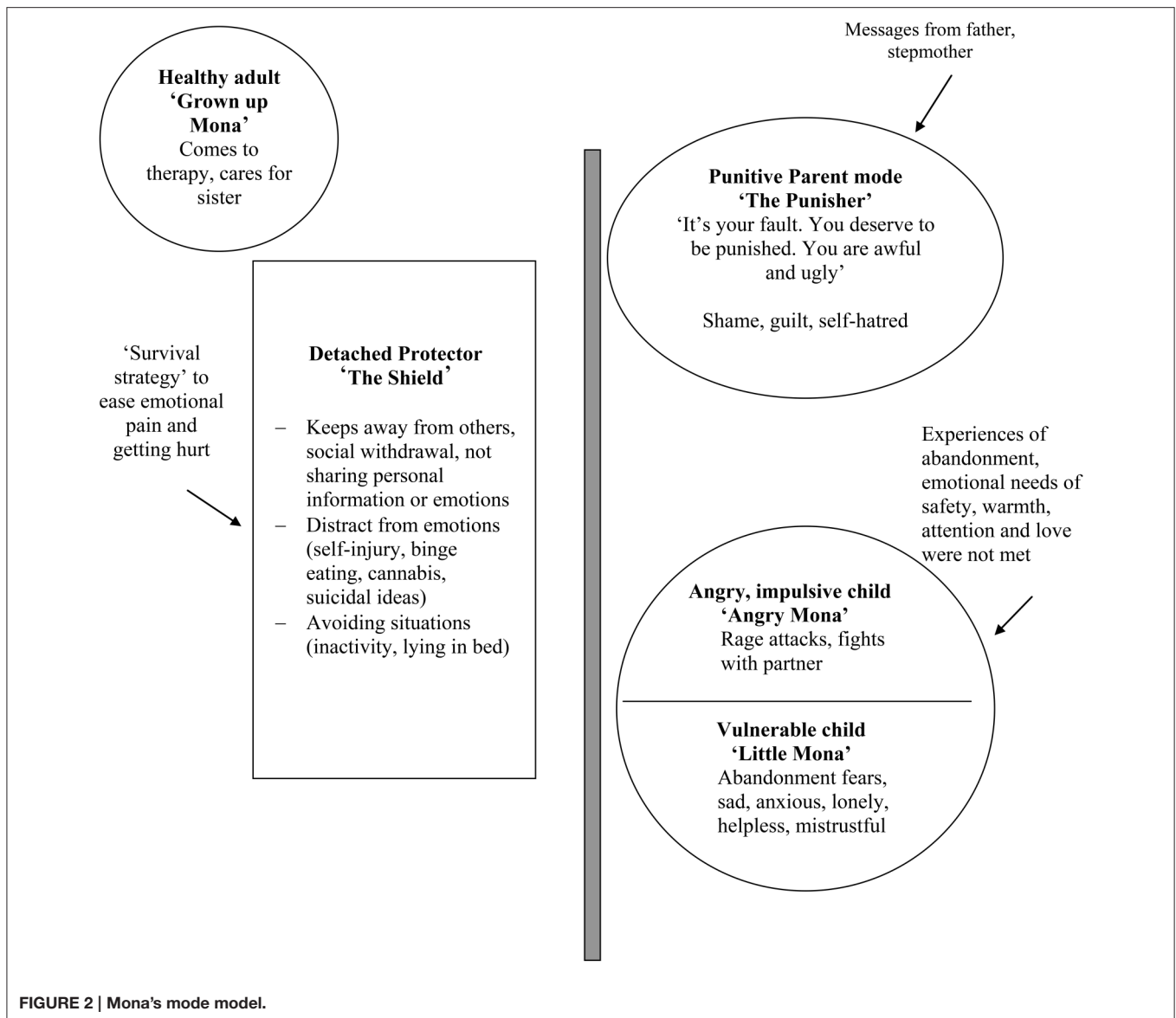
father, if she showed any feeling and that it was very painful, when her mother died. Nobody was there to help her. It was good, that you came to protect her." After that the therapist aims to work out disadvantages of the "Shield" mode "I have the impression that something happened to little Mona last week, and that she feels overwhelmed and lonely. I really want to help her. But at the moment I can't see what it is, because you stand very strong in front of her and I cannot reach her. And I think this is not, what little Mona needs right now. What do you think?" Mona begins to cry and switches to the vulnerable child mode. The therapist takes another chair for "Little Mona" and places it next to his chair. She tells that she saw her ex-boyfriend with another woman and that she feels so sad, lonely and worthless. The therapist soothes and comforts her. A popping up of a punitive parent mode ("It's your fault. You screwed it up. You are just not lovable. And then you cut yourself. Loser") is fought by the symbolic

action of placing the chair of the "Punisher" out of the therapy room.

Healing the Child Modes and Fighting the Punitive Parent Mode

In the next phase of treatment dysfunctional child and parent modes are addressed with a strong emphasis on experiential techniques and therapy relationship techniques. An example is an imagery rescripting exercise on the physical abuse of the father. In the image Mona had accidently broken a bowl, the father shouts at her and loses his belt to beat her. The therapist enters the image, since he does not want Mona to relive the whole trauma. He steps between little Mona and her father to protect her and talks harshly to the father: "Stop at once. You are not allowed to beat little Mona. Nobody is allowed to beat children. It is quite normal that a bowl breaks from time to time. Mona has not

TABLE 3 | Pros and Cons of Mona's Detached Protector Mode.

Pros of "The Shield"	Con's of "The Shield"
• Nobody can hurt me or abandon me	• I have no connection to others, I feel lonely and depressed
• I have fewer conflicts with others	• It feels empty and cold
• I do not have such awful feelings	• It is boring
• I do not feel my needs and this is less painful, as I never get what I need anyway	• It still hurts and never stops
• I can control myself better e.g., do not have to cry	• I do not have good contact with myself, I have no idea what I want in life. I have no control in my life
• I feel safer	• I have no idea about my emotions and needs, thus I can't fulfill my needs
• I have less awful memories	• I can't learn other strategies to deal with my problems and emotions
• There is more silence	

done anything wrong!" Since the father gets even more aggressive the therapist has four police men enter the image and arrest the father. Mona sees how he is brought to jail. Asked for her feelings and needs, little Mona tells the therapist that it is good, that her father cannot harm her anymore, but that she still feels lonely and that she misses her mom, who died 3 months ago. And that she does not know where to go. The therapist listens to little Mona and soothes her. Finally, he takes her and her sisters to their aunt Mary, who Mona likes very much. At the end of the image aunt Mary reads Mona and her sisters "Pooh, the Bear."

Strengthing the Healthy Adult Mode

More imagery rescripting exercises of other adverse childhood memories are performed and with the course of therapy Mona herself in the healthy adult mode can comfort and soothe little Mona in the rescripting part. Also Mona and the therapist perform several chair dialogs in which Mona understands her contradicting emotional processes. She understands why she can feel guilty (punitive parent), angry (angry child), and sad (vulnerable child) at the same time. She learns to recognize and reduce her punitive parent mode including her feeling of guilt, self-hatred, and shame and to experience and validate the needs of her vulnerable child mode. First her therapist models these tasks for her, but with the course of therapy Mona can take over the role of her healthy adult mode herself each time a little better.

EMPIRICAL EVIDENCE AND FUTURE DIRECTIONS

Empirical Evidence for DBT

A systematic review and a Cochrane Review summarize the evidence for the efficacy of DBT in the treatment for patients with BPD, which has been shown in several randomized controlled trials (Kliem et al., 2010; Stoffers et al., 2012). The main effects are reduction of suicidality, self-injuring and impulsive behaviors, therapy dropouts and inpatient admissions. DBT has also shown effect in treating BPD with several comorbidities and other psychiatric conditions such as substance misuse (Linehan et al., 1999, 2002; Dimeff and Linehan, 2008), eating disorder (Safer et al., 2001; Telch et al., 2001; Kröger et al., 2010), post-traumatic

stress disorder (Steil et al., 2011; Harned et al., 2012, 2014; Bohus et al., 2013), or depression (Lynch et al., 2007).

Research on mechanism of change has revealed that experiential avoidance impedes the reduction of depression in DBT-treatment of BPD and thus should be targeted (Berking et al., 2009). Experiential avoidance was decreased better in DBT compared to Community Treatment by Experts in a randomized controlled trial (Neacsiu et al., 2014a). Neacsiu et al. (2010) showed that increasing use of DBT skills is a mechanism of change for suicidal behavior, depression, and anger control in the treatment of BPD. This study supports the skills deficit model for BPD. Also DBT as a transdiagnostic treatment of emotion dysregulation was superior to activities-based support group in decreasing emotion dysregulation, increasing skill use and decreasing anxiety, but not depression in patients with mood and anxiety disorders. Skill use mediated the changes (Neacsiu et al., 2014b). Thus, behavioral skills are likely a potent mechanism of change for emotion dysregulation across disorders. However, evidence is preliminary and more research in other disorders than BPD is needed. Moreover, there are more than 60 DBT-skills and we do not know whether some skills are more important and useful than others in general, whether this varies over psychiatric disorders (e.g., patients with eating disorders needing other skills than patients with social phobia) or individual needs, whether some skills are more suitable for specific situations than others or how an individual determines to "use the right skill at the right time" and whether it executes that skill. Although, DBT has been evaluated intensively in efficacy and effectiveness studies, there is limited research on specific mechanisms of change in DBT. Clarifying the mechanisms of change could lead to a more focused and effective treatment and improvement on emotion dysregulation.

Empirical Evidence for ST

Empirical studies indicate high effectiveness of ST in the treatment of BPD regarding decreases in all nine BPD symptoms, improvements in quality of live and high treatment retention rate (Jacob and Arntz, 2013; Sempértegui et al., 2013). But also for other PDs results are encouraging: In a Dutch randomized controlled trial including patients with non-BPD PD with a majority of cluster-C-PDs (avoidant, dependent, and obsessive compulsive) ST was superior to two comparison conditions (Bamelis et al., 2013). Promising results are also reported for depression (Malogiannis et al., 2014; Renner et al., 2016).

Research on mechanism of change is in its infancy in ST: With regard to the "limited reparenting" approach, scores of the therapeutic alliance both of patients and therapists were higher in ST when compared to transference-focused therapy in the treatment of BPD (Spinhoven et al., 2007). Low ratings at early treatment predicted dropout, whereas positive ratings of patients predicted clinical improvement. Thus, the therapeutic alliance in ST may serve to facilitate change processes underlying clinical improvement in patients with BPD. Other hints on mechanism of change come from the non-BPD-trial (Bamelis et al., 2013): Therapists in this trial were trained in two waves, with the second wave of therapists being trained mainly by practicing in role plays and the first wave therapist by lecture and video-watching. The

second wave of therapists had significantly less drop-out and stronger effects than the first wave of therapists. Therapists of the second wave reported to feel better equipped for the treatment and to have integrated all techniques. It is hypothesized that these therapist felt more secure in experiential techniques and thus experiential techniques were used to a greater extent and that this might have led to a better outcome. Several studies showed that imagery rescripting as a stand-alone technique is successful in a broad range of psychiatric disorders, including post-traumatic stress disorder (Arntz et al., 2007; Grunert et al., 2007; Raabe et al., 2015), social phobia (Wild et al., 2008; Brewin et al., 2009; Wild and Clark, 2011; Nilsson et al., 2012; Frets et al., 2014), or depression (Wheatley et al., 2007; Brewin et al., 2009; Review in Arntz, 2012). Therapeutic techniques using imagery instead of verbalization probably have greater impact on emotions (Holmes et al., 2009). It might be assumed, that imagery rescripting is an important technique to facilitate change in ST, however empirical evidence to support this hypothesis lacks. Other techniques used in ST, such as chair dialogs or historical role play, call for further investigation. How all these techniques provided by ST and ST in general impact emotion dysregulation remains up to date unclear and needs further study. Also, it would be very interesting to compare the effects on emotion dysregulation of ST to DBT and other methods.

Future Directions

From this comparison of DBT and ST with respect to emotion regulation several questions arise calling for further research. Stated in a simplified manner, DBT argues that emotion dysregulation skills deficits are the key to psychopathology, while ST assumes that early maladaptive schemas and modes underlie psychopathology and emotion dysregulation is a secondary consequence. If it is hypothesized that a treatment which addresses the key underlying factors of psychopathology has better treatment effects, the empirical question is to understand what underlies psychopathology. A question that is complicated to test, since assessment methods that specifically assess these underlying constructs with high validity need to be developed first.

Other important questions address the mechanisms of change for each method, but also differences between the two methods. Above for each method putative mechanism of change are discussed, e.g., skill use and targeting experiential avoidance for DBT or therapeutic alliance and use of experiential techniques in ST. However, the therapeutic alliance also plays an important role in DBT and ST is also targeting experiential avoidance, while skill use and use of experiential techniques are more specific to one of the methods. The question of specificity in these processes is very interesting, since basic processes that overlap in both methods and unique factors might be revealed and enable improvement of psychotherapy in general. Both treatments offer a variety of techniques and features. Currently it is impossible to say which ones are the most relevant for change. Component-analysis-studies are needed to reveal the most important features.

Treatment trials comparing DBT and ST are completely lacking, thus it remains an open question if one of the two methods is superior in efficacy and if the two methods have different efficacy for different groups of patients or different problems.

SUGGESTED READINGS AND FURTHER RESOURCES

For further information on *DBT* we suggest the recent manual from Linehan (2015a,b), and the chapter from Neasciu et al. for the transdiagnostic DBT treatment model for emotion dysregulation (Neacsiu et al., 2015). A meta-analysis on treatment effects for DBT in the treatment of BPD can be found in Kliem et al. (2010).

For further information on *ST* we suggest the original book on ST from Young et al. (2003), a detailed manual on the work with the mode model from Arntz and Jacob (2012) and the manual for treating BPD from Arntz and van Genderen (2009). Recent reviews summarize current research findings on ST for BPD (Sempértegui et al., 2013) and PD in general (Jacob and Arntz, 2013).

AUTHOR CONTRIBUTIONS

EF, US, and AA planed the concept and design of the paper. EF wrote the first draft of the paper. US, AA, DM, and OB provided critical revisions both from DBT and ST perspective. All the authors edited and revised the paper.

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Mindfulness and Emotion Regulation: Insights from Neurobiological, Psychological, and Clinical Studies

Simón Guendelman[1]*, Sebastián Medeiros[2,3] and Hagen Rampes[4]

[1] Social Cognition Group, Berlin School of Mind and Brain, Humboldt Universität, Berlin, Germany, [2] Research Unit on Psychotherapeutic Interventions and Change Processes, Millennium Institute for Research in Depression and Personality, Santiago, Chile, [3] Health Psychology, Department of Psychology, Pontificia Universidad Católica de Chile, Santiago, Chile, [4] Community Mental Health Team East, Central North West London Foundation NHS Foundation Trust, London, UK

There is increasing interest in the beneficial clinical effects of mindfulness-based interventions (MBIs). Research has demonstrated their efficacy in a wide range of psychological conditions characterized by emotion dysregulation. Neuroimaging studies have evidenced functional and structural changes in a myriad of brain regions mainly involved in attention systems, emotion regulation, and self-referential processing. In this article we review studies on psychological and neurobiological correlates across different empirically derived models of research, including dispositional mindfulness, mindfulness induction, MBIs, and expert meditators in relation to emotion regulation. From the perspective of recent findings in the neuroscience of emotion regulation, we discuss the interplay of top-down and bottom-up emotion regulation mechanisms associated with different mindfulness models. From a phenomenological and cognitive perspective, authors have argued that mindfulness elicits a "mindful emotion regulation" strategy; however, from a clinical perspective, this construct has not been properly differentiated from other strategies and interventions within MBIs. In this context we propose the distinction between top-down and bottom-up mindfulness based emotion regulation strategies. Furthermore, we propose an *embodied emotion regulation* framework as a multilevel approach for understanding psychobiological changes due to mindfulness meditation regarding its effect on emotion regulation. Finally, based on clinical neuroscientific evidence on mindfulness, we open perspectives and dialogues regarding commonalities and differences between MBIs and other psychotherapeutic strategies for emotion regulation.

Keywords: mindfulness, emotion regulation, neuroimaging, top down and bottom up processing, emotion dysregulation disorders, embodied cognition

Increasing interest has emerged about the therapeutic effects of mindfulness meditation and its clinical applications. Several studies have shown positive results in fostering emotional mental health among clinical and healthy populations (Bohlmeijer et al., 2010; Fjorback et al., 2011; Gotink et al., 2015). Neurobiological studies indicate that this type of mental training may have an effect on the plasticity of brain structure and functioning (Tomasino et al., 2013; Fox et al., 2014). Some of the main neurocognitive mechanisms implicated in mindfulness meditation include attention control, emotion regulation, and self-awareness (Tang et al., 2015). In this article, we will focus on the relationship between mindfulness and emotion regulation, taking into account diverse psychological, clinical and neuroimaging evidence.

Unlike other reviews on the topic, this article does not focus on the problematic aspects involved in the operationalization and definition of mindfulness itself. Instead, the intention is to offer a comprehensive perspective linking different empirical models including mindfulness as a trait, mindfulness inductions, MBIs and mindfulness experts, and emotion regulation-related mechanisms including psychological and top-down/bottom-up brain systems. Moreover, we propose a preliminary framework for better understanding of emotion regulation changes due to mindfulness practice, tackling problematic aspects of the notion of "mindful emotion regulation" widely used in mindfulness clinical research, and complex involvement of top-down and bottom-up mechanisms in MBIs.

MINDFULNESS, EMOTION REGULATION, AND CLINICAL APPLICATIONS

Contemporary psychology considers emotion regulation a central component of mental health, and its imbalances might underlie several mental disorders (Berenbaum et al., 2003; Mennin and Farach, 2007). Emotion regulation includes all of the conscious and non-conscious strategies we use to increase, to maintain or decrease one or more components of an emotional response (Gross, 1998). Originally, trying to bring together ideas from psychoanalysis and the field of stress and coping behaviors, Gross developed a *process* or *time model* of emotion regulation, in which emotions can be modulated in five different stages: selecting a situation, modifying a situation, deployment of attention, changing cognition (cognitive reappraisal), and modulating the experience, behavior or physiological response (Gross, 2001). Gross and John in a correlational study demonstrated that individual differences in the usage of these strategies (more cognitive reappraisal) were related to better emotional health, well-being and interpersonal functioning (Gross and John, 2003).

In line with this approach, Aldao et al. performed a meta-analytic review focused on how emotion regulation strategies, measured by self-report scales, vary across different psychopathological conditions. The main findings showed that *avoidance*, *rumination,* and *suppression* (as strategies) were each positively associated with anxiety, depression and eating disorders. *Problem-solving* was negatively associated with anxiety, depression and eating disorders. *Reappraisal* and *acceptance*-based strategies were negatively associated, but not significantly, with anxiety and depression (Aldao et al., 2010). Emotion dysregulation has been recognized as a core psychopathological factor in many other psychological disorders such as borderline personality disorder (BPD; Linehan, 1993; Schore, 2003), emotional trauma (Corrigan et al., 2011), attention deficit hyperactivity disorder (ADHD; Shaw et al., 2014), bipolar disorder (Van Rheenen et al., 2015), and anorexia and bulimia nervosa (Lavender et al., 2015). Emotion dysregulation has been demonstrated to mediate the link between child abuse/neglect and later depressive disorder (Crow et al., 2014), and also the link between cumulative adversity in lifetime and depressive symptoms (Abravanel and Sinha, 2015).

Taking into account how individual differences in emotion regulation strategies influence mental health, and the extensive role of emotion dysregulation in many psychopathological conditions, it is reasonable to believe that clinical interventions focused on emotion regulation/dysregulation might have substantial benefits for these psychological disorders. This argument is in line with several studies in which MBIs seem to be particularly effective in clinical and non-clinical conditions characterized by distress and negative emotions.

Mindfulness meditation has its origin in the Buddhist psychology tradition, more specifically in the texts known as *Satipatthana Sutra* (Analayo, 2003) and the *Abhidharma* (from Sanskrit, means higher teachings), a cycle of teachings concern about how the mind, including emotions and consciousness work (Trungpa, 2001; Analayo, 2003; Rapgay and Bystrisky, 2009). The word "mindfulness" corresponds to the translation of the original terms *smrti* (from Sanskrit) or *sati* (Pali), which captures the capacity to retain an object in the mind, but in a broad sense also implies being aware of and attentive to the present moment (Lutz et al., 2015). In clinical and research contexts, mindfulness as a specific type of meditation practice has been described as a "non-elaborative, non-judgmental awareness" of present-moment experience (Kabat-Zinn, 2005), a non-reactive awareness that emerges as a result of intentionally paying attention to present experience, and a capacity that can be trained through formal meditation practice. Several MBIs have been developed, including mindfulness meditation and other components, such as body awareness, yoga, and psychoeducation. These are group interventions, specially designed for targeting specific psychopathological substrates (like emotion dysregulation), in particular those related to psychiatric conditions (Shonin et al., 2013).

The mindfulness-based stress reduction (MBSR) program was developed by Jon Kabat-Zinn during the late seventies (Kabat-Zinn, 2005). Several revisions and meta-analyses have highlighted its robust benefits for healthy subjects, increasing well-being, and decreasing stress and negative emotions (Eberth and Sedlmeier, 2012). For clinical population, highlights the decrease in pain intensity, stress, and psychological complaints among patients suffering from diverse chronic pain/inflammatory diseases (Cramer et al., 2012; Lauche et al., 2013) and cancer (Ledesma and Kumano, 2009). Recently, a standardized review of meta-analysis of randomized controlled trials (RCTs) for MBSR and mindfulness-based cognitive therapy (MBCT) demonstrated a significant improvement in different domains (calculated as Cohen's d effect sizes): depressive symptoms ($d = 0.37$), anxiety ($d = 0.49$), stress ($d = 0.51$), quality of life ($d = 0.39$), physical functioning ($d = 0.27$; Gotink et al., 2015).

MBCT is a program derived from MBSR, developed for preventing recurrence/relapse in recurrent major depressive disorder (MDD; Segal et al., 2002). Several RCT and systematic reviews have demonstrated its effectiveness in relapse prevention and residual symptoms (Chiesa and Serretti, 2011; Piet and Hougaard, 2011; Clarke et al., 2015), and lately, also, in depressive symptoms in MDD (Jain et al., 2015). Another MBI is mindfulness-based relapse prevention (MBRP), which

TABLE 1 | Summary of mindfulness-based interventions (MBIs) and main evidence-based targeted conditions.

MBI	Main conditions with evidence support for MBI
MBSR	Stress, burnout (health professions)
	Chronic pain (low-back pain, fibromyalgia)
	Cancer
MBCT	MDD (relapse prevention and acute treatment). BD
MBRP	Substance use disorders (relapse prevention)
ACT	Chronic pain, anxiety and depressive disorders
DBT	Borderline personality disorder, substance use disorders

MBSR, mindfulness based stress reduction; MBCT, mindfulness based cognitive therapy; MBRP, mindfulness based relapse prevention; ACT, acceptance and commitment therapy; DBT, dialectical behavioral therapy.

is designed for preventing relapse in substance use disorders (Bowen et al., 2010). Available studies have demonstrated its efficacy in reducing relapse into drug and drinking use, as well as substance usage after a period of abstinence (Bowen et al., 2014; for summary of results, see **Table 1**).

Acceptance and commitment therapy (ACT) is a particular psychotherapeutic orientation developed from behavioral analysis, with mindfulness and acceptance as core principles (Hayes et al., 1999), whose effectiveness is similar to that of cognitive behavioral therapy (CBT) for relevant mental disorders (A-Tjak et al., 2015). Dialectical behavioral therapy (DBT) was developed within a CBT framework, and combines mindfulness and ACT elements. It is organized as a yearlong program, targeting self-harm, and chronic suicidal behavior in BPD (Linehan, 1993). Systematic reviews of ACT find decreases in impulsivity and suicidal attempts, and improvements in general mental health (Stoffers et al., 2012). Interestingly, for the MBIs clinical programs, the central aim is to target dysfunctional strategies of emotion regulation, which are claimed to drive the maintenance and recurrence of these disorders. In this sense, the claim is that mindfulness might re-establish emotion regulation capacities, which leads to symptomatic and clinical recovery.

PSYCHOLOGICAL MECHANISMS OF EMOTION REGULATION INVOLVED IN MINDFULNESS

Despite the effectiveness of MBIs in different psychological disorders, the underlying psychological and neurobiological mechanisms are still unclear. Several authors have proposed psychological models to account for the therapeutic effects of MBIs. Shapiro et al. claim that mindfulness might act through changing attention, intention, and attitude (Shapiro et al., 2006). Others suggest that positive effects of MBIs could be explained by mechanisms such as observing, describing, acting with awareness, non-judging of inner experiences, and non-reactivity to inner experiences (Baer et al., 2006). Based on an integration of Buddhist psychology and empirical evidence, Grabovac et al. proposed a model in which changes in acceptance, attention regulation, ethical practice, and attachment/aversion to feelings

lead to decreased mental proliferation (rumination narrative based), and through this to salutary effects (Grabovac et al., 2011).

Other authors have proposed neurocognitive models, integrating psychological and neuroscientific data. Vago and Silbersweig proposed that mindfulness leads to changes in self-processing, through the development of self-awareness (meta-awareness), self-regulation (modulation of behavior), and self-transcendence (prosocial characteristics). These changes reflect modulation in neurocognitive networks related to intention and motivation, attention and emotion regulation, extinction and reconsolidation, prosociality, non-attachment, and decentering (Vago and Silbersweig, 2012). Hölzel et al. proposed that mindfulness enacts its effects through plastic changes of mental and brain functions related to attention regulation, body awareness, emotion regulation and self-perspectives (Hölzel et al., 2011a). Recently, Lutz et al. developed a multidimensional model for understanding mindfulness in expert meditators and MBIs, proposing a neurophenomenological "matrix model" in which categorical orthogonal dimensions, including object orientation, dereification and meta-awareness, are central cognitive mechanisms underlying contemplative practices (Lutz et al., 2015; for summary of models, see **Table 2**).

As can be seen, the nature and usage of the construct of mindfulness are complex and elusive. In order to understand the myriad of studies reviewed in this article, it's necessary to clarify the different usage of the mindfulness construct. *Dispositional mindfulness* is understood as a mental trait or stable characteristic of personality, which can vary between and within individuals across time. *Mindfulness as practice* refers to the concrete practice of mindfulness meditation, the deployment (and training) of a non-elaborative (non-conceptual), present-centered, exploratory and non-judgmental (non-valorative) awareness. *Mindfulness as a state* corresponds to the actual proper first-person experience of the non-elaborative, present-centered, non-judgmental awareness (Chambers et al., 2009; Davidson, 2010).

Although most of these models include cognitive, self-awareness, emotional, and attitudinal components, none of them provide an in-depth understanding of the relationship between mindfulness and emotion regulation changes. As can be derived from previous section, a lot of clinical evidence indicates that MBIs seem to be particularly effective in psychological conditions characterized by different forms of emotion dysregulation (see **Table 1**). In accordance with this, authors studying the psychological mechanisms underlying *mindfulness as a trait* or *as a practice* have focused specially on the relationship between mindfulness and its capacity to enhance emotion regulation as a key route to yielding mental health benefits.

Cross-Sectional Studies

Studies measuring dispositional mindfulness consist of cross-sectional surveys using self-report scales in a healthy population. The frequency of these studies has grown exponentially and their scope has moved beyond psychiatry and psychology issues to include several other positive health-related outcomes. For example, recent studies suggest that higher dispositional

TABLE 2 | Psychological and neurocognitive models of mechanisms of MBIs.

Author	Type of model	Components
Shapiro et al., 2006	Psychological	Attention, attitude, intention
Baer et al., 2006	Psychological	Observing, describing, acting with awareness, non-judging of inner experiences and non-reactivity to inner experiences
Grabovac et al., 2011	Psychological	Acceptance, attention regulation, ethical practice and decreased attachment/aversion to feelings. Final pathway: *decreased mental proliferation* (rumination narrative based)
Vago and Silbersweig, 2012	Psychological-Neurocognitive	Intention and motivation, attention and emotion regulation, extinction, and reconsolidation, prosociality, non-attachment, and decentering. Final pathway: *increasing self-awareness, self-regulation, self-trascendence*
Hölzel et al., 2011a	Psychological-Neurocognitive	Attention regulation, body awareness, emotion regulation, and change in perspective of the self. Final pathway: *increasing self-regulation*
Lutz et al., 2015	Phenomenological-Neurocognitive	Primary (orthogonal) dimensions: object orientation, dereification, and meta-awareness. Secondary qualities: aperture, clarity, stability, and effort

mindfulness is correlated to improved self-care behaviors (Slonim et al., 2015), and among people with adverse childhood experiences, mindfulness as a trait is related to fewer medical conditions, and better health behaviors (Whitaker et al., 2014).

Giluk performed a meta-analysis of 29 studies investigating the relationship between mindfulness and personality (Big Five) and aspects of affect/mood, finding a negative correlation between mindfulness, neuroticism and negative affect, and a positive correlation between mindfulness and conscientiousness and positive affect (Giluk, 2009). Feltman et al., in a study with 289 participants, found that mindfulness and neuroticism were independent and inverse predictors of depressive symptoms and trait anger; importantly the relationship between neuroticism and symptoms was stronger with low mindfulness, suggesting that mindfulness might play a role in buffering the negative emotionality of neuroticism (Feltman et al., 2009). In line with this, Wupperman et al. found that deficits in mindfulness predict borderline symptoms in a healthy population, independently of neuroticism (Wupperman et al., 2008).

Other studies have evaluated what factors mediate the effect of mindfulness on emotion symptomatology. Bao et al. found a mediation effect of mindfulness, through increases in emotional intelligence (including factors such as emotion regulation) over perceived stress (Bao et al., 2015). Selby et al. looked at how borderline symptoms predict low mindfulness levels. Performing a bootstrapping mediation analysis revealed a significant effect of rumination as a mediator between borderline features and mindfulness deficits, indicating the maladaptive role of rumination as a regulatory strategy (Selby et al., 2016). These results are congruent with intervention studies that highlight the positive effect of DBT and ACT in the BPD population (Gratz and Gunderson, 2006; Stoffers et al., 2012).

Looking to further clarify and understand psychological mechanisms of mindfulness, Coffey et al. conducted a correlational study with 399 healthy people using the five-factor mindfulness questionnaire, the difficulties in emotion regulation scale and the trait meta-mood scale. Using factor analysis and structural equation modeling, the authors found that mindfulness and emotion regulation corresponded to shared and distinct constructs, distinguishing four factors: present-centered attention and acceptance of experience (for mindfulness), clarity about one's internal experience, and the ability to manage negative emotions (for emotion regulation). A path analysis supported the stance that mindfulness (including the factors "present-centered attention" and "acceptance of experience"), through clarity about one's own experience, improves the ability to deal with negative emotions (the model had a good data fit, having a RMSEA of 0.059; $p < 0.0001$). The authors also found that clarity about experience was negatively correlated to rumination and psychological distress, and positively related to flourishing (Coffey et al., 2010). Acknowledging methodological limitations, studies using dispositional mindfulness as a trait or personality characteristic (statistically as independent variable or predictor) provide interesting preliminary evidence that mindfulness, even though partially overlapping with emotion regulation constructs, might exert its beneficial salutary effects through higher emotion regulation capacities.

Longitudinal Studies

In the area of clinical and psychotherapy research, the question of change mechanisms, or "active ingredients," that drive therapeutic effects has been a central concern over the last 20 years (Kazdin, 2007; Nock, 2007). As we stated in previous sections, hundreds of longitudinal studies have demonstrated the efficacy of MBIs in a healthy or clinical population, but also studies have evaluated change factors that might mediate the salutary effects of these interventions.

Recently, Gu et al. performed a systematic review and meta-analysis only of MBSR and MBCT studies that included mediation analysis. Starting from 169 trials and ending with 20 included in further analyses, the authors found consistent and strong evidence of emotional and cognitive reactivity, repetitive negative thinking (such as rumination and worry), and mindfulness itself as change factors/mechanisms. Only for mechanisms with sufficient studies (mindfulness and repetitive negative thinking) was quantitative synthesis using two-stage meta-analytic structural equation modeling used, further confirming mindfulness and rumination/worry as mediators of the effects of MBIs (Gu et al., 2015). In the same vein, intending to understand change mechanisms using MBCT

TABLE 3 | Evidence-based putative psychological mechanisms of MBIs (MBSR/MBCT).

Author	Emotional	Cognitive	Attitudinal
Gu et al., 2015	<Emotional reactivity	<Cognitive reactivity <Rumination <Worry	>Mindfulness
Van der Velden et al., 2015	>Self-compassion	>Meta-awareness <Worry <Rumination	>Mindfulness

for recurrent depressive disorder, Maj van der Velden et al. performed a systematic review of mediation studies. Out of 23 studies, 12 showed that mindfulness skills, worry, rumination, self-compassion and meta-awareness mediated or predicted treatment outcomes of MBCT (Van der Velden et al., 2015).

From these meta-analytic reviews, including high-quality RCT mediation studies, it is possible to state that mindfulness, emotional and cognitive reactivity, rumination/worry, self-compassion, and meta-awareness might be mechanisms underlying the therapeutic effects of MBIs (for summary of mechanisms, see **Table 3**). On the one hand, increases in *mindfulness*, *self-compassion,* and *meta-awareness* might account for adaptive emotion regulation strategies; on the other hand, decreases in emotional, cognitive reactivity, and rumination/worry might represent the dismantling of dysfunctional emotional-cognitive and self-processing strategies of emotion regulation. This evidence is concordant with the work of Aldao et al. in which *avoidance*, *rumination,* and *suppression* as emotion regulation strategies were correlated to anxiety, depression, and eating disorders (Aldao et al., 2010). Therefore, MBIs might target specific emotion regulation deficits of emotion-related disorders.

NEURAL MECHANISMS OF EMOTION REGULATION INVOLVED IN MINDFULNESS

As we have stated before, emotion regulation can be defined as all the conscious and non-conscious strategies we use to increase, maintain or decrease one or more components of an emotional response (Gross, 2001), including *implicit*, non-conscious, and automatic processes, as well as *explicit*, voluntary and conscious mental processes (Gyurak et al., 2011). From a neural perspective, these processes are realized by different and complex distributed brain systems. Subcortical regions like the amygdala, periaqueductal gray, ventral striatum (VS), anterior insula (AI), and dorsal-anterior cingulate cortex (dACC) are involved in *emotional reactivity*, as emotion generation regions leading changes in arousal and valence regarding the triggering stimuli. Cortical regions such as the dorso-lateral prefrontal cortex (dLPFC), the ventro-lateral prefrontal cortex (vLPFC), the pre-supplementary and supplementary motor area

(pre-SMA and SMA) and parietal cortex are involved in *explicit emotion regulation*. These regions conform to the so-called *central executive network* (CEN), usually involved in top-down emotion regulation, but also in attention and voluntary cognitive control. Finally, the ventral-anterior cingulate cortex (vACC) and the ventro-medial prefrontal cortex (vMPFC) are involved in *implicit emotion regulation*, the outside of awareness processing of emotion, but also in encoding subjective value of the stimuli or condition experienced by the subject (Frank et al., 2014; Kohn et al., 2014; Etkin et al., 2015). From now on, we will refer to the explicit emotion regulation system as the top-down system, and to the emotion generation and the implicit emotion regulation systems as both part of a bottom-up system, since both feed up the top-down system with information regarding arousal, visceral homeostasis, aversiveness and rewardingness of a given stimuli or situation, among others.

It has been stated that different emotion regulation strategies might differentially activate these brain systems implicated in emotion regulation processes. For example, Dörfel et al. found that *detachment*, *distraction (two forms of reappraisal), and expressive suppression* increase brain activation in the same regions of the right fronto-parietal network, reducing activation of the left amygdala. This suggests a common underlying neural process for these strategies, but somewhat contrary to theoretical predictions, since *expressive suppression* as a less adaptive strategy might have a different neural correlate from reappraisal strategies. Interestingly, only *reinterpretation* induced a different activation pattern, recruiting the left vLPFC and orbitofrontal gyrus, but not decreasing amygdala activation (Dörfel et al., 2014). In another study comparing *reappraisal* and *affect labeling*, authors found a common activation pattern including activation in the right and left dLPFC, right and left vLPFC, and pre-SMA, and decreased amygdala and vMPFC activation (Burklund et al., 2014). Recently, a meta-analysis of 48 studies of cognitive reappraisal emotion regulation neuroimaging studies concluded that this strategy particularly activates the bilateral dLPFC, vLPFC, dMPFC, posterior parietal cortex, and left-middle temporal gyrus, and deactivates the amygdala bilaterally. Clearly involving the explicit emotion regulation network. Unexpectedly, no other regions related to emotion reactivity decreased their activation level during reappraisal down regulation (Buhle et al., 2014).

Interestingly, some studies have demonstrated that the top-down or explicit emotion regulation system (dLPFC, vLPFC, parietal cortex) can also be involved in generating emotional states and not only in controlling them, in conjunction or in parallel with the implicit emotion generation system (Ochsner et al., 2009; McRae et al., 2012). In particular, in two studies, applying cognitive reappraisal to emotions generated via implicit stimulation resulted in a paradoxical increased activation of the amygdala (Herwig et al., 2010; McRae et al., 2012). In Herwig et al.'s study, the usage of emotional body-awareness strategy decreased amygdala activation compared to reappraisal strategy (Herwig et al., 2010). These studies highlight the question of whether top-down emotion regulation strategies are always the most appropriate, and whether there are other effective forms of emotion regulation that are not based on top-down mechanism.

Of particular interest for the mindfulness-based emotion regulation field is the notion of bottom-up emotion regulation. At the brain mechanisms level, the main assumption of this model is that the bottom-up systems implying emotional generation regions (like the amygdala, dACC and AI) and implicit emotion regulation regions (like the vMPFC) can also be modulated without the involvement of cognitive control (like the v-d LPFC), or semantic processing regions (temporal cortex). Several authors have argued that mindfulness might exert a unique emotion regulation strategy, termed "mindful emotion regulation," different from cognitive reappraisal (based on top-down system), mainly through the privileged engagement of these bottom-up emotion regulation systems (Chambers et al., 2009; Farb and Segal, 2012; Chiesa et al., 2013; Grecucci et al., 2015a). Nevertheless, whether mindfulness-based emotion regulation is a unique phenomena, and whether it only relies on the involvement of bottom-up systems excluding cognitive control regions (top-down systems), and what the exact brain signature of mindfulness is as an emotion regulation strategy, among other questions, are still a matter of debate and will be addressed in the following sections of the article.

Structural Brain Changes in Mindfulness Experts and Mindfulness-Based Interventions

Several studies have investigated the effect of MBIs and long-term mindfulness meditation practice using structural brain imaging, like morphometry-based magnetic resonance imaging (MRI) techniques. Cross-sectional design studies comparing healthy controls with expert meditators (EMs) from different meditation traditions have demonstrated structural MRI changes in: the hippocampus (Hölzel et al., 2008; Luders et al., 2009; Kang et al., 2013); right anterior insula (AI; Lazar et al., 2005; Hölzel et al., 2008); orbitofrontal cortex (OFC; Hölzel et al., 2008; Luders et al., 2009; Kang et al., 2013); anterior cingulate cortex (ACC; Grant et al., 2013); left temporal pole (TP; Hölzel et al., 2008; Luders et al., 2009; Kang et al., 2013); left frontal gyrus (Vestergaard-Poulsen et al., 2009; Kang et al., 2013); right frontal sulcus (Lazar et al., 2005); corpus callosum (Luders et al., 2012; Kang et al., 2013); and regions in the brainstem (Vestergaard-Poulsen et al., 2009). Moreover, a study using machine learning structural pattern recognition analysis estimated that brains of meditators were 7.5 years younger than matched control subjects (Luders et al., 2016).

As can be seen, covering a wide range of brain regions, according to recent reviews and meta-analysis of neural bases of emotion regulation (Frank et al., 2014; Kohn et al., 2014; Etkin et al., 2015), would partially overlap with emotion reactivity (AI, ACC), and with implicit emotion regulation regions (OFC and vMPFC), and very loosely with explicit emotion regulation (medial PFC, but not lateral PFC regions) systems. From this, if mindfulness meditation would involve cognitive reappraisal, or top-down emotion regulation strategies, one would expect changes in lateral PFC morphometry. It is important to note that due to the design of the studies, it is not possible to infer causality between brain changes and long-term meditation practice; also,

because of the nature of brain structural imaging, it is not possible to derive any information about brain regions' functions. Another limitation of these studies is the variability of hours of meditation practice within this population, ranging from 1,000 to 10,000 or more hours. Nevertheless, they might offer preliminary evidence of the effects of long-term mindfulness practice on brain plasticity.

During the last few years, longitudinal studies have assessed the impact of MBIs on brain morphology, particularly the MBSR 8-week program. Hölzel et al., using MRI voxel-based morphometry (VBM), found changes in gray matter density in the left hippocampus, posterior cingulate cortex, right temporo-parietal junction (TPJ), some small regions in the brainstem, and cerebellum (Hölzel et al., 2011b). In a similar uncontrolled longitudinal study with MBSR, the authors found that decreases in perceived stress were correlated to a decreased gray matter density in the right amygdala (Hölzel et al., 2009). They also found a correlation between major psychological well-being and plastic changes in the brainstem (Singleton et al., 2014). Santarnecchi et al. performed a controlled longitudinal study with MBSR, finding a significant increase in cortical thickness in two clusters: the right SSC and right paracentral lobule, and AI and right inferior frontal gyrus (operculum). The authors found a significant interaction between structural changes in the right insula and a decrease in alexithymia levels, suggesting "body or interoceptive awareness" as a possible mechanism responsible for salutary effects of mindfulness practice (Santarnecchi et al., 2014).

These studies suggest that an 8-week MBI (MBSR) might induce neuroplastic changes in key areas for emotional reactivity (amygdala, insula), body awareness or interoception/exteroception (insula, somatosensory cortex), self-consciousness (posterior cingulate cortex, pons), mood, and arousal regulation (brainstem regions—locus coeruleus, and raphe nuclei), perspective taking (TPJ) and memory systems (hippocampus, cerebellum). Interestingly, none of these studies suggest changes in PFC areas or regions involved in the top-down emotion regulation system, thereby indicating that salutary effects of MBI might be mediated mainly by changes in particular relevant subcortical and cortical regions related to bottom-up or non-emotion regulation related functional systems.

Functional Brain Changes in Emotion Tasks in Mindfulness Studies
Dispositional Mindfulness

Cross-sectional studies in healthy populations have investigated how individual differences in mindfulness as trait might be related to specific brain functions during emotion elicitation task experiments. Creswell et al., in an affect labeling task during fMRI, found that levels of dispositional mindfulness were related to higher activations in the right vMPFC and right vLPFC and major deactivation of the right amygdala (Creswell et al., 2007). In a similar study, participants were asked to observe emotional faces during fMRI, and higher levels of DM were correlated to less amygdala reactivity. Using resting-state functional connectivity (rs-fMRI) analysis, the authors found a relationship between higher dispositional mindfulness and

decreased connectivity within the midline regions, including the PCC and MPFC (Way et al., 2010). Importantly, the midline regions like the MPRC, PCC, precuneus, ACC, and parietal cortex are part of the so-called default mode network (DMN; Raichle and Snyder, 2007), which has been related to mind-wandering (task-unrelated thought) and self-referential processing (Qin and and Northoff, 2011). Brown et al. assessed 46 participants with an electro-encephalogram (EEG) while viewing emotionally laden pictures, particularly looking at the late positive potential (LPP) as a marker of affective processing. Authors found that higher dispositional mindfulness correlated to lower LPP during high-arousal negative images (Brown et al., 2013). Finally, Kong et al., using rs-fMRI and local synchronization measurements (estimated by regional homogeneity) with 290 subjects, found that major dispositional mindfulness correlated to local synchronization in the right insula, left OFC, left parahippocampal gyrus (regions involving emotion reactivity, implicit emotion regulation), and decreased local synchronization with the inferior frontal gyrus (IFG; related to explicit emotion-regulation). Furthermore, levels of local synchronization in the OFC predicted positive emotions, and in the IFG predicted a sense of meaning and purpose in life, both effects mediated by DM (Kong et al., 2016). This study suggests that local synchronization in key regions of emotion regulation might engage differently in subjects high in dispositional mindfulness, accounting for positive emotions' salutary effects. Also it shows no correlation between lateral PFC local synchrony and dispositional mindfulness in emotion regulation-related variables, suggesting that individuals high in dispositional mindfulness might engage in emotion-related processes involving different regulatory systems than top-down ones (for summary of results, see **Table 4**).

Interestingly, these findings are concordant with psychological studies linking dispositional mindfulness to better emotional life outcomes (positive affect and emotional intelligence and minor neuroticism, negative affect, rumination, and borderline symptoms) thereby providing preliminary support for the construct validity of DM. These studies face many limitations, such as the difficulty in deriving causal inferences, and disentangling relevant confounders such as psychological traits and biological differences. Another problematic claim of these studies is the assumption that dispositional mindfulness really reflects daily-life mindful attitudes. At this time, to the best of our knowledge, no study has empirically clarified this point.

Mindfulness Inductions

Studies using brief meditation practice, or mindfulness inductions, have started to explore the clinical utility (effectiveness) and neural underpinnings of these types of interventions. Westbrook et al. performed a cross-sectional study with smokers looking to stop smoking. Participants were asked to watch specific craving-inducing images during fMRI, using "mindful attention" vs. "passive viewing" as strategies. When applying "mindful attention," subjects reported less craving impulse; additionally, they presented decreased activation in the subgenual ACC (sg-ACC), and reduced functional connectivity between this same region and bilateral AI and VS. At the same time, no involvement of the PFC was detected (Westbrook et al., 2013). Interestingly, sg-ACC, AI, and VS correspond to emotion generation regions, but are also implicated in other relevant affective functions such as craving and reward processing (VS), processing of salient stimuli and interoception (AI), and the subjective encoding of value and processing of emotional conflict (sgACC; Wilcox et al., 2016).

Lutz et al., in a cross-sectional study with healthy participants, compared one group applying mindfulness with a no-strategy group while looking at a set of emotional pictures during fMRI. When expecting negative pictures, the mindfulness group displayed increased activation of the left AI, right and left dMPFC, and left dLPFC. During perception of negative pictures, the mindfulness group showed reduced activation in the right amygdala and parahippocampal gyrus, with no involvement of the PFC (Lutz J. et al., 2013). The same researchers also compared groups using mindfulness vs. cognitive reappraisal using the same emotional task as in fMRI. During the expectation of negative pictures, both groups showed a similar pattern of activation of the MPFC and the amygdala, and during the perception of negative images, decreased activation of the head of the right caudate in the mindfulness group was the only difference (Opialla et al., 2014). Interestingly, the first experiment comparing mindfulness vs. baseline conditions suggests a bottom-up (targeting emotion reactivity regions, with no changes in PFC) mechanism of mindfulness as emotion regulation strategy; instead, when adding an active regulatory strategy as comparison, it is almost impossible to differentiate at the neural level between the two emotion regulation strategies. However, the observed deactivation of the right caudate head might index decreased engagement of automated cognitive and motor responses (Parent and Hazrati, 1995), which might be linked to decreased automatic cognitive reactivity, known as a mindfulness mechanism (Gu et al., 2015).

Interestingly, this draws attention to the fact that even a short mindfulness induction, in people naive about meditation, can induce a distinguishable bottom-up brain activation pattern when comparing mindfulness as a strategy to baseline or no-strategy condition. Nevertheless, when compared to cognitive reappraisal, differences seem to vanish. This suggests that mindfulness meditation in naive practitioners is performed with the engagement of widespread brain regions including top-down and bottom-up regulatory systems. From the clinical perspective, these studies provide a valuable outlook for understanding neurobiological substrates of brief meditation practices, which are central components of many MBIs, like MBCT, ACT, or DBT, that intend to elicit "mindfulness states" to face difficult emotions and emotion dysregulation states.

As previously stated, these studies share limitations with cross-sectional design studies. These investigations raise particularly relevant problems in the discussion of mindfulness and emotion regulation mechanisms, starting with the question of the acquisition of the so-called mindfulness emotion regulation strategies—in other words, when and how a person *acquires* the capacity to elicit a "mindfulness state," different from other mental states. And also, when and how a person *acquires* the capacity to use mindfulness as an emotion

TABLE 4 | Summary of neuroimaging studies using emotion-task experiments in different mindfulness conditions.

Mindfulness condition (different models) vs control condition (Waiting list, or active control)	Study design	Population	Sample size: mindfulness (M) vs control groups (C)	Experimental task and neuro-imaging method: resting state functional magnetic resonance imaging (rs-fMRI), task based functional magnetic resonance imaging (fMRI), electroencephalography (EEG)	Main finding: summarized in terms of brain, and/or physiological response changes	References
DISPOSITIONAL MINDFULNESS						
Dispositional mindfulness	Cross sectional/Uncontrolled study	Healthy	M: 27	Affect labeling task during fMRI	Level of DM mediates the relationship between right vMPFC, right vLPFC activation and right amygdala deactivation	Creswell et al., 2007
Dispositional mindfulness	Cross sectional/Uncontrolled study	Healthy	M: 27	Viewing negative emotional faces during fMRI + rs-fMRI	Higher DM correlated with less amygdala reactivity. Also with less resting connectivity in midline brain regions (self-referential processing)	Way et al., 2010
Dispositional mindfulness	Cross sectional/Uncontrolled study	Healthy	M: 46	Viewing negative/positive pictures during EEG (LPP: late positive potential)	Higher DM correlated to lower LPP during high-arousal negative emotions	Brown et al., 2013
Dispositional mindfulness	Cross sectional/Uncontrolled study	Healthy	M: 290	rs-fMRI—local synchronization	Higher DM correlated to local synch in left OFC, left parahippocampal gyrus, right insula. Local synch in OFC-predicted positive affect, and in IFG-predicted purpose/meaningful life	Kong et al., 2016
MINDFULNESS INDUCTION						
Mindfulness induction	Cross sectional/Uncontrolled study	Smokers looking for treatment to stop smoking	M: 47	Cue-induced craving during fMRI.	Reduced neural activity in sg-ACC [craving-related—emotion reactivity region] and a reduced functional connectivity between this same region with the bilateral insula and ventral striatum with no direct involvement of PFC regions (*)	Westbrook et al., 2013
Mindfulness induction	Cross sectional/Non-randomized controlled study	Healthy	M: 24/C: 22	Cued expectation and perception of negative pictures during fMRI	During expectation major activations in prefrontal regions: left AI, right and left dMPFC and left dLPFC. During perception reduced activation in right amygdala and parahippocampal gyrus [emotion processing reactivity] (*)	Lutz A. et al., 2013
Mindfulness induction vs Reappraisal strategy	Cross sectional/Non-randomized controlled study	Healthy	M: 24/C: 23	Cued expectation and perception of negative pictures during fMRI	Both groups: similar activity of the m-PFC and the amygdala. Major activations in MI group, during expectation: vLPFC, vLPFC, Supramarginal gyrus and left insula. During perception: major activity in the caudate in the cognitive group	Opialla et al., 2014
MINDFULNESS-BASED INTERVENTIONS						
Mindfulness-based stress reduction	Cross sectional/Non-randomized controlled study (novice vs those who attended the course)	Healthy	M: 20/C: 16	Self-reference task during fMRI	Significant difference in the neural correlates of the self-reference task, during experiential focus an increased activation in right brain regions: lateral PFC, insula, second somatosensory area, and IPL	Farb et al., 2007

(Continued)

TABLE 4 | Continued

Mindfulness condition (different models) vs control condition (Waiting list, or active control)	Study design	Population	Sample size: mindfulness (M) vs control groups (C)	Experimental task and neuro-imaging method: resting state functional magnetic resonance imaging (rs-fMRI), task based functional magnetic resonance imaging (fMRI), electroencephalography (EEG)	Main finding: summarized in terms of brain, and/or physiological response changes	References
Mindfulness-based stress reduction vs Waiting list	Longitudinal/Non-randomized controlled study	Healthy	M: 20/C: 16	Sadness induction paradigm during fMRI	MBI group changed activation pattern in key emotion regulation regions: major activation in the right anterior insula, r-IPFC and sg−ACC.	Farb et al., 2010
Mindfulness-based stress reduction	Longitudinal/Non-Controlled trial	Social Phobia	M: 16	Breath focus task during fMRI	Reduced amygdala activity, major activation in precuneus, SPL, IPL compared to distraction focus task	Goldin and Gross, 2010
Mindfulness Training (4 days)	Longitudinal/Non-Controlled trial	Healthy (pain)	M: 15	Breath focus meditation during noxious stimulation task in fMRI	MBI reduction in pain intensity: major activation in ACC, anterior insula. MBI reduction in pain unpleasantness: major activation in OFC and thalamus (*)	Zeidan et al., 2011
Mindfulness-based stress reduction vs Aerobic exercise	Longitudinal/Randomized controlled trial	Social Phobia	M: 31/C: 25	Self-reference task during fMRI	MBIs during negative self-view: major activation in PCC, and dMPFC activity-associated less social anxiety disability and mindfulness level	Goldin et al., 2012
Mindfulness-based stress reduction vs Aerobic exercise	Longitudinal/Randomized controlled trial	Social Phobia	M: 31/C: 25	Emotion regulation of negative self-beliefs task during fMRI	MBI regulating negative self-beliefs: fewer negative emotions, major activation in R-IPL, R-SPL	Goldin et al., 2013
Mindfulness-based stress reduction vs Stress management education	Longitudinal/Randomized controlled trial	Generalized Anxiety Disorder	M: 15/C: 11	Affect labeling of emotional expressions during fMRI	Both groups less amygdala activation. MBI major activation in vLPFC. Increase functional connectivity between amygdala and PFC regions	Hölzel et al., 2013
Mindfulness Training (6 weeks) vs Shared reading and listening group	Longitudinal/Randomized controlled trial	Healthy	M: 30/C: 31	Affective Stroop conflict resolution task during fMRI	Both groups improved significantly in a response inhibition task. MBI reduced emotional interference, in negative emotion processing: increased bilateral dLPFC, right anterior insula and m-PFC (*)	Allen et al., 2012
Mindfulness Training (8 weeks) vs Compassion training vs Health discussion group	Longitudinal/Randomized controlled trial	Healthy	M: 12/C: 12/Compassion Training: 12	Observation of emotional pictures during fMRI	In MBI: decrease in right amygdala activation (all valences). In Compassion Training: trend increase in right amygdala response in negative pictures (*)	Desbordes et al., 2012
Mindfulness Training (4 days) vs Sham mindfulness vs Placebo vs Control	Longitudinal/Randomized controlled trial (four-arm)	Healthy (pain)	M: 80	Pain regulation strategy during noxious stimulation task in fMRI	MBI reduction in pain intensity: major activation in sg−ACC, anterior insula, OFC. Placebo analgesia: major activation in DLPFC and secondary somatosensory cortex (*)	Zeidan et al., 2015

(Continued)

TABLE 4 | Continued

Mindfulness condition (different models) vs control condition (Waiting list, or active control)	Study design	Population	Sample size: mindfulness (M) vs control groups (C)	Experimental task and neuro-imaging method: resting state functional magnetic resonance imaging (rs-fMRI), task based functional magnetic resonance imaging (fMRI), electroencephalography (EEG)	Main finding: summarized in terms of brain, and/or physiological response changes	References
EXPERT MEDITATORS						
Tibetan Buddhist monks	Cross sectional/Case-control study	Healthy	M: 14/C: 16	Auditory stimuli during focus attention task in fMRI	EM: amygdala deactivation	Brefczynski-Lewis et al., 2007
Tibetan Buddhist monks	Cross sectional/Case-control study	Healthy	M: 15/C: 15	Auditory stimuli during active compassion meditation in fMRI	EM: increased activation in the anterior insula and ACC, proportional to compassion experience intensity	Lutz et al., 2008a
Zen Western vs novices meditators	Cross sectional/Case-control study	Healthy	M: 12/C: 8	Observation of emotional pictures during active meditation in fMRI	EM during meditation: major deactivation of m-PFC and PCC. Relative deactivation of amygdala and insula vs novice meditators. Novice during meditation: downregulation of amygdala	Taylor et al., 2011
Zen Western	Cross sectional/Case-control study	Healthy	M: 13/C: 13	Noxious stimulus during fMRI	EM during pain: reduced activation in PFC, amygdala, hippocampus. Major activations in ACC, insula, thalamus.	Grant et al., 2011
Vipassana	Cross sectional/Case-control study	Healthy	M: 17/C: 17	Noxious stimulus during fMRI	EM during pain in meditation: reduced activation in lateral PFC, major activation in ACC, R-posterior insula	Gard et al., 2012
Tibetan tradition	Cross sectional/Case-control study	Healthy	M: 14/C: 14	Noxious stimulus during fMRI	EM: equal pain, less unpleasantness. During pain: major AI, ACC. Minor baseline activation AI, ACC, amygdala	Lutz A. et al., 2013
Buddhist Western	Cross sectional/Case-control study	Healthy	M: 18/C: 26	Dictator Game (DG) and Ultimatum Game (UG) during Skin Conductance Level (SCL)	EM: in DG reduced arousal, distress and SCL. In UG accept more unfair offers	Grecucci et al., 2015b
Buddhist Western	Cross sectional/Case-control study	Healthy	M: 26/C: 40	Ultimatum game during fMRI	EM: in UG accept more unfair offers. Major activation of the posterior insula (interoception) versus anterior insula (emotion reactivity) in controls; major activation in somatosensory and posterior superior temporal cortex	Kirk et al., 2011
Zen Western	Cross sectional/Case-control study	Healthy	M: 34/C: 44	Monetary incentive delay during fMRI	EM during reward anticipation: reduced activation in caudate nucleus, major activation in bilateral posterior insula. During reward receipt: reduced activation in vMPFC	Kirk et al., 2011
Buddhist Western	Cross sectional/Case-control study	Healthy	M: 28/C: 30	Passive conditioning task during fMRI	EM during reward prediction: reduced positive and negative prediction error BOLD in putamen. Major activation in posterior insula	Kirk et al., 2015

*Finding indicates bottom-up mechanisms.

regulation strategy. Finally, the question of how this learning process can be distinctly measured from behavioral and brain signatures. These are central questions that future studies need to unravel.

Mindfulness-Based Interventions: Longitudinal Studies on Emotion, Pain, and Anxiety

Over the last few years, longitudinal studies using fMRI have used a myriad of experimental tasks investigating emotion regulation changes secondary to MBIs. Farb et al. studied the impact of MBSR using fMRI under a sadness induction paradigm. After the intervention, the mindfulness group changed the activation pattern in key diverse emotion regulation regions: comparatively increased activation in the right AI, right LPFC and sg-ACC. The control group showed major activation in the left PFC, left superior temporal sulcus (STS), precuneus, and PCC, areas usually involved in self-awareness and semantic processing (Farb et al., 2010). From the same lab, using a self-referential task (self-narrative vs. self-experiential) during fMRI, an increased activation was found in similar right brain regions, LPFC, AI, second SSC and inferior parietal lobule (IPL), for the *self-experiential* focus. Conversely, a *self-narrative* focus engaged major activation in the left vMPFC, dMPFC, and PCC, all midline regions that mainly correspond with the DMN (Farb et al., 2007). These studies indicate a different engagement of brain regions during emotion regulation; although both groups displayed top-down mechanisms linked to explicit emotion regulation systems (right or left LPFC), only the MBI groups employed regions related to emotion reactivity (AI, ACC), interoception (AI) and somatosensory awareness (SSC, IPL).

Attempting to unravel the involvement of different emotion regulation systems implicated in mindfulness meditation, Allen et al. performed an RCT comparing a 6-week mindfulness training and an active control (sharing and listening training). Despite both groups improving significantly in a response inhibition task, only the MBI group showed reduced emotional interference under an affective Stroop conflict resolution paradigm (a task known to activate implicit emotion regulation processes). The authors found no differences between groups in behavioral and neural activations during negative affect processing. Nevertheless, the greater amount of mindfulness practice predicted increased activation of bilateral dACC, right AI, and MPFC during implicit negative emotional processing, suggesting both implicit and explicit emotion regulation plasticity as mechanisms underlying mindfulness training (Allen et al., 2012). Another RCT study compared the effects of an 8-week Mindful Attention Training (MAT) vs. Cognitively Based Compassion Training (CBCT) vs. active control while participants passively viewed affective pictures during fMRI. In a region of interest analysis, the authors found decreased activation in the right amygdala in the MAT group in response to images of all valences. Interestingly, a trend increase in activation of the right amygdala when viewing negative images in the CBCT group was found, and the extent of this increase was significantly correlated to reductions in depressive symptoms (Desbordes et al., 2012). Although not conclusive, both RCT studies provide evidence that MBIs might exert their effects on the level of emotion reactivity and implicit emotion regulation.

Other studies have evaluated the impact of MBIs on pain processing. Zeidan et al. performed a longitudinal uncontrolled study with 4-day MBI training, using Artetial Spin Labeling (ASL), a technique for estimating cerebral blood flow with MRI across time points. After the intervention, during a breathing meditation task, the authors found decreased perfusion of the MPFC and PCC (DMN), and a major activation of the AI, ACC, pre-SMA, OFC, VS, SSC, and posterior insula (PI). During a pain induction paradigm, minor activation of the contra-lateral SSC and increased activation in the ACC, AI, PI, and fronto-parietal operculum were reported. It is worthy of note that participants reported a significant decrease in pain intensity and unpleasantness (Zeidan et al., 2011). Later, the same authors performed a four-arm RCT comparing MBI vs. placebo vs. sham mindfulness using a pain induction paradigm with ASL MRI. Interestingly, all groups showed a significant reduction in pain intensity and unpleasantness, but the MBI demonstrated a unique brain mechanism including greater activation of the OFC, sg-ACC, and AI. In line with previous evidence, these studies highlight emotion reactivity (AI, ACC, VS) and implicit emotion regulation (OFC, vMPFC) systems as the main emotion regulation targets of MBIs, again notably without any major involvement of PFC-related systems (top-down emotion regulation).

Other researchers have explored the effects of MBIs in clinical populations. In one of the first such studies, Goldin and Gross conducted an MBSR longitudinal study with people suffering from social anxiety disorder (SAD). Comparing two emotion regulation strategies using an anxiogenic task with negative self-beliefs, the authors found that being breathing-focused (vs. distraction-focused) produced minor negative emotional experiences, decreases in amygdala activation, and increased activation of the PCC, SPL, and IPL (areas involved in top-down emotion regulation, but also in self-awareness and attention processing; Goldin and Gross, 2010). The same authors performed an RCT comparing MBSR with aerobic exercise (AE), also in SAD patients, in this case comparing mindful attention (metacognitive perspective of mental content) and reacting (thinking according to negative self-beliefs) as strategies for dealing with negative-self-belief-induced emotions. During the task, the MBSR group reported fewer negative emotions, and showed differential engagement of attention regulation areas, with increased activation of the right IPL and SPL, and decreased activation of the culmen and left lingual gyrus (Goldin et al., 2013), areas involved in the orienting-attention network, implicated in early spatial detection of stimuli (Posner et al., 2006). The authors interpreted this finding as suggesting that MBIs enhance approaching behavior/attention toward anxiogenic stimuli, a core deficit in SAD (Goldin et al., 2013). In the context of the same trial condition, both groups significantly decreased social anxiety symptoms, disability and negative self-attribution, while also increasing positive self-views. Examining the neural correlate of self-views, the MBSR group displayed larger responses in the PCC, and dMPFC, which correlated with minor social anxiety, disability, and increased mindfulness (Goldin et al., 2012). Finally, Hölzel et al. ran an RCT with generalized anxiety disorder (GAD) patients, comparing MBSR and psychoeducation treatment groups performing an

emotion labeling task during fMRI. The findings highlighted small increases in amygdala activation in both groups, and major increases of activity in the vLPFC, as well as increased functional connectivity between these regions (Hölzel et al., 2013). These studies point toward the idea that MBIs target basic cognitive processes broadly involved in attention regulation, including information updating, response inhibition, and goal maintenance (Malinowski, 2013). Interestingly, these are core functions for the CEN, and for the top-down emotion regulation system (Okon-Singer et al., 2015). In sum, these studies provide evidence that MBIs might exert their effects through top-down/cognitive-control emotion regulation mechanisms. Besides sample size, noteworthy limitations of these studies include the lack of control of basal cognitive deficits in patients, and of personality and comorbidity factors, which might influence basal neuroimaging results.

Expert Meditators (EMs): Cross-Sectional Studies on Emotion, Pain, and Reward

Lutz et al. used an annoying auditory task during fMRI, comparing Tibetan monks and controls during active compassion meditation. They found increased activity in the AI and ACC, which were proportional to first-person experience of compassion intensity (Lutz et al., 2008a). Using the same experimental task, but during focused-attention meditation, researchers also found a direct relationship between meditation expertise (total hours of practice) and amygdala deactivation (Brefczynski-Lewis et al., 2007). Taylor et al. compared Western EMs with novel meditators using emotional pictures during fMRI, and observed a decrease in activation levels of the PCC and MPFC (DMN) during active meditation in EMs. During passive observation, beginner meditators showed major amygdala activation increases for negative affective pictures (Taylor et al., 2011). These studies highlight a specific modulation of the emotion generation system in EMs during emotion tasks.

Other studies have explored the effects of EMs in pain processing. Gard et al. compared Western EMs with controls, contrasting active meditation, and resting state using a pain induction paradigm with fMRI. The authors found no differences between groups in pain intensity, but in active meditation during pain induction, EMs referred less unpleasantness and a major activation in the right AI and a deactivation in the right and left inferior PFC (Gard et al., 2012). Grant et al. also compared EMs with controls during a pain induction task in fMRI. EMs showed decreased activation of the PFC, amygdala and hippocampus, and increased activity in the AI, ACC, and thalamus. Interestingly, the decreased functional connectivity between PFC and AI and ACC predicted lower pain in EMs (Grant et al., 2011). In a similar study, EMs showed lower baseline activation in the AI, ACC, and amygdala, and during pain induction higher activation of AI and ACC regions than controls (Lutz A. et al., 2013). These studies indicate that EMs specifically increases activation of subcortical emotion generation regions, related to affective processing of pain, and deactivates top-down mechanisms, evidencing a unique emotion regulation bottom-up mechanism.

Other studies have used reward or economic behavioral paradigms for studying emotion processing in EMs. Grecucci et al. compared EMs with a control group contrasting a "cognitive" vs. an "experiential" emotion regulation strategy during two monetary distribution tasks. While receiving offers in the dictator game, EMs showed decreased emotion arousal and physiological reactivity, with no effect of the strategy observed. While receiving unfair offers in the ultimatum game (UG), EMs accepted more unfair offers and performed less punishment, particularly during the "experiential" emotion regulation strategy (Grecucci et al., 2015a). Another study used fMRI during the execution of the UG. Compared to controls, EMs accepted more unfair offers, and during that particular condition engaged a particular functional brain response with greater activation of the PI than the AI, and major activation in the SSC and posterior superior temporal cortex (Kirk et al., 2011). Note that the PI is preferentially involved in interoception and the AI in emotion reactivity/generation and emotional awareness (Craig, 2009; Gu et al., 2013). These studies show that during socially induced negative emotions, EMs showed stronger modulation of their interactive behavior (less punishment) and greater emotion regulation, which was mediated via increased activation of interoception and exteroception brain regions, modulating emotion generation regions.

Kirk et al. used the monetary incentive delay task in EMs during fMRI, looking to disentangle the neural differences between anticipation and receipt of monetary reward. Compared to controls, during the anticipation phase EMs displayed decreased activation of the bilateral caudate, and increased activation of the bilateral PI. During the encoding of gains of reward, a minor activation of the vMPFC was seen (Kirk et al., 2015), indicating a dampening of the reward system. The same authors used a passive conditioning task (pairing a yellow light to juice intake) to evaluate how changes in the predictability of reward, encoded by the prediction error (PR) neural signal, differ between EMs and matched controls. In this task, the delay of the reward decreases PE (negative PE), while the intake of unexpected reward generates an increase in PE signal (positive PE). EMs were found to be less prone to positive and negative PE signals in the putamen (part of the striatum and the reward system), which again was associated to major activation in the PI (Kirk and Montague, 2015). Interestingly, both studies show a specific modulation in value reward processing in the striatum and vMPFC, from interoceptive body awareness regions (PI) that correspond to bottom-up emotion regulation systems, in line with the bottom-up mechanism hypothesis of emotion regulation changes derived from mindfulness practice.

INTEGRATING PSYCHOLOGICAL, CLINICAL AND NEUROSCIENCE EVIDENCE ON EMOTION REGULATION IN MINDFULNESS RESEARCH

The field of contemplative science, the scientific study of the effects of mindfulness, and contemplative practices in mental health and biological functions, is fairly new but growing quickly.

In this article we have focused exclusively on the relationship between mindfulness practices, using diverse empirical models (dispositional mindfulness, mindfulness inductions, MBIs, and EMs), and emotion regulation functions from psychological and neurobiological perspectives. A range of MBIs have demonstrated utility in several clinical conditions (see **Table 1**), targeting a myriad of emotion dysregulation symptoms (Gotink et al., 2015).

With the aim of understanding mechanisms underlying mindfulness health benefits, authors have proposed several psychological and neurocognitive models (see **Table 2**) that cover attention, emotion, and self-awareness systems as target mechanisms (Tang et al., 2015). Here we focused particularly on emotion regulation mechanisms targeted by mindfulness meditation, reviewing different studies using psychological and neuroimaging measurements, ranging from correlational to randomized longitudinal designs.

In the field of mindfulness and emotion regulation, one main claim is that mindfulness might elicit a particular type of emotion regulation strategy often called "mindful emotion regulation" that relies on bottom-up mechanisms, in contrast to cognitive reappraisal, which relies on a top-down mechanism. Although there is no single definition, mindful emotion regulation is conceived as a unique emotion regulation strategy, that results from encountering diverse emotional states from a mindful mental state, which includes awareness and acceptance (Chambers et al., 2009; Farb and Segal, 2012; Chiesa et al., 2013; Grecucci et al., 2015a). In particular, it is stated that bottom-up emotion regulation strategies (like those implied in mindfulness) don't require PFC and top-down mechanisms (Chambers et al., 2009; Farb and Segal, 2012; Chiesa et al., 2013; Grecucci et al., 2015a). In terms of neurobiological emotion regulation systems, these strategies might rely on modification of implicit emotion regulation and emotion generation systems, but not on changes in the explicit emotion regulation system. In this section, in accordance with the reviewed studies, we will assess whether this claim and its assumptions are met.

Studies measuring structural brain changes in EMs highlight changes in the MPFC and diverse subcortical regions, including regions devoted to meta-awareness, memory consolidation, extero-interoception, and emotion regulation (Fox et al., 2014), with no exact matching to bottom-up systems, but with no involvement of typical LPFC. Longitudinal studies with MBIs have also implicated regions typically involved in the same functions described above (like the AI and amygdala), but no changes in the MPFC and LPFC have been found, regions known for top-down emotion regulation. Strikingly, only AI and brainstem regions overlap between EM and MBIs studies, suggesting neuroplasticity in key areas for emotion generation, interoception, mood, and viscerosomatic processing. As mentioned, no inference about causality (in EM studies), nor about brain functions, can be derived from these studies.

Studies measuring dispositional mindfulness have found negative correlations with negative affect and positive correlations with positive affect traits; factorial analysis has pointed out the distinct and interrelated nature of mindfulness and emotion regulation as constructs. Mental health outcomes of mindfulness might be mediated by emotion regulation capacities (Coffey et al., 2010). Similarly, dispositional mindfulness has been linked to a higher right PFC, minor amygdala activation and changes in rs-fMRI in regions from all the emotion regulation systems (see **Table 4**). These studies provide evidence of top-down regulation mechanisms. As stated early, several limitations preclude an unequivocal interpretation of these findings in the context of mindfulness and emotion regulation research.

Two studies using mindfulness inductions (mindfulness as emotion regulation strategy) have provided preliminary evidence of direct bottom-up regulation engagement, changing the emotion generation system, with no involvement of the PFC. However, these studies lack an alternative cognitive emotion regulation strategy for contrasting the specificity of the strategy (see **Table 4**). In addition to the noted methodological limitations, we argue that using a unique mindfulness induction session might be insufficient for eliciting a "mindful emotion regulation" strategy and the recruitment of the bottom-up brain systems. Secondly, central to this discussion is the question of how mindfulness as an emotion regulation strategy is defined and operationalized. Is it a formal practice, identical or derived from mindfulness meditation? Or is it a particular state, related to the notion of mindfulness as a transient state? We will return to this discussion in the next section.

Longitudinal studies have yielded mixed results regarding the involvement of different emotion regulation systems (top-down vs. bottom-up). Studies with healthy populations using self-experiential focus recruit emotion-generation (AI, sg-ACC) and body-awareness (AI, SSC) systems. Well-designed RCTs with active control groups have mostly (but not exclusively) demonstrated changes in emotion generation (amygdala, AI, ACC) and implicit emotion regulation systems (v-MPFC, OFC), while being effective in regulating negative emotions. Clinical studies with anxiety disorder populations have shown major involvement of explicit emotion regulation systems (see **Table 4**). It is worth noting that these differences might be due to methodological limitations (e.g., simple size), but also to the specific cognitive demands of the experimental tasks (such as self-reference, regulation of self-beliefs or affect labeling tasks) that by nature require top-down regulation mechanisms. Overall, changes in bottom-up neural mechanisms are in line with the findings of psychological studies of MBIs, in which decreases in *emotional cognitive reactivity,* and *rumination* strategies, and increases in *mindfulness skills*, *self-compassion,* and *meta-awareness* emotion regulation strategies, appear to underlie the beneficial effects of MBIs (see **Table 3**).

Finally, studies with EMs using emotion and pain paradigms have consistently demonstrated changes in bottom-up emotion generation systems (amygdala, AI, sg-ACC), with reported deactivations in, or no involvement of, the PFC. In some studies involving social emotion or reward processing tasks, EMs displayed increased engagement of interoception brain system (mainly PI), modulating emotion generation, and implicit emotion regulation systems of reward-related areas (caudate, putamen, v-MPFC; see **Table 4**), providing evidence of the engagement of a bottom-up emotion regulation system in EMs.

From the reviewed studies, we argue that there is support for the claim that mindfulness practice changes the bottom-up emotion regulation systems (emotion generation and implicit emotion regulation systems), although this effect diverges across different empirical models dispositional mindfulness, mindfulness inductions, MBIs and EM studies. In line with Chiesa et al. (2013), studies with EMs show a clearer engagement pattern of bottom-up systems, suggesting that these types of strategies are developed through long-term meditation training. However, intervention studies with a RCT design are better suited for providing evidence about a causal relationship between mindfulness training and bottom-up emotion regulation system changes.

The Problem of Mindful Emotion Regulation

From psychological studies, including theoretical and evidence-based psychological models (**Table 3**), as well as neuroimaging studies (**Table 4**), it becomes evident that mindfulness (in MBIs and EMs) also engages and requires top-down emotion regulation. As Lutz et al. stated, mindfulness meditation can be conceived as "a family of complex emotional and attentional regulatory strategies developed for various ends" (Lutz et al., 2008b). From a traditional Buddhist psychology perspective, the development and refinement of attention (attention regulation; Grabovac et al., 2011), and the capacity for monitoring and labeling affective states (Analayo, 2003), are central for achieving the intended effects of mindfulness meditation. From this viewpoint, and taking into account models of different emotion regulation brain systems and different emotion regulation strategies, the notion of "mindful emotion regulation" (Chambers et al., 2009; Farb and Segal, 2012; Chiesa et al., 2013; Grecucci et al., 2015a) seems to imply certain problematic aspects.

The notion of "mindful emotion regulation" entails two problematic aspects. The first refers to the nature and definition of the construct "mindful emotion regulation" itself, and the second refers to its brain correlates or engagement/functioning of emotion regulation systems, which we will address separately.

Although we have extensively shown that emotion regulation is (somehow) enhanced by mindfulness practice, we argue that the notion of "mindful emotion regulation" has not been accurately and properly defined. Is "mindful emotion regulation" a psychological trait, stable in time, that diverges across subjects? Or is it a particular mental practice derived from mindfulness? Or is it a mental state, like a transient moment of mindfulness? Generally, the common view across authors is that "mindful emotion regulation" is a *somehow unique* emotion regulation strategy, the result of encountering diverse emotional states from a mindful mental state, including awareness and acceptance (Chambers et al., 2009; Farb and Segal, 2012; Chiesa et al., 2013; Grecucci et al., 2015a). From a first-person perspective, this definition does not make explicit specifications regarding what the practitioner should do while engaging within the emotional state, only succinctly suggesting the gradual development of experiential qualities (attentiveness, acceptance, etc.). What

should the focus of attention be (external or internal stimuli)? And, in terms of behavior, what exactly should be done to *perform* the regulation (approach, stop, or hold back)? From a psychological perspective, there is not a clear commitment regarding the unique (or common) involvement of attentional or emotional or body awareness processes. Thus, in line with clinical evidence (**Table 3**), it is not clear whether "mindful emotion regulation" is properly a unique emotion regulation strategy, with a unique neurocognitive underlying mechanism.

In light of this debate, we argue that "mindful emotion regulation" entails a variety of emotion regulation *processes*, including top-down processes which are cognitively based, involving attention and voluntary cognitive control, conscious monitoring, and explicit regulatory functions; and bottom-up processes, which are affect driven, based on emotion functions that modulates arousal, valence and the encoding of subjective value regarding the triggering stimuli. We argue that "mindful emotion regulation" entails as well a variety of emotion regulation *strategies*, in accordance with the different strategies taught within MBIs and EMs trainings. In this context, we propose a distinction between primarily *top-down* mindfulness-based emotion regulation strategies and *bottom-up* mindfulness-based emotion regulation strategies. Since emotions are multi-componential processes (Thompson, 1990), and like Gross's classification of emotion regulation strategies, our distinction is based on the primary component of the *emotional response* that is targeted and drive the regulation of the emotional state (Koole, 2009).

Top-down mindfulness-based emotion regulation strategies correspond to affect labeling, mindful detachment, dereification, meta-awareness, and cognitive reappraisal, among others, for which *cognitions* and *thought process* are the primary targets of the strategy. Within this group we can find impulses control and emotion dysregulation managing strategies, like those delivered in MBIs (like in DBT and ACT) in which subjects use intentional efforts to increase their attention and awareness capacities for better regulation and control of emotions (Linehan, 1993; Hayes et al., 1999). In this group, dereification and meta-awareness would correspond to more sophisticated strategies, since they involve the development of insight into the nature of the thought process itself (e.g., see thoughts not as facts; Dahl et al., 2015). Using the *process model* of emotion regulation by Gross, we can understand that increases of mindfulness can indeed modulate any of the five stages: selecting or modifying a situation, deployment of attention, changing cognition (cognitive reappraisal), modulating the experience, and behavior, or physiological response (Gross, 2001). This distinction is in line with findings in MBIs (**Table 4**), and by Chiesa et al. (2013), and is consistent with the claim that novel practitioners in MBIs use primarily top-down emotion regulation strategies.

In bottom-up mindfulness-based emotion regulation strategies, *sensory-perception* and *interoceptive-proprioception* are the primary aspects of the emotional response targeted by the strategies. The bottom-up strategies are characterized by the intentional stance to directly feel (instead of think) or to experience, thus targeting primarily the *feeling* processes (sensory-perception and interoceptive-proprioception).

Bottom-up mindfulness-based emotion regulation strategies include concrete experiential explorations that focus for example on unimodal body sensations, like feeling the temperature of the skin, or exteroceptive sensations, feeling the peri-personal space around, to interoceptive sensations, like feeling the internal sensations of the body. Other strategies focus on the broad multi-modal sensory perception of the body, in which interoceptive, exteroceptive sensations, and basic sensory (auditory and visual) perceptions are used as *a whole* as the main focus of intentional experiential explorations (Kabat-Zinn, 2005).

From the above, the bottom-up mindfulness-based emotion regulation strategies range from the titrated exposure to negative sensations (e.g., physical pain), to different body and perception modalities conscious explorations, to the exposure to the complete range of negative and positive emotions without holding or avoiding/rejecting, which are thought within MBIs and EMs trainings. In sum, there is an explicit intention of experiential exploration of bodily sensations (e.g., the *felt sense)* underlying *all* type of emotion and mental content (Hölzel et al., 2011a). For example in the MBCT program, participants are instructed to use the "opening the door of the body" strategy, which invites to be aware of the body sensations that accompany any intense emotions, stepping back from cognitive analysis and rumination and thus cultivating "intimacy" with the raw and usually rejected experience of emotions (Segal et al., 2002). As we have argued, these strategies are primarily the result of changes in bottom-up emotion regulation systems (e.g., exposure to painful feelings), and can be present in mindfulness inductions, MBIs and EMs.

We further noted that studies applying cognitive reappraisal to emotions generated via bottom-up stimulation can result in a paradoxical increase in amygdala reactivity (Herwig et al., 2010; McRae et al., 2012), which in turn can be related to ruminative or repetitive negative thinking as maladaptive cognitive emotion regulation strategies (see **Table 3**), characteristic of anxiety and depression disorders (Aldao et al., 2010). Dysfunctional top-down emotion regulation in psychiatric conditions such as MDD (Johnstone et al., 2007) might be related to dysfunctional forms of self-evaluative processes such as rumination and worry (Farb and Segal, 2012). In this sense, emotions can be generated from top-down and bottom-up systems (Ochsner et al., 2009; McRae et al., 2012), and the way/pathway emotions are generated seems to play a crucial role in the successfulness of emotion regulation strategies. Bottom-up-generated emotional states, as pain and reward in EM studies reveal, might be best targeted by bottom-up mindfulness emotion regulation strategies (see **Table 4**).

Embodied Emotions and Emotion Regulation

Classical theories of emotions from Aristoteles, Spinoza, and Hume have highlighted the importance of the body and physiological aspects of emotions, conceiving them essentially as psychosomatics states (Colombetti and Thompson, 2008). Post Jamesian contemporary authors like Damasio and Prinz assert that emotions are basically the perception of the actual physiological condition, affirming in a broad sense the embodied nature of emotions (Damasio, 1999; Prinz, 2004). As Colombetti et al. noted, cognitivist theories of emotions have neglected the role of the body in the generation of emotional states (Colombetti and Thompson, 2008), and as we argue, as well in the regulation of emotional states.

In this context, one of the problematic aspects of Gross's "process model" of emotion regulation is the assumption of a linear fixed sequence through which emotions are generated, starting from attention to relevant external stimuli, cognitive appraisals, to emotional responses and behaviors as secondarily generated (Koole, 2009). Nevertheless, relevant stimuli can trigger emotions without cognitive reappraisal (e.g., Neumann et al., 2003) and emotions can be generated from the bottom-up systems (Ochsner et al., 2009; McRae et al., 2012). Using magneto-encephalography Rudrauf et al. showed that emotional stimuli elicited early brain activation in the visual cortex, spreading through the ventral visual stream, temporopolar regions, to OFC/vMPFC, ACC, and SSC. This early activation was correlated to arousal ratings and heart beats changes (Rudrauf et al., 2009). Also, it is known that bodily movements can actively influence emotions (Strack et al., 1988; Niedenthal et al., 2005), the manipulation of body posture can alter the regulation of mood (Veenstra et al., 2016), and intentional movement can regulate emotional states (Shafir et al., 2013). From this, even more relevant is the fact that *previous* emotional states can strongly influence cognitions and attention processes (Okon-Singer et al., 2015), which then will drive the emotion regulation process. We argue that this model is fairly reductionist (neurocentric), since it denies the constitutive interwoven nature of body and brain and that their widely known continuous bi-directional interactions are essential for adaptive behavior (Chiel and Beer, 1997).

We argue that the cognitivist "neurocentric" model also disregard the complex reciprocal influences between cortical (high-order) and subcortical (low-order) regions (Okon-Singer et al., 2015). This "corticocentric" model of the brain, in which "high"-order regions dominate "low"-order regions (Parvizi, 2009), fits very well with the "process model" of emotion regulation, in which only the cortical top-down emotion regulation system has a privileged role for regulating emotional states. As we have shown in this article, bottom-up (mindfulness-based) emotion regulation strategies modulate *sensory-perception* and *interoceptive-proprioception* components of the emotional state, due to changes in bottom-up emotion regulation systems. These subcortical systems are central in the homeostatic regulation of neuro-vegetative and visceral functions which provide the *bodily* aspect of emotion experience (Bechara et al., 2000; Critchley et al., 2002).

The enactive approach to mind-brain considers cognition, emotion, and body functions as parts of an integrated system at neurobiological, psychological, and phenomenological domains (Thompson and Stapleton, 2009). One of its central principles is the notion of embodiment, or embodied cognition, which in simple terms claims that the whole body (not only the brain) is involved in building up cognition (Varela et al., 1991; Kiverstein, 2012), and in this particular case the experience of emotions (Colombetti and Thompson, 2008; Slaby et al.,

2013; Colombetti, 2014). From this perspective, the emotional or affective dimension is connatural and constitutive of organism's adaptation and agency in the world. Organisms have to be "sensible" to their environment in order to *make sense* and *adaptively respond* to new demands, in this account emotions are inseparable from cognitions (Colombetti, 2014). Central for the affective constitution of organisms, three interrelated activities characterize the embedded body-brain system: the capacity of *self-regulation* of internal states, *sensorimotor coupling* with the environment and *intersubjective interaction* with other agents (Thompson and Varela, 2001).

In this context, we argue that emotions are the *ensuing* and *guiding* state of the organism engagement with the environment (world), in which the regulation of its own internal homeostatic states (humoral, visceral, somatic-motor) is inseparable from the emotional state itself (that is targeted with the regulation). As an example, we cannot think that body temperature (the target of the regulation) is something separate and distinct from the homeostatic mechanisms that continuously regulate body functions to keep the temperature constant (regulation mechanism). In fact, the actual body temperature emerges as the result of the reciprocal interactions of diverse regulatory mechanisms. Derived from this, we propose a preliminary account of emotion regulation as an embodied process, basically rejecting the dualism between emotional states (and its somatic expressions, motor and autonomic systems), and the processes and mechanisms of emotion regulation. Emotions and its experience are the result of the continuous reciprocal interactions of top-down, bottom-up, sensory-perception and interoception processes, in which top-down and bottom-up systems can serve as generative and regulatory mechanisms. As we have reviewed in this paper, both emotion systems participate in the generation and expression of emotional states (Ochsner et al., 2009; McRae et al., 2012), at the same time, both are engaged in the regulation of internal homeostatic states (humoral, visceral) and expressive somatic-motor responses (Frank et al., 2014; Kohn et al., 2014; Etkin et al., 2015).

The embodied approach to emotion regulation regarding the problem of "mindful emotion regulation" allows us to conceive top-down and bottom-up mindfulness based strategies in a dimensional and continuous way. These strategies primarily target different aspects of the emotional state, *cognitions* and *thought process, sensory-perception,* and *interoceptive-proprioception,* and their corresponding neural substrates, in this way, at the same time regulating and *ensuing* the current emotional state. From this, it is possible to understand that even mindfulness induction and MBIs can deploy bottom-up regulation strategies, and also EMs can use top-down emotion regulation strategies as part of their repertoire. At the same time, different mindfulness related practices (as samatha, vipashyana and compassion, etc.), as taught within MBIs and EMs trainings might differentially engage the components of the emotional state (Dahl et al., 2015).

In sum, our approach to emotions and emotion regulation intends to overcome the "neurocentrism" and "corticocentrism" of current cognitivist model of emotion regulation. Our embodied account of emotion regulation considers emotional states and regulatory mechanisms as *inseparable,* relying in shared neural networks. It offers a preliminary new framework for integrating neurobiological, psychophysiological, and psychological systems perspectives on emotion regulation and clinical interventions. It aims to be a multilevel and non-reductive paradigm to advance the understanding of emotion dysregulation psychopathologies and their changes in the context of various biological and psychological treatments.

CLINICAL IMPLICATIONS: EMOTION REGULATION, MINDFULNESS, AND PSYCHOTHERAPY

As we have seen, MBIs have shown efficacy in a myriad of psychological disorders, characterized by emotion dysregulation psychopathology (see **Table 1**). From the perspective of longitudinal, clinical, and affective neuroscience studies, we hypothesize that changes in bottom-up emotion regulation systems might be a key differential feature of MIBs vs. the usual Western psychotherapeutic approaches—more specifically, not in the sense that only MBIs elicit changes in these systems (which is not the case), but in the sense that MBIs explicitly involve the engagement of bottom-up mindfulness emotion regulation strategies, using the *sensory* and *interoceptive* components of emotions as targets and *vehicles* for emotion regulation (according to embodied emotion regulation account).

From a clinical psychotherapeutic perspective, this means that the therapist (or MBI instructor) will be able to guide the patient/client into the application of different top-down and bottom-up mindfulness based strategies. In the case of bottom-up strategies, the clinician encourages the participants to focus on the "bodily" components of different emotional state, always conveying the attitudinal stance of acceptance and openness. In this way, discouraging the intend to control and subjugate negative emotional states, but more importantly, discouraging the use of maladaptive top-down emotion regulation strategies like *avoidance*, *rumination,* and *suppression* among others.

In this sense, there is a constant incentive to shift from a *self-narrative* perspective (ruminative), based on past or future stories, to a *self-experiential* present-centered perspective, so the experience of emotion is decoupled from maladaptive evaluative cognitions. As stated by Chambers, one main difference between psychotherapeutic interventions like psychoanalysis and CBT, and MBIs, is that the former aim to change the content of emotional states (*self-narratives* and cognitions), while MBIs focus on changing the relationship (and not the content) with the emotional (painful) states (Chambers et al., 2009); changing the perspective from which it is experienced, encouraging acceptance and curiosity about the experience itself (*self-experiential focus)*. From an emotional learning perspective, this process can be seen as an exercise of *exposure* (to certain emotions or experiences), *extinction* of maladaptive cognitions or reactive responses, and *reconsolidation* as a new relationship pattern regarding own experiences or daily life problems (Hölzel et al., 2011a).

Mindfulness and Mentalization in the Context of Psychotherapy

Mindfulness and mentalization can be conceived as different heuristics and approaches to understand mental health, clinical interventions, and psychopathological developments. The notion of mentalization has a heterogeneous origin, starting from the construct of *theory of mind* developed in the field of etiology/cognitive science (Premack and Wooddruff, 1978), the concept of *symbolization* from psychoanalysis (Choi-Kain and Gunderson, 2008) and the notion of *meta-cognition* from novel developments in the empirical study of attachment (Main, 1991). In clinical terms mentalization is defined as the capacity to understand one's own actions and those of others in terms of intentional mental states like desires, needs, and feelings (Choi-Kain and Gunderson, 2008). According to psychodynamic theories, mentalization is a developmental capacity that depends on the quality of the early mother–infant relationship, the development of secure attachment in the infant and a mother's capacities for mentalization (Fonagy et al., 2002). Originally developed to understand BPD psychopathology, actually its deficit has been implicated in a wide range of conditions including autism and schizophrenia, among others (Roffman et al., 2012). Enhancing mentalization is viewed as a common factor responsible for psychotherapeutic change processes, not only in psychodynamic approaches, but also in other clinical perspectives (Björgvinsson and Hart, 2006 for CBT; Lewis, 2006 for DBT). Moreover, in patients with BPD, increased capacity for mentalization is considered the central mechanism of change in all effective treatments (Fonagy and Bateman, 2006).

Exploring the common ground between mindfulness and mentalization, Goodman (2014) uses four aspects of mentalization: (1) observing mental phenomena, (2) describing or labeling mental phenomena, (3) describing the meaning and motivation of one's own and others' behavior as the product of mental states, and (4) understanding the intrinsic linkage and mutual influence of mental states in oneself and others. Taking into account Baer et al.'s models (see **Table 2**), Goodman suggests that mentalization and mindfulness overlap in two key areas: observing mental phenomena, and labeling/describing mental phenomena. From the perspective of emotion regulation systems, both mental processes correspond to top-down emotion regulation strategies, such as metacognitive awareness and affect labeling. However, the capacity for attributing intentionality to mental states and for understanding the interpersonal influences of mental states, are distinctive factors of mentalization (Goodman, 2014). Given the interpersonal nature of psychotherapy, mentalization capacities constitute central skills for the therapist (to work with patients) and for the patients (to be developed within the treatment; Fonagy and Bateman, 2006).

Another important difference between mindfulness and mentalization, is the type of relationship intended with mental contents and temporality of life events. As we stated, MBIs don't intend to change mental contents, neither explore life events from the past or future possibilities, its main focus is the present-centered non-evaluative awareness of the self-experience. Unlike mentalization interventions, in which the focus is to explore, cognitively understand and change mental contents, which may be referred to future or past life events, but also to emotions and dysregulated emotional states (Allen, 2006). In line with this, mentalization as an emotion regulation strategy has been considered a top-down strategy, relying in the explicit emotion regulation and in the theory of mind brain systems (Fonagy and Luyten, 2009; Vrticka and Vuilleumier, 2012). As we have stated, MBIs engages bottom-up emotion regulation strategies, which constitutes the distinctive ingredient from other forms of psychotherapies. From our perspective, mindfulness and mentalization have common and different psychobiological functions, which are complementary in the context of treatments for diverse psychopathologies related to emotion dysregulation and mentalization deficits. Nevertheless, further research needs to be done with a view to achieving a better understanding of the biological and psychological differences between these constructs, as well as integrating them properly in psychotherapeutic treatments.

CONCLUSIONS AND FUTURE DIRECTIONS

Over the last few years, research on contemplative and affective sciences has grown considerably. In this article we have shown how mindfulness is related to emotion regulation using different theoretically and empirically derived models. The main hypothesis explored is that emotion regulation changes are a core mechanism underlying the salutary effects of mindfulness and MBIs. Nevertheless, many of the psychological and neurocognitive theoretical models of mindfulness's mechanisms are not properly and empirically validated. At the same time, empirical studies face many methodological limitations as well.

One important problem is the notion of mindfulness itself. As was mentioned, it has been used for referring to a wide range of psychological phenomena, like a trait (or dispositional mindfulness), a proper meditation practice or a mental state (Davidson, 2010). Even the concept of mindfulness lacks a unique operationalization, since many authors have proposed different definitions, understanding it as an attention capacity, an attitude, a characteristic type of awareness, or even a combination of these (Quaglia et al., 2015). As Grossman states, the complexity of the concept seems more related to a lack of consensus between experts, among other critical issues that constructors of inventories might disregard (Grossman, 2008).

On one side, studies measuring dispositional mindfulness using self-report scales have demonstrated good reliability and convergent validity (Quaglia et al., 2015) and a preliminary coherent putative neural correlate (see **Table 4**). Coffey et al. have demonstrated that mindfulness and emotion regulation correspond to related but different constructs (Coffey et al., 2010). Nevertheless, the construct of dispositional mindfulness entails several problematic aspects, starting from the assumption that self-report mindfulness scales (basically the self-perception of a person) actually tap into the proper practices of mindfulness

(Grossman, 2011). For instance, the specificity of the instruments to MBIs is unknown, e.g., other interventions not based on mindfulness might change the mindfulness level (Lutz et al., 2015). Finally, using these instruments in the context of MBIs might induce biased responses because of the verbal exposure to the word and concept of mindfulness itself, and not because of any actual acquired capacity (Van Dam et al., 2012). Another problematic issue with dispositional mindfulness is the wide range of confounders or variables that actually impact the dispositional "mindfulness level," including other overlapping and related psychological traits that also vary within normative and clinical populations, like: attention and emotional functions, attitudinal and biased dispositions, prior socialization with the construct and experience with related practices (like yoga or psychotherapy; Quaglia et al., 2015). Future studies will have to control for these factors to better disentangle the nature of dispositional mindfulness as a construct itself.

For longitudinal clinical studies, RCTs with active control groups and multi-arm designs seems to be methodologically the "gold standard" for unraveling the efficacy and effectiveness of a given therapeutic intervention, either for inferiority or superiority studies. As in Zeidan et al. (2015), comparing mindfulness, sham mindfulness, placebo, and control could demonstrate the efficacy of all interventions for pain relief, but noting a differential brain mechanism in emotion regulation of pain (Zeidan et al., 2015). For further understanding the differential engagement of the emotion regulation systems in MBIs, future neuroimaging longitudinal studies will have to explicitly compare different mindfulness instructions within the experimental manipulations (i.e., top-down—attention based vs. bottom-up bodily-based). Then they can explore the acquisition and development of the strategies and their neural correlates. For avoiding problematic aspects of self-report scales, clinical studies should try to include behavioral outcome measures of mindfulness. For better understanding putative mechanisms, longitudinal studies should use several prospective measurements of variables of interest to better disentangle how changes in independent variables and mediators affect dependent variables (Kazdin, 2009).

Using neurobiologically based emotion regulation systems as a framework, we have described how top-down strategies (explicit emotion regulation system) and bottom-up strategies (emotion generation and implicit emotion-regulation systems) can be present within novice and expert meditators. In order to deal with the controversy of emotion regulation mechanisms underlying mindfulness in MBIs and EMs, we have proposed the distinction between mindfulness-based top-down emotion regulation strategies based on attention and acceptance, vs. mindfulness-based bottom-up strategies, which target bodily representations of emotional states. We proposed an *embodied* perspective on emotion regulation as a preliminary framework as a means for understanding different emotion regulation systems, rejecting the dualism between *somatic* emotional states and the processes and mechanisms of emotion regulation. From this, the experience of emotional states is build up from the continuous reciprocal interactions of regulatory mechanisms. This perspective offers an integrative view of

cognitive and emotion processes within homeostatic regulatory mechanisms, as well as a non-hierarchical view for conceiving cortical and subcortical systems, as well as brain and body interactions. Further developments might complement this framework integrating first-person phenomenological accounts of emotions and emotion regulation, looking for further integrate experiential and subjective reports with psychophysiological and neurobiological measurements (see Colombetti, 2014, for affective neuro-physiophenomenology).

In line with these recommendations and limitations, from the perspective of methodological and measurement techniques, we suggest that research on mindfulness and emotion regulation should take advantage of mobile device technologies, for example using experience sampling methods, or biological measurements including mobile EEGs or galvanic response devices, thereby increasing the ecological validity of measurements, variables and constructs of interest. Serum biological markers of inflammatory response and neuroplasticity (BDNF, for example) are also of relevance as putative biological mechanisms of MBIs. As regards neuroimaging technologies, future studies might integrate different methods, taking advantage of the specificity of each, for example combining the spatial resolution of MRIs with positron emission tomography (PET), which might help to disentangle differences in neurotransmitters or neuroradiological markers of neuroinflammation. Within MRI techniques, the use of computational modeling might help to build and test more precise and sophisticated theoretical models for understanding cognitive emotional systems underlying mindfulness and emotion regulation. Finally, multivariate pattern analysis is situated at a privileged level for decoding mental states (certain emotion regulation strategies or mindfulness states) from brain signatures using trained classifiers.

Clinical applications of MBIs will require a very good understanding of what's better for whom, and distinguishing what types of psychological treatments, regular psychotherapy (of different types) or MBIs (of different types) are better for different types of depression or anxiety disorder. This leads to another question regarding how to combine different forms of psychotherapy with MBIs in the context of a wider and more comprehensive model of healthcare, even including psychopharmacological treatments. A better understanding of emotion regulation mechanisms underlying mindfulness and psychotherapy, from biological and clinical perspectives, will foster new insights into emotional life and its disturbances, with the purpose of refining and developing better therapeutic interventions for the widespread mental health disorders characterized by emotion dysregulation.

AUTHOR CONTRIBUTIONS

SG: conceive the original idea of the article, decided the design of each part. Completed the revision of all scientific literature. Performed all draft versions of the document, as well as the final (approval) version to be published. SG is totally accountable for all aspects of the work, and ensures that all different questions regarding any part of the work can be appropriately investigated

and resolved. SM: conceive the original idea of the article, decided the design of each part. Completed the revision of all scientific literature. Performed all draft versions of the document, as well as offering important intellectual content for the final version. Also, gave the final approval of the version to be published. HR: conceive the original idea of the article, decided the design of each part. Completed the revision of most scientific literature. Participated in the elaboration of almost all draft versions of the document, as well as offered very important intellectual content for the final version. Also, gave the final approval of the version to be published. HR and SM are totally accountable for all aspects of the work, and ensures that all different

questions regarding any part of the work can be appropriately investigated.

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Online Coaching of Emotion-Regulation Strategies for Parents: Efficacy of the Online Rational Positive Parenting Program and Attention Bias Modification Procedures

Oana A. David*, David Capris and Alexandra Jarda

Department of Clinical Psychology and Psychotherapy, Babes-Bolyai University, Cluj-Napoca, Romania

Parenting programs are currently treatment of choice for behavioral disorders in children and one of their main components is reducing the negativity bias in the child–parent dyad. The Rational Positive Parenting Program (rPPP) is a program with a special focus on parent emotion-regulation functional reappraisal strategies, which has recently received consistent support for reducing child externalizing and internalizing disorders. In the last years, online interventions were proliferated and the Attention Bias Modification (ABM) becoming a promising implicit therapeutic intervention based on attention deployment emotion-regulation strategy, or adjunctive module to usual treatments, with results in multiple domains, varying from pain to self-esteem and emotional disorders (e.g., anxiety). We conducted two studies to investigate (1) the efficacy of the ABM procedures applied to parents and (2) the efficacy of the online version of the rPPP augmented with an ABM module. A total of 42 parents of children aged 2–12 years old participated in the first study, being allocated either to the ABM training or wait-list. Positive results were reported by the parents participating in the ABM group for own distress, satisfaction, positive interactions with the child, and child's strengths. In the second study, 53 parents and their children were allocated either in the rPPP group or in the rPPP + ABM group. Results show that ABM training can boost the effects of the rPPP on the strengths of children reported by the parents after the intervention. Findings are discussed in the light of limited research on using online tools for coaching effective emotion-regulation strategies for parents.

Keywords: parent attention bias modification, the rational positive parenting program, positive parenting, parent reappraisal, acceptance parenting

INTRODUCTION

Attentional distraction is considered an antecedent emotion-regulation strategy (Gross, 1998) that involves shifting attention from one aspect of a situation to another one, or shifting ones' attention away from the situation altogether. It is well known that in the case of children with externalizing disorders, a negative interaction cycle arises, which is affecting the child–parent relationship and is thus contributing to maintaining children's problems (Barkley, 1997). Parents get biased to pay attention preponderantly to the negative behaviors of their children, which in turn

impacts negatively on the parent–child relationship and their parenting style. Parenting programs (cognitive-behavioral) are considered treatment of choice for child disruptive behavior, receiving considerable support (Lundahl et al., 2006). More recently, parent emotion-regulation has started to be addressed in such parenting programs and this was shown (David et al., 2014b) to augment their effects on both parent and child outcomes.

Starting from the promising results regarding the effects of computerized psychological treatments, during the past 15 years parenting programs have started to be adapted for being implemented online (Feil et al., 2008; Enebrink et al., 2012), in order to make them more accessible to the parents in need. A recent review shows (see Nieuwmboer et al., 2013) robust positive effects of such parenting programs, similar to those of the "face to face" programs. The online format of such programs, however, opens unlimited opportunities for innovative procedures which could improve their outcomes.

Newly developed interventions aimed at modifying negative attentional biases (i.e., attention preferentially allocated to negative, disliked, or threat like stimuli) by training implicit associations have been recently suggested (David and Podina, 2014) as offering important strategies in fostering positive parenting. Training of implicit attentional associations from negative stimuli toward to positive or neutral stimuli has received much interest with the introduction of the Attention Bias Modification (ABM) training. Negative attention biases have been etiologically linked (Bar-Haim et al., 2007; Hakamata et al., 2010; Hallion and Ruscio, 2011; Eldar et al., 2012; Waters et al., 2013) to various mental health issues in both adults and children. In parents, current negative attention biases toward their children's negative behavior can impede them in implementing the strategies learned during a parenting program. In this context, we consider that ABM bares the promise of helping parents to allocate attentional resources toward prospective positive responses in children, which in turn could increase the efficacy of the parenting programs.

Although the ABM paradigm has not been extended to the parenting field up until now, there is great potential for this domain. Our aim was to investigate the efficacy of the ABM as an online intervention based on attention deployment emotion-regulation mechanisms delivered to parents on various parenting and child outcomes; then, in a second step, we aimed to investigate the additive effect of including an ABM module within an online parenting program curriculum.

STUDY 1

ABM is based on the emotion-regulation attentional deployment strategy, considered a new intervention within the cognitive-behavioral therapy framework, that has been documented to have promising clinical effects in both youth and adult population (Bar-Haim, 2010; Hakamata et al., 2010; Hallion and Ruscio, 2011; Eldar et al., 2012; Waters et al., 2013), regarding anxiety and emotional related issues. The initial forms of ABM trained attention to neutral benign stimuli and was found to have mixed results. More recent procedures were developed, however, as alternative that train attention toward positive or rewarding stimuli (Dandeneau et al., 2007).

When involved in the ABM training to positive stimuli [e.g., visual search task training (VSTT) paradigm; Dandeneau and Baldwin, 2004; Dandeneau et al., 2007], participants are instructed to preferentially process happy faces to the expense of the angry ones. Although it represents a work in progress (due to mixed findings and unknown mechanisms of change), the ABM could be an essential component for parenting programs.

It is known that negative cognitive biases in parents can affect their parenting skills (Podina et al., 2013; David et al., 2014a), and at the same time parental cognitive biases can facilitate an intergenerational transmission of mental health issues. Thus, the present paper aims to extend the existing ABM paradigm, namely to investigate for the first time its efficacy in boosting parenting skills. More specifically, we intend to use faces of children to reduce negative biases in parents. The novelty of this approach is that the beneficiaries of the ABM training will not be the user, meaning the parents, but their children. Given the previous arguments, such a procedure would be useful especially in the context in which parents' negative biases regarding their children behaviors interferes with a good parent–child relationship.

The current study aims at investigating the efficacy of an ABM intervention delivered by itself in reducing parents' negative interactions with children, distress, and improving their parenting, self-efficacy, satisfaction, and child externalizing and internalizing reported symptoms. We will compare in a superiority trial design the efficacy of the ABM intervention for parents with a wait-list (WL) group. Thus, we expect that the parents participating in the ABM intervention will report better outcomes compared to the WL condition.

Methods

Participants

A total of 42 parents participated in this study, 36 mothers and 6 fathers of children aged 2–12 years old ($M = 5.93$, $SD = 2.59$). Their age range varied between 24 and 43 years old, with a mean age of 32.96 ($SD = 5.31$). Forty-one percent of the parents included in the study had only one child, while 25% had two children, and 2% had three children. They were asked to report regarding the behavior on one child, and 25 of the children selected were boys, while the rest were girls. Ninety-two percent of the parents were married, one parent was in an unofficial relationship, and three were divorced. Most of the parents had bachelor (33.8%) and college education (45.6%), while most of them (89.7%) had urban residence; 41 had a socio-economic background above the minimum wage of the country, while 22 were earning above the mean medium salary of the country.

The ABM Procedure

We chose the standard ABM procedure (Amir et al., 2009; Bar-Haim, 2010; Waters et al., 2013) using the faces of children. The parent ABM task aims to redirect the attention of parents from angry faces of children to happy faces of children, for prevention purposes.

We used a modified version of the dot-probe task (MacLeod et al., 1986), and developed our training using the Inquisit

3 version of the software Milliseconds, which is used on a large scale by researchers (e.g., Thoern et al., 2016). During the probe, participants view pictures with faces of children. The faces represent negative emotions (e.g., anger), positive (e.g., joy), or neutral emotions, with two types of emotions being presented at once. After being presented with the pair of pictures, participants are asked to press the E or F keyboards that appear in their places. During the ABM training, similar with the probe task, the letters E and F follow only pictures presenting faces of children that convey positive emotions in order to train orientation of implicit attention from negative stimuli toward the positive ones. The underlying mechanism is classical conditioning, and thus the focus of attention is associated with positive stimuli.

The training was delivered over the course of 1 week, with five online sessions, as recent studies indicate that even a few (one to two) sessions are sufficient to train a positive bias. We chose to use more sessions as we wanted to boost the learning of positive stimuli and provide the opportunity for the training to be delivered in multiple contexts (e.g., at home, at work). The chosen stimulus set consisted of angry and happy faces of children selected from the NIMH-ChEFS data base (Egger et al., 2011). Each training session lasted approximately 15 min daily and thus 60 min per week. Participants had a first contact with a clinical psychologist, and then they maintained contact via email and phone, being provided with information regarding their status and following steps. Parents were instructed not to take breaks during the training session and the completion of their training was monitored online daily.

Measures

Parents completed questionnaires regarding their child strengths and difficulties and their own parenting practices, stress, and attitudes. The measures used were chosen based on their relevance for outcomes considered in the study, their psychometric properties and large use in the parenting or emotion-regulation field.

The Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997)

SDQ is an instrument measuring behavioral and emotional problems in children and adolescents. The instrument produces scores for five subscales: conduct problems, hyperactivity, emotional problems, peer problems, and prosocial behavior. Each subscale consists of five items (Graf et al., 2014). The scale has demonstrated adequate psychometric properties on national population (Colvert et al., 2008) and in our sample ($\alpha = 0.82$). We used the standard SDQ in the study.

The Parent Behavior Inventory (PBI; Lovejoy et al., 1999)

The PBI is a 20-item self-report scale. Parents rate the frequency of various parenting behaviors (e.g., hugging, teaching new things) using a 6-point Likert scale (0, never true to 5, almost always true). This instrument includes two factors: supportive/engaged parenting and hostile/coercive parenting. The total scores for the supportive/engaged parenting subscale range from 0 to 50, higher scores representing higher levels

of supportive/engaged parenting. The total scores for the hostile/coercive scale range from 0 to 35, with higher scores representing higher levels of hostile/coercive parenting. The scale has adequate psychometric properties ($\alpha = 0.82$, Bruce et al., 2006; and $\alpha = 0.72$ in our sample).

The Parent Stress Scale (PSS; Berry and Jones, 1995)

The PSS is an 18-items self-report scale which measures the positive aspects of parenthood (emotional benefits, self-enrichment, personal development) as well as negative indicators (demands on resources, restrictions, and opportunity costs). The final score is given by the sum of items, higher scores indicating greater stress. This scale demonstrated good internal reliability on the national population included (Cronbach's $\alpha = 0.85$; David et al., 2014a used on national population) and in our sample ($\alpha = 0.82$).

The Parenting Sense of Competence Scale (Gibaud-Wallston and Wandersman, 1978)

The Parenting Sense of Competence (PSOC) Scale is a 16 items questionnaire which measures parents' views of their competence as parents. This questionnaire includes two subscales: satisfaction with their parenting role and feelings of efficacy as a parent. Satisfaction subscale examines parents' anxiety, frustration, and motivation, while the efficacy subscales examines parents' competence, capability levels, and problem-solving abilities in their parenting role. High scores suggest a higher level of satisfaction, while low self-efficacy scores were correlated with behavioral problems in children. Psychometric proprieties of the total score and the subscales are adequate (alpha Cronbach's for the total score is $\alpha = 0.71$; Johnston and Mash, 1989; for national population: David et al., 2014a, and $\alpha = 0.85$ in our sample) showing that it can be used in research.

Mean Positive and Negative Interactions

Parents were asked to estimate the weekly number of positive and negative interactions which they had with their child, keeping in mind the number of daily interactions. The examples of positive interactions taken into account by parents were the following: praise, physical affection, laughter, performing an act requested by the child, positive gestures or any other positive interaction. The examples of negative interactions were the following: yelling, negative physical contact (pulling, pushing, slapping), not performing an act requested by the child, negative gestures, repeating a request insistently or any other negative interaction.

Procedure

Parents were recruited from the kindergartens and schools where their children were enrolled. Parents were randomly distributed among the experimental group and the waitlist. They filled the baseline assessment (pre-test) and the same questionnaires after 1 week (post-test). Participants signed an online informed consent about participating in the study and received detailed information about study procedure. This study was approved by the Institutional Review Board of the Babes-Bolyai University (GTC-34060/2013).

Data Analysis

We used repeated measures ANOVA with Time (pre–post) as a within-subject factor and Group (ABM, WL) as a between subjects variable, for each of the outcomes. Pre-test data was lost in the case of the SDQ and PBI questionnaires due to an error in the online platform and thus only univariate analyses of the post-test data were possible for these measures. We use intent to treat analyses, imputing the missing data at post-test in order to minimize the risk for type 1 error.

Results

No significant differences were found in terms of the demographics among the groups ($ps > 0.5$). The phases of the trial are presented in **Figure 1**. Due to high drop-out rates registered (54% in the ABM group and 40% in the WL), we analyzed potential reasons, and found that drop-outs had significantly lower educational level [$\chi^2(4) = 0.38, p = 0.034$], and monthly income [$\chi^2(5) = 15.69, p = 0.008$].

Descriptive Analyses

Means and standard deviations for the outcomes in each group are presented in **Table 1**.

Inferential Analyses

For parental distress, multivariate tests show a significant main effect of Time, $F(1,47) = 9.73, p = 0.004, \chi^2 = 0.166$, a significant main interaction effect of Time × Group, $F(1,47) = 13.32, p = 0.001, \eta_p^2 = 0.221$, and a non-significant main effect of Group ($p > 0.05$). No significant differences were obtained pre–post for the experimental group ($p > 0.05$), while the WL group reported increases in stress [$t(21) = 3.69, p = 0.001$].

For parent satisfaction, multivariate tests show a significant main effect of Time, $F(1,49) = 6.59, p = 0.013, \eta_p^2 = 0.11$, a significant main interaction effect of Time × Group, $F(1,49) = 7.47, p = 0.009, \eta_p^2 = 0.1032$, and a non-significant main effect of Group ($p > 0.05$). Pre–post significant reductions in parent satisfaction were registered only in the WL condition [$t(23) = 4.38, p < 0.001$].

For parent self-esteem, multivariate tests show a marginally significant effect of Time, $F(1,49) = 3.10, p = 0.084, \eta_p^2 = 0.06$, a significant main interaction effect of Time × Group, $F(2,56) = 5.19, p = 0.003, \eta_p^2 = 0.17$, and a non-significant main effect of Group ($p > 0.05$). No significant differences were obtained pre–post for the experimental group ($p > 0.05$), while the WL group reported increases in self-esteem [$t(23) = 3.62, p = 0.001$].
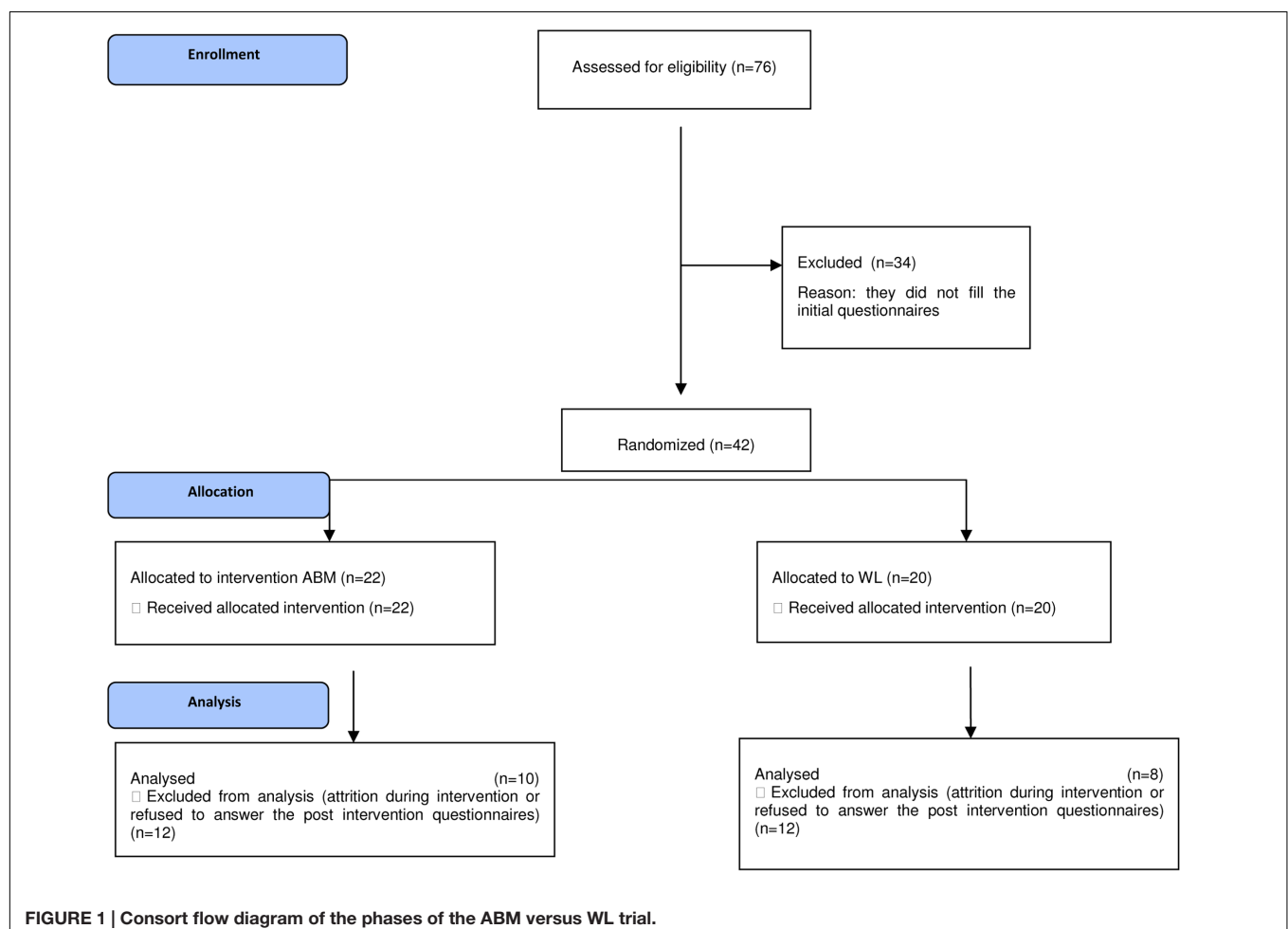

FIGURE 1 | Consort flow diagram of the phases of the ABM versus WL trial.

TABLE 1 | Means and standard deviations for the outcomes in each of the groups.

Group	Time	ABM		WL		Total	
		M	SD	M	SD	M	SD
Parental distress	Pre	34.82	4.79	31.00	7.62	32.37	6.24
	Post	34.73	6.01	35.22	11.36	33.58	8.38
PSOC—self-efficacy	Pre	32.82	4.14	35.20	6.49	34.20	5.23
	Post	33.45	5.05	33.95	5.89	34.20	5.26
PSOC—parent satisfaction	Pre	40.86	4.31	41.45	8.12	41.80	6.04
	Post	40.68	5.58	38.95	8.59	40.76	6.60
PSOC—self-esteem	Pre	73.68	6.47	76.65	13.59	76.00	9.73
	Post	74.18	8.10	72.90	13.46	75.14	10.12
Positive interactions	Post	7.38	4.09	5.75	1.69	6.39	3.57
Negative interactions	Post	5.10	4.00	3.31	0.79	4.24	3.60
PBI-supportive parenting	Post	43.88	7.08	38.20	6.94	41.40	7.43
PBI coercive parenting	Post	19.88	7.64	12.80	3.79	16.36	6.64
SDQ strengths	Post	12.40	1.96	4.50	3.03	7.93	4.19
SDQ difficulties	Post	35.30	3.43	18.80	5.49	26.15	8.85

For parental self-efficacy, multivariate tests show a significant main interaction effect of Time × Group, $F(1,49) = 10.21$, $p = 0.002$, $\eta_p^2 = 0.172$, and a non-significant main effect of Time or Group ($p > 0.05$). No significant differences were obtained pre–post for the experimental group ($p > 0.05$), while the WL group reported pre–post significant increases in self-efficacy [$t(23) = 2.51$, $p = 0.019$].

In terms of the child and parenting at post-test, univariate analyses showed that parents in the ABM group reported significantly more daily positive interactions $F(1,22) = 6.29$, $p = 0.012$, $\eta_p^2 = 0.059$, more child strengths $F(1,22) = 6.29$, $p = 0.005$, $\eta_p^2 = 0.70$, and more supportive parenting $F(1,20) = 3.25$, $p = 0.086$ (not statistically significant), $\eta_p^2 = 0.14$, compared to the WL group. No significant differences were obtained in terms of daily negative interactions, child difficulties or coercive parenting between groups at post-test.

Discussion

We investigated the efficacy of a 1 week ABM procedure in parents compared to a wait-list. Parents participating in the intervention group registered significantly better outcomes compared to the wait-list, in terms of parent distress, satisfaction, and child strengths, as reported by the parents. However, we cannot exclude the fact that the effects could be explained by the wait-list condition changes rather than the significant changes in the ABM group. There are findings in the literature showing that patients on the wait list can improve during the trial (Hesser et al., 2011) due to factors such as the therapeutic contact or expectations, and thus such an effect could have arisen in our study. Future studies would need to also investigate potential mechanisms involved, such as hope or expectancies. Since it was suggested (Bar-Haim, 2010) that the ABM procedure might augment the effects of the standard treatments, further research should investigate the efficacy of such programs. An important limitation of the study is the missing baseline data regarding child behavior and parenting.

STUDY 2

One of the key components of any parenting program is to train parents for detecting and reinforcing positive (i.e., adaptive) behaviors, attitudes, and emotions in children in order to increase their frequency in the expense of the maladaptive ones. Although numerous advantages can be derived from positive reinforcement of the adaptive responses in children and obvious focus of the parenting programs of reinforcing an adaptive response when detected, the actual detection and reinforcement to positive responses in children remains an issue of concern. Most parenting programs fail to provide parents with training on how to spot and recognize the targeted cluster of positive responses (behavior, attitudes, and cognitions) in their children. Such training would be most important for a specific group of parents, the ones with children who display disruptive behaviors.

Some online parenting programs curricula have been recently investigated (Feil et al., 2008; Enebrink et al., 2012) in terms of their effects for child and parent outcomes. A meta-analytic review of these studies (see Nieuwmboer et al., 2013) shows medium effect sizes of the online parenting programs across both parent and child outcomes. The Rational Positive Parenting Program (rPPP; Gavita et al., 2013; David and DiGiuseppe, 2015) is a cognitive-behavioral program which has recently received support for both its full-length format (David et al., 2014b) and short-lenght format (Gavita et al., 2012), face to face and self-help (Gaviţa and Călin, 2013). Moreover, this program is emphasizing the focus on parent emotion-regulation skills and has documented (David, 2014) the importance of these improvements as mechanisms for child outcomes.

This study aims to investigate the efficacy on the online version of the rPPP compared with its version augmented with the ABM procedure in improving parent and child outcomes. We hypothesize that the parents participating in the rPPP + ABM intervention will report better outcomes compared to the parents participating in the rPPP intervention.

Methods

Participants

A total of 53 parents participated in this study, 48 mothers and 5 fathers. Parents were aged 24–57 years old ($M = 35.97$, $SD = 5.25$). 60.4% the parents (30) had only one child, while 33.2% had two and 6.9% had three children. Parents chose the child to which they referred while responding to the questionnaires. Children referred to were aged 2–12, with a mean age of 6.45 ($SD = 3.34$), 30 of them being boys and 23 girls. 79.2% of the parents were married and 1.9% declared themselves to be unmarried, while 5.7% were in an unofficial relationship, 7.5% were divorced, and 5.7% were separated. 92.5% of the parents had earnings above the minimum country wage, while 43.4% of them earned above the mean country wage. In terms of the educational status, 71.7% had graduate and higher level of education. Forty-three of the parents lived in the city, while the rest lived in the rural areas.

Measures

The SDQ, PBI, PSS, PSOC, and positive/negative daily interactions were measured using the same measures presented above. The Parent Rational and Irrational Beliefs Scale (P-RIBS; Gavita et al., 2011a) was used to measure irrational cognitions in parents.

The P-RIBS (Gavita et al., 2011a)

P-RIBS is measuring rational and irrational beliefs conceptualized as opposite constructs, but not at opposite poles. The scale contains 20 items, constructed to reflect the four irrational beliefs (demandingness, awfulizing, low frustration tolerance, and global evaluation) and four rational beliefs (preferences/flexibility, negative evaluations, frustration tolerance, and unconditional acceptance). The first part of the scale measures the child behavior and the second, the parent behavior. The total score of the scale is given by the sum of items, with rational items scored in a reversed way. Internal consistencies of the scale showed adequate psychometric properties on national population (Gavita et al., 2011a; $\alpha = 0.85$ in our sample).

Procedure

All parents were recruited from the kindergartens and schools where their children were enrolled. Parents were randomly allocated 25 in the rPPP group and 28 in the rPPP + ABM group, as presented in **Figure 2**. Participants signed an online informed consent form prior to being included in the study, and were informed about the main purposes of the study, about the confidentiality of the data, risks and the possibility to withdraw from the study at any time. Participants had a first face to face contact with the clinical psychologist delivering the program, after which they were provided with information regarding their status, following steps, and reminders via the email and phone texts.

The Rational Positive Parenting Program

The online version of the rPPP consists of eight modules (David and DiGiuseppe, 2015). Participants received via e-mail web links in order to access each module, with a constant rhythm of tow modules per week. At 2 days after receiving the e-mail with a module, participants who did not access it, were sent a reminder via e-mail and a text message by phone. If they did not reply, the next day they received a phone call. The first module of the program offers a rationale for the program, sets goals for change, and educates about the behavioral problems of children and their causes. Parents are asked to monitor their child's behavior using a chart based on functional analysis. The next two modules aim to teach participants emotional regulation strategies based on the cognitive-behavioral theory. Parents are taught the ABC model and how to identify the cognitions that cause their emotions toward their children, and how to tackle these cognitions. A difference between dysfunctional and non-dysfunctional negative emotions is made and homework is given (to fill cognitive ABC forms and rational statements). After participants learn to manage their parental stress, the next five modules aim to teach them positive parenting skills and strategies needed for child behavior management (e.g., functional analysis of the behavior, efficient rewarding, ignoring and distraction, family rules, prompting, efficient usage of consequences, time-out, reflective listening). The last of the modules is used to help parents to establish a prevention plan, teach them problem solving skills, and summarize what has been learned in the program.

The Rational Positive Parenting Program plus Attention Bias Modification (rPPP + ABM)

The rPPP + ABM consisted, besides the standard rPPP, of the ABM component described in Study 1, delivered in the so called 7th+ session, with the purpose of reducing the cognitive bias of parents toward the negative stimuli (angry faces of children) and training it toward the positive emotion faces. Participants were asked to follow the ABM training at least once a day for 1 week.

Data Analysis

We used repeated measures ANOVA with Time (pre–post) as a within-subject factor and Group (rPPP, rPPP + ABM) as a between subjects variable, for each of the outcomes. Pre-test data could not be used the case of the SDQ and PBI questionnaires due to the online platform error and thus only univariate analyses of the post-test data was possible for these measures.

Results

No differences were found between groups in terms of the demographic variables. In terms of the attrition rate, 10 parents of the rPPP group dropped out, while 14 of the rPPP + ABM dropped until the end of the trial. The phases of the trial are presented in **Figure 2**. We used intent to treat analyses in order to minimize the risk for type 1 error. Due to the high drop-out rate, we analyzed the differences between completers and dropouts in terms of their demographic characteristics and found that significantly more fathers dropped-out [$\chi^2(1) = 0.0368$, $p = 0.032$].

Descriptive Analyses

Table 2 presents the means, standard deviations, and effect sizes of the pre–post changes (Cohen's d) for the outcomes in each of the groups.

FIGURE 2 | Consort flow diagram of the phases of the rPPP versus rPPP + ABM trial.
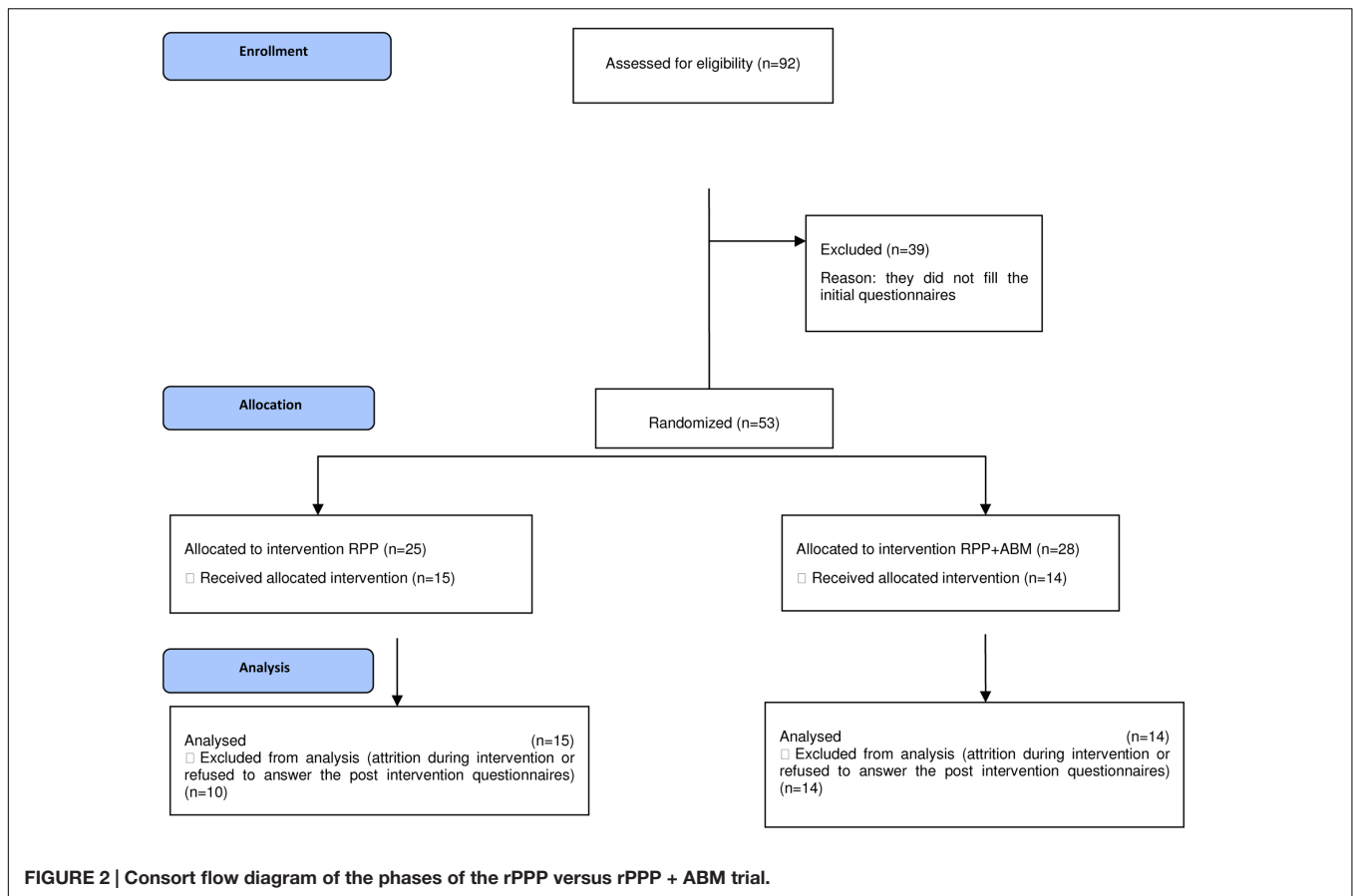
TABLE 2 | Means, standard deviations, and effect sizes (Cohen's *d*) for the outcomes in each of the groups.

Variable	Group Time/coefficient	rPPP			rPPP + ABM			d
		M	*N*	*SD*	*M*	*N*	*SD*	
Parental distress	Pre	31.40	25	7.35	34.61	28	8.68	–
	Post	28.64	25	7.86	32.50	28	9.10	−0.49
Parent irrational beliefs	Pre	53.40	25	6.38	55.29	28	8.50	–
	Post	51.64	25	5.92	52.85	28	10.43	0.14
Parental self-efficacy	Pre	34.12	25	6.23	33.07	28	4.89	–
	Post	37.32	25	6.34	36.35	28	6.48	−0.15
Parental satisfaction	Pre	41.52	25	7.98	42.14	28	6.71	–
	Post	43.96	25	7.55	44.78	28	8.03	0.10
Parental self-esteem	Pre	75.64	25	12.82	75.21	28	9.43	–
	Post	81.28	25	13.16	79.78	28	12.32	−0.11
Supportive parenting	Post	47.27	11	3.00	46.50	10	2.64	−0.27
Coercive parenting	Post	15.45	11	8.35	14.80	10	9.54	−0.07
Child strengths	Post	10.18	11	4.17	13.27	11	1.56	0.98
Child difficulties	Post	16.27	11	7.20	16.82	11	5.64	0.08
Daily positive interactions	Post	6.50	24	1.93	6.57	28	3.01	0.02
Daily negative interactions	Post	3.21	24	2.30	3.79	28	2.35	0.24

Inferential Analysis

For parental distress, multivariate tests show a significant main effect of Time, $F(1,51) = 11.73$, $p = 0.001$, $\eta_p^2 = 0.187$, a non-significant interaction effect of Time × Group, and main effect of Group ($ps > 0.05$). We obtained significantly lower scores in parent's distress from pre to post intervention for both the rPPP group [$t(24) = 3.22$, $p = 0.004$], and marginally for the rPPP + ABM group [$t(27) = 1.90$, $p = 0.067$].

For parent irrational cognitions, multivariate tests show a significant main effect of Time, $F(1,51) = 10.88$, $p = 0.002$, $\eta_p^2 = 0.176$, a non-significant interaction effect of Time × Group, and main effect of Group ($ps > 0.05$). Significant pre–post reductions in irrational thinking were obtained for the rPPP group [$t(24) = 2.21$, $p = 0.036$] and for the rPPP + ABM group [$t(27) = 2.51$, $p = 0.018$].

In terms of parent satisfaction, multivariate tests show a significant main effect of Time, $F(1,51) = 11.005$, $p = 0.002$, $\eta_p^2 = 0.177$, and a non-significant interaction effect of Time × Group, or main effect of Group ($ps > 0.05$). Significant pre–post improvements in parents' satisfaction were obtained for both the rPPP group [$t(24) = -3.27$, $p = 0.003$], and for the rPPP + ABM group [$t(27) = -2.24$, $p = 0.034$].

For parent self-esteem, multivariate tests show only a significant main effect of Time, $F(2,51) = 18.18$, $p < 0.001$, $\eta_p^2 = 0.263$, and a non-significant interaction effect of Time × Group or main effect of Group ($p > 0.05$). Significant pre–post changes in parents' self-esteem were obtained for the rPPP group [$t(24) = -3.65$, $p = 0.001$], and for the rPPP + ABM group [$t(27) = 2.54$, $p = 0.017$].

For parental self-efficacy, multivariate tests show a significant main effect of Group, $F(2,51) = 20.99$, $p < 0.001$, $\eta_p^2 = 0.292$, a non-significant main interaction effect of Time × Group or main effect of Group ($ps < 0.05$). Significant pre–post improvements in parents' self-efficacy were obtained for the rPPP group [$t(24) = -3.13$, $p = 0.004$], and for the rPPP + ABM group [$t(27) = -1.27$, $p = 0.002$].

In terms of the daily positive or negative interactions reported at post-test, we did not obtain significant differences between the groups ($ps > 0.05$). For coercive parenting and supportive parenting we did not found significant differences between the groups ($ps > 0.05$). No differences were obtained regarding the difficulties experienced after the programs ($ps > 0.05$). In terms of the strengths of children reported by parents after the interventions, rPPP + ABM worked better $F(1,19) = 5.31$, $p = 0.032$, compared with the rPPP group.

Discussion

The present study investigated the efficacy of the online version of the rPPP as standalone versus its augmented version with ABM. Results show that both versions of the rPPP proved to be effective in improving the emotional and attitudes outcomes, with high effect sizes. The magnitude of changes obtained following participation in the online sPPP, both in terms of parent-related outcomes (parenting, self-efficacy, self-esteem, distress) and child-related outcomes (interactions), is in line with findings in the literature reporting comparable effects of the online parenting programs to those delivered face to face (see Nieuwmboer et al., 2013). No significant differences were obtained between the effects of the programs, as hypothesized, regarding parent distress, parent self-efficacy, satisfaction, self-esteem, parenting practices. The additive effects of the rPPP augmented with the ABM was found to be significantly higher only in the case of parent reported child strengths, with a high effect size.

This is the first study investigating the additive effects of an ABM enhanced online parenting program, namely the rPPP. The study offers important preliminary data regarding the effects of integrating the ABM module within the well-researched parenting programs. Considering the accessible format of the online parenting programs, the ABM computer-based format is especially suitable. However, more studies are necessary for documenting the cost-benefits balance, considering the high attrition rate of a longer intervention and the little support for augmented changes. Moreover, future studies should use a componential analysis, while incorporating intermediate measures. An important limitation of our study is the lack of the baseline measure for child behavior and parenting, the small sample size and high attrition rate.

GENERAL DISCUSSION AND CONCLUSION

Training parents for detecting positive responses in children can be considered central to current parenting programs, in that it can assist parents in effortlessly detecting positive behaviors in their children, and giving them the chance to reinforcing them. We proposed (see also David and Podina, 2014) that the ABM procedures can be especially suited for online delivered parenting programs. Thus, we integrated the ABM training at the end of the rPPP but found no benefits on most of the outcomes compared with the parenting program alone. However, this could be due to the fact that its integration might be most useful in the initial phases of the parenting intervention, for helping parents in detecting positive responses from their children. The ABM procedures could be also integrated both throughout the parenting programs, and during additional booster sessions. Additionally, ABM could be an especially useful tool for parents with a negative cognitive pattern (e.g., distressed or depressed mothers). Since a positive attentional bias can transfer to other processing levels, such as interpretation or memory bias, boosting emotion-regulation could bring important effects on optimal parent–child interaction. In fact, it might be that parents of children with externalizing disorders would profit from the addition of the ABM training to standard parenting tools. For these parents ABM could offer special coaching in detecting positive behaviors in their children, due to their pre-existing biases to primarily detect the negative ones.

An important limitation of both studies is that we used a classical ABM paradigm as opposed to the VSTT paradigm (Dandeneau and Baldwin, 2004) which showed positive results and offers the gaming advantage. David and Podina (2014) developed a parent VSTT involving a game-based search for a happy child face embedded in a matrix of angry faces. The nature of the task and its interactive features make it and attractive and promising tool for boosting self-esteem, based on the previous findings regarding improvement of self-referential processing. Future studies should document its effectiveness in training parents' attention toward positive child cues.

We believe that online delivered parenting tools with implicit components, like the ABM training, are in support of their aims. The online format can make the intervention more easily accessible and bring cost-effectiveness benefits compared to the standard parenting programs Moreover, the implicit component is could ease the work of parents, by automatizing the negative bias correction. Future studies will need to document ways to minimize the high dropout rates registered by us and reported in the internet-based and parenting programs literature (Gavita et al., 2011b). Since another limitation of present studies is the lack of follow-up assessment, future studies will need to investigate the long-term efficacy of such parenting interventions. Also, future studies will need to investigate comparative efficacy of the online parenting program with an active control group, such as parental support.

Building on studies indicating that cognitions are key determinants of parenting skills (Gavita, 2011), the rPPP brings a new spin to available programs, in that it focuses on components related to boosting emotion-regulation of parents; it builds on developing effective reappraisal strategies in the form of rational cognitions, known as protective factors against psychopathology. It seems that the ABM procedures focused on positive attention deployment emotion-regulation can be next incorporated in this program, given that it is a short intervention, which in newly developed game interface can be enjoyed by both parents and their children, with potential positive benefits for parental skills and parent–child relationships. Moreover, future studies should test whether involving children in the program, for playing an attention training game, would bring benefits in terms of its efficacy for child outcomes.

To sum up, we aimed to test an implicit parenting intervention for tracking positive responses in children is taking a step further explicit strategies used in parenting interventions for enhancing the positive facets of parent–child relationship. Our findings are in line with novel lines of research in the clinical field, providing initial support for the positive effects of implicit attention deployment and reappraisal-based emotion-regulation strategies used within online parenting programs. Future studies should focus on integrating innovative tools for improving emotion-regulation strategies in parents within online parenting programs and test their cumulative efficacy. Positive results could offer short enhancements to current evidence-based parenting programs with great benefits for children.

AUTHOR CONTRIBUTIONS

OD designed the study, the online platform, analyzed the data, and wrote the manuscript; DC and AJ contributed to the implementation of the protocol and data collection.

FUNDING

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Using Movement to Regulate Emotion: Neurophysiological Findings and Their Application in Psychotherapy

Tal Shafir[1,2]*

[1] The Graduate School of Creative Arts Therapies, Faculty of Social Welfare and Health Sciences, University of Haifa, Haifa, Israel, [2] The Department of Psychiatry, University of Michigan, Ann Arbor, MI, USA

Emotion regulation is a person's active attempt to manage their emotional state by enhancing or decreasing specific feelings. Peripheral theories of emotion argue that the origins of emotions stem from bodily responses. This notion has been reformulated in neurophysiological terms by Damasio, who claimed that emotions are generated by conveying the current state of the body to the brain through interoceptive and proprioceptive afferent input. The resulting brain activation patterns represent unconscious emotions and correlate with conscious feelings. This proposition implies that through deliberate control of motor behavior and its consequent proprioception and interoception, one could regulate his emotions and affect his feelings. This concept is used in dance/movement (psycho)therapy where, by guiding to move in a certain way, the therapist helps the client to evoke, process, and regulate specific emotions. Exploration and practice of new and unfamiliar motor patterns can help the client to experience new unaccustomed feelings. The idea that certain motor qualities enhance specific emotions is utilized by the therapist also when she mirrors the client's movements or motor qualities in order to feel what the client feels, and empathize with them. Because of the mirror neurons, feeling what the client feels is enabled also through observation and imagination of their movements and posture. This principle can be used by verbal therapists as well, who should be aware of its bi-directionality: clients seeing the therapist's motor behavior are unconsciously affected by the therapist's bodily expressions. Additional implications for psychotherapy, of findings regarding mirror neurons activation, are discussed.

Keywords: emotion regulation, dance/movement therapy, psychotherapy, embodiment, embodied simulation, empathy, neuroscience, motor behavior

One of the goals often sought out in psychotherapy is emotion regulation. Emotion regulation is defined as a person's active attempt to manage his emotional state by enhancing or decreasing specific feelings. This is the "processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (Gross, 1998, 2002). Emotion regulation is essential for healthy psychological functioning. Deficits in the regulation of interpersonal emotions have been linked to psychiatric disorders, and teaching patients emotion regulation strategies has improved symptoms in a variety of emotional disorders

(Farchione et al., 2012). While most previous studies of applied techniques for emotion regulation concentrated on cognitive strategies such as reappraisal, distancing, and distraction, or on behavioral strategies such as exposure for desensitization or response modulation, one of the most readily available but underutilized strategies is emotion regulation through changes to posture and movement. Until recent years this strategy was considered a body-mind based alternative therapy approach and was rarely studied scientifically, but it is in fact highly compatible with neurophysiological findings.

Peripheral theories of emotion argue that the origin of emotional feelings stem from bodily responses. This notion, suggested by Darwin (1872) and James (1884), has been reformulated in neurophysiological terms by Damasio. According to Damasio, emotions are generated by conveying the current state of the body to the brain through interoception (input representing the physiological state of the body, such as thermal, metabolic, hormonal) and proprioception (input from muscles and joints). The resulting brain activation patterns represent unconscious emotions, and correlate with subjective conscious feelings (Damasio, 1999; Damasio et al., 2000; Damasio and Carvalho, 2013). Damasio's framework implies that through deliberate control of motor behavior and its consequent proprioception and interoception, one could regulate one's feelings (Riskind, 1984).

Another neurophysiological finding supporting emotion regulation through movement, is the mirror neurons activation during motor observation. Although the linkage between mirror neuron activity and the behavior of larger neuronal networks is unknown, it was suggested that mirror neurons have a role in embodied simulation. It is posited that embodied simulation creates in the observer an internal simulation of the observed movements, leading to elicitation of the same emotions felt and expressed by the observed moving person (Niedenthal, 2007; Heberlein and Atkinson, 2009; Gallese and Sinigaglia, 2011). This embodied simulation process that takes place during motor observation is the base for emotional empathy (Nummenmaa et al., 2008; Decety, 2011).

Lastly, it was found that during motor imagery, the motor system is activated similar to its activation during motor execution (Grezes and Decety, 2001; Filimon et al., 2007), except for an additional inhibition of the final motor output (Guillot et al., 2012), leading to embodied simulation of the movements. This in turn generates a simulated sensory experience of those movements (Naito et al., 2002) and sometimes even real changes in heart rate and respiration (Decety et al., 1991) that consequently can elicit the associated emotion, similar to its elicitation by motor execution of the same movements. The following paragraphs will demonstrate how the regulatory effects on emotions, of motor execution, observation and imagery, are utilized in psychotherapy.

Different types of motor-behavior modifications contribute to emotion regulation based on different underlying mechanisms (Shafir, 2015). *Quantitative* changes in motor behavior, i.e., increased intensity and/or duration of muscular activity such as during exercise, produce changes in autonomic nervous system activation (e.g., increased heart rate) and in metabolic processes, which generate a myriad of physiological changes (e.g., alterations in the levels of hormones, neurotransmitters, trophic factors, endocannabinoids, immune system function) that both elevate mood and contribute to the reduction of stress, anxiety, and depression. In addition, there is evidence to suggest that *qualitative* modifications of motor behavior, such as engaging in specific facial expressions, postures, and whole body movements, probably use a different mechanism to enhance their corresponding affects. This mechanism is likely based on proprioceptive input to the brain regarding the current state of the body's muscle activation pattern and joint configuration, and existing associations in the brain between certain proprioceptive input and specific emotions (Lee et al., 2006; Hennenlotter et al., 2009). These associations are probably partly innate and partly learned: some associations, such as between freezing and fear, between shrinking and lowering the body and expression of timidity and submissiveness, or between displacement activities such as grooming or lip biting and stress (Troisi, 2002), exist also in the animal kingdom and are probably innate. Other associations are probably learned through the process of Hebbian learning, similar to the learning process of conceptual representations of actions, based on the theory of embodied semantics for actions (Aziz-Zadeh and Damasio, 2008), although this proposition has yet to be proven by research. Two other muscle-activation based strategies for emotion regulation are progressive muscle relaxation, which reduces stress (Pawlow and Jones, 2005), and specific breathing patterns, which are capable of reducing stress (Brown and Gerbarg, 2005) or inducing differentiated emotional states (Philippot et al., 2002).

Exercise (i.e., quantitative changes in motor behavior) has been shown to be effective in reducing mild to moderate depression in both clinical and non-clinical populations (Rethorst et al., 2009; Josefsson et al., 2014) as well as reducing anxiety in a variety of anxiety disorders (Strohle, 2009; Asmundson et al., 2013). As a result, exercise is now increasingly recommended as a natural, safer, low-cost alternative to medication, or as an augmented intervention alongside medication, for a series of mental conditions and disorders. Progressive muscle relaxation and specific breathing patterns are often taught and used for stress reduction as part of the strategies taught in cognitive behavioral therapy. As for the associations between certain postures and movements and specific emotions, they are widely used in somatic therapies and in dance/movement (psycho)therapy (DMT). These associations between specific movements and corresponding emotions are used in DMT for regulation (i.e., elicitation or diminution) of specific emotions through motor execution, motor observation, and motor imagery of their associated movements, and all three of these processes can be used in the practice of other forms of psychotherapy as well.

During motor execution, as mentioned above, the proprioceptive input from the muscles and joints to the brain evokes an associated emotion. Since our body is always in some type of a posture, whether we lie down, sit, stand or are in motion, the posture that an individual assumes and the type of movements he is engaged in have a constant and continuous effect on his affective state. Different postures and movement patterns

are associated with and evoke different emotions (Duclos and Laird, 2001; Carney et al., 2010; Shafir et al., 2013, 2016; Koch, 2014; Koch et al., 2014). This concept is used in behavioral therapy, when patients are encouraged to smile as a behavioral intervention to help them elevate their mood, even when the smile is initially artificial. The activation of the facial muscles into an expression that is associated with happiness evokes or enhances this associated emotion, leading to the improvement in mood. This notion is similarly used in DMT in various ways, by activating muscles of the entire body: to help clients bring up and/or process their feelings, dance/movement therapists guide clients to move their entire bodies in particular ways.

Clients are often encouraged during a DMT session to embody, improvise and express in movement the problem they are trying to solve and how they would go about solving it, as well as their attitude toward a certain person or situation, or their behavioral or emotional response to specific conditions or stimuli (Bernstein, 1995). These movements elicit and enhance the emotions that are associated with them, helping the client to consciously identify, fine-tune and process the associated feelings (Mills and Daniluk, 2002). In addition, therapists help clients to explore their feelings by suggestions to move in ways associated with different attitudes (Ginsburgs and Goodill, 2009). Therapists also guide clients to regulate their emotions by suggesting to move in specific ways which promote movements associated with a desired emotion, and/or by suggesting to reduce and avoid motor patterns associated with undesired emotions. For example, by suggesting to practice moving with the head erect, the gaze directed straight forward, and with his back straight and chest raised and expanded, a therapist can help a client to experience and increase feelings of self-confidence and pride. Conversely, giving "homework" to a client, to consciously avoid looking down, slumping his shoulders and chest, etc., during daily activities, can help reduce feeling "down." Another important way by which dance/movement therapists use movements to affect their clients' emotional state is inviting the client to explore and practice new and unfamiliar motor patterns. By guiding the client to expand their motor vocabulary, the therapist helps them to learn and practice new motor patterns, leading to experience of desirable feelings that the client may not have had access to before.

The principle of motor execution as a mean to affect emotion can be used not only in DMT but also in other forms of psychotherapy by, for example, asking clients to change their sitting posture during a verbal therapy session: if a client who is used to sitting in a closed, bent posture changes his sitting posture into an open, erect one, this could affect his entire experience during the therapy session.

The principle of motor execution as a way to enhance the associated feelings can be utilized not only by clients, but by therapists as well. It is not uncommon for a DMT therapist to mirror her client's movements or motor qualities. While motor mirroring usually serves to give feedback to the client and/or a feeling of being noticed and accepted, it is also used to increase the therapist's empathy and understanding of the client's emotional state (McGarry and Russo, 2011). Imitating the client's movements or the quality of their movements evokes

in the therapist the same emotions that are felt by the moving client. This too can be done by a verbal psychotherapist. By mirroring the sitting posture of a client and the changes in his posture throughout the therapeutic session, the therapist can better feel the client's emotional fluctuations during the session.

In addition to motor execution, motor observation can also enhance in the observer the emotion associated with the observed movements (Shafir et al., 2013). This is accomplished probably through activation of the mirror neurons, as explained above. By observing the client's movements while paying special attention to the feelings they evoke within her, the therapist can better feel what the client is feeling. This is true not only for dance/movement therapists but for any (verbal or other) therapist observing clients' movements both as they enter the room and during the therapy session. Movements for this purpose need not only be big movements involving the entire body, as are often performed during DMT sessions, but can be any type of movement performed while sitting and talking, including facial expressions, gestures, displacement activities that express stress (Troisi, 2002), changing sitting positions, etc.

It should be mentioned, however, that although motor observation enhances the feelings associated with the observed movements, research has shown that motor execution leads to more intense feelings when compared to the feelings evoked by motor observation of the same movements (Shafir et al., 2013). Thus, if a therapist observing a client is unsure about the client's feelings, mimicking the client or moving with similar motor qualities (Shafir et al., 2016) could help the therapist clarify and identify those feelings, by enhancing them within herself. Indeed, Sletvold (2015) adopted this idea in his model for clinical supervision, in which the supervisee is asked to assume physically the position of his patient and from there to explore embodied empathy in depth.

Although mirroring the client's movements is a technique often used in DMT, it is sometimes inappropriate, and the therapist must rely solely on motor observation to understand and empathize with the client's emotions. On such occasions, it is important to know that the ability to transform observations of motor expressions into an internal simulation of those movements and thus feel the associated emotions is a skill that therapists can develop and improve. Two neuroscientific findings support this notion. The first is Catmur et al.'s (2007, 2008) finding that the mirror neuron system is plastic and develops through sensorimotor learning. The implication of this finding is that by practicing unfamiliar movements which are not normally within a therapist's motor repertoire, such as for example, stereotypical movements of autistic children, dyskinetic movements of people with Parkinson, or very fast, frantic movements for a therapist whose natural motor behavior is slow and calm, dance/movement therapists can teach themselves to better sense the feelings associated with and evoked by such unfamiliar movements. The second discovery is that of Calvo-Merino et al. (2005, 2006) who found that the mirror system is activated more when we observe movements that are within our motor repertoire, as compared to movements that we have little or no experience doing. This finding implies that the

more personal experience one has moving a certain movement, the easier it will probably be for her to internally simulate that movement and feel its associated emotion. This finding emphasizes the importance for dance/movement therapists of having a wide range of movement experiences and large motor vocabulary: the more experience a dance/movement therapist has in a variety of different movement styles, the easier it will be for her to mirror, empathize and "feel" a variety of people moving with diverse motor patterns.

One important thing to remember in relation to the activation of the mirror neurons during motor observation is that it happens to everyone. This means that, similar to the ability of the therapist to infer what the client is feeling based on the client's movements and posture, the client can feel the therapist's feelings when observing the therapist's body language. Therapists should be aware of this reciprocity and constantly monitor and control their body language, avoiding movements and postures that can negatively affect clients, and adopting postures and movements that can positively affect the therapeutic process. We all have a natural tendency to automatically and unconsciously mimic the behavior of the people we interact with (Chartrand and Lakin, 2013). During a therapeutic session with for example, a depressed client, the therapist should be aware of how much she automatically adopts the hopeless, lethargic posture of the client in front of her. While adopting a slightly similar posture may give the client a sense of empathy, fully adopting the client's helpless, slumped posture might give the client a message of despair and the inability of the therapist to help him. Another obvious example would be to consciously avoid any facial or bodily expression of disgust that a client may evoke in a therapist.

Although some clients may feel uncomfortable seeing themselves being mirrored, studies have shown that most people feel more positive about someone who imitates them. While some researchers ascribed this phenomenon to increased social bonding and interpersonal closeness (Lakin et al., 2003) or an indication of pre-existing rapport (Scheflen, 1964), recent findings suggest that the reason is that observing mimicry triggers reward related processing regions in the brain, leading to elicitation of positive affect. Kühn et al. (2010) has shown that being imitated compared to not being imitated activates brain areas that have been associated with emotion and reward processing, namely the medial orbitofrontal cortex/ventromedial prefrontal cortex, and that these regions show higher effective connectivity with the striatum and mid posterior insula while being imitated compared to not being imitated. This phenomenon is used in DMT when the therapist joins the client and moves in front of him or at his side, mirroring

his movements. Such behavior of the therapist often makes the client feel reassured, supported and empathized by the therapist, and it strengthens the connection between client and therapist (McGarry and Russo, 2011). This strategy too, can be utilized by other types of therapists, who can consciously imitate their clients' small gestures or changes in sitting position during therapeutic sessions. In fact, extant literature contains several examples that demonstrate the effectiveness of such a strategy: Maurer and Tindall (1983) found that high school juniors perceived their counselors' level of empathy as higher when the counselors sat in a posture that was congruent with their own posture during the counseling session when compared to a non-congruent posture. Ramseyer and Tschacher (2011) found that psychotherapeutic relationships that were characterized by higher non-verbal synchrony between the patient and therapist during face to face sessions were rated by the patients as having higher relationship quality between the patient and therapist, and they increased the patients' self-efficacy more than therapeutic relationships characterized by lower such non-verbal synchrony. In addition, patients with high synchrony had a higher reduction of symptoms and less insecure attachment patterns at the end of treatment.

Motor imagery has also been found to enhance the emotions associated with imagined movements (Shafir et al., 2013). Motorically disabled or physically sick clients with limited motor capabilities can use motor imagery instead of motor execution to elicit desired emotions, imagining themselves, for example, running on the beach or dancing at a party, to improve their mood. Clients can also use motor imagery as part of practicing through mental simulation a desired behavioral response, for example, by imagining themselves standing in a grounded, open, and firm posture, to help themselves feel more confident and self-assured when mentally practicing being assertive during a difficult social interaction. Therapists, on the other hand, could use motor imagery to enhance the empathic effects of motor observation, by imagining themselves doing the movements they observe their clients doing.

In conclusion, based on peripheral theories of emotion, the mirror neuron system, and specific brain activation during motor observation and motor imagery, motor behavior, its observation, and its imagination can affect one's emotional state, and these can be utilized in various ways during psychotherapy.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and approved it for publication.

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Conflict of Interest Statement: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Synchrony in Psychotherapy: A Review and an Integrative Framework for the Therapeutic Alliance

Sander L. Koole * *and Wolfgang Tschacher*

[1] *Department of Social Psychology, Vrije Universiteit Amsterdam, Amsterdam, Netherlands,* [2] *University Hospital of Psychiatry Bern, University of Bern, Bern, Switzerland*

During psychotherapy, patient and therapist tend to spontaneously synchronize their vocal pitch, bodily movements, and even their physiological processes. In the present article, we consider how this pervasive phenomenon may shed new light on the therapeutic relationship– or alliance– and its role within psychotherapy. We first review clinical research on the alliance and the multidisciplinary area of interpersonal synchrony. We then integrate both literatures in the Interpersonal Synchrony (In-Sync) model of psychotherapy. According to the model, the alliance is grounded in the coupling of patient and therapist's brains. Because brains do not interact directly, movement synchrony may help to establish inter-brain coupling. Inter-brain coupling may provide patient and therapist with access to another's internal states, which facilitates common understanding and emotional sharing. Over time, these interpersonal exchanges may improve patients' emotion-regulatory capacities and related therapeutic outcomes. We discuss the empirical assessment of interpersonal synchrony and review preliminary research on synchrony in psychotherapy. Finally, we summarize our main conclusions and consider the broader implications of viewing psychotherapy as the product of two interacting brains.

Keywords: interpersonal sychrony, linguistic alignment, co-regulation, inter-brain coupling, interpersonal neural synchronization, interpersonal emotion regulation, implicit emotion regulation

Psychotherapy is traditionally known as 'the talking cure', a term that originates from Bertha Pappenheim, one of the first patients to receive psychotherapeutic treatment (Breuer and Freud, 1895/1995). Patient and therapist undeniably do much talking in modern psychotherapy. Yet, psychotherapy is more than mere talk. Patient and therapist have bodies that interact with each other in space and time. Consequently, patient and therapist do not just communicate through words, but also through their bodily behavior. Indeed, the bodily behavior of patient and therapist tends to become synchronized during psychotherapy, such that they display coupled patterns in vocal pitch (Imel et al., 2014), head movements (Ramseyer and Tschacher, 2014), and whole body movements (Ramseyer and Tschacher, 2011, 2014). Patient and therapist may even literally get under each other's skin, as evidenced by matching levels of skin conductance (Marci et al., 2007).

The pervasive synchrony between patient and therapist have so far received little attention within mainstream clinical psychology. This seems unfortunate because research outside the clinical domain has shown that synchrony plays a key role in establishing rapport

(Vacharkulksemsuk and Fredrickson, 2012), perspective taking (Wheatley et al., 2012), and the development of adaptive emotion-regulation (Feldman, 2007). There are thus strong grounds to suspect that synchrony is highly relevant to psychotherapy. The need to understand non-verbal processes in psychotherapy has become especially urgent now that new technologies make it possible to conduct psychotherapy without face-to-face contact (Newman et al., 2011) and large-scale implementation of these new technologies is at hand (Kazdin and Blase, 2011).

In the present article, we develop a theoretical framework for understanding the role of synchrony in psychotherapy. In the first section, we begin by reviewing prior theory and research on the patient-therapist relationship, or *alliance*. In the second section, we discuss the notion of synchrony and the pervasive influence that it has on interpersonal relationships. In the third section, we integrate the alliance and synchrony literatures. Specifically, we propose the Interpersonal Synchrony (In-Sync) model, a new theoretical model that explains how patient-therapist synchrony may foster the alliance, and thereby, adaptive emotion regulation. We also consider recent advances in the empirical assessment of patient-therapist synchrony and review relevant research. Finally, in the fourth section of this article, we summarize our main conclusions and discuss some of the broader implications of the In-Sync model.

THE ALLIANCE

During psychotherapy, patient and therapist work together in structured sessions to alleviate the patient's problems. This working together is the alliance, also known as the therapeutic bond, therapeutic relationship, treatment alliance, helping alliance, or working alliance. It seems intuitively obvious that a good alliance should benefit psychotherapy. However, the therapeutic significance of the alliance has been highly debated among clinical psychologists (Elvins and Green, 2008; Horvath et al., 2011; Wampold and Imel, 2015). In this section, we selectively review theories of and research on the alliance. We begin by situating the alliance among the major therapeutic traditions within clinical psychology. Next, we turn to the main empirical findings that have accumulated with regard to the alliance. We conclude by discussing how scientific understanding of the alliance may be further enhanced.

Conceptualization of the Alliance

There are presently at least 500 psychotherapies within clinical psychology, which share certain formal characteristics (e.g., delivery by a trained therapist, structured sessions), but differ in contents (Prochaska and Norcross, 2013). Because of the large number of psychotherapies, it is convenient to group them into psychoanalytic, humanistic, and cognitive-behavioral traditions (Wampold and Imel, 2015). These three major therapeutic traditions have each contributed in their own way to the modern notion of the alliance (for more details, see Hougaard, 1994).

Notions related to the alliance first arose within the psychoanalytic tradition. Sigmund Freud, the founder of

psychoanalysis, recognized that a positive attachment between patient and therapist helps the patient to stay committed to psychotherapy (Freud, 1912, 1913) (see Horvath and Luborsky, 1993). Sterba (1934) later spoke of an "alliance" between the therapist and the rational parts of the patient's ego, an idea also present in Freud's later writings (Freud, 1937). The work of Greenson in the 1960s helped to make the alliance a widely used concept within psychoanalysis (Greenson, 1965, 1967). According to Greenson, the alliance reflects the patient's motivation and capacity to perform psychoanalytic work. The alliance has remained a major focus in contemporary psychoanalytic approaches, which regard the patient-therapist relationship as a bond that can become deeply meaningful and highly emotionally charged for the patient (Shedler, 2010).

The alliance has further been a major interest in the humanistic tradition in psychotherapy, which has developed in the 1950s from the ideas of philosophers such as Kierkegaard, Husserl, and Heidegger (Cain, 2002; Yalom, 2002; Van Deurzen, 2012). The humanistic tradition has mainly held the therapist responsible for the alliance. Particularly influential has been client-centered therapy (Rogers, 1951; Erekson and Lambert, 2015), which suggests that the therapist should relate authentically with the patient, while offering acceptance and empathy for the patient's perspective. Carl Rogers, the founder of client-centered therapy, believed that the effectiveness of every form of psychotherapy is ultimately due to the therapist's capacity to form an authentic, accepting, and empathic relationship with the patient (Rogers, 1957).

Compared with the psychoanalytic and humanistic traditions, the alliance has received less attention within the cognitive-behavioral tradition to psychotherapy (for a comprehensive overview, see Dobson, 2009). Although cognitive-behavioral therapists have regarded a good alliance as a precondition for psychotherapy, most of them do not regard the alliance as directly curative. Focusing on the alliance has also been taken as a devaluation of specific therapeutic techniques that are advocated by the cognitive-behavioral tradition, given that the alliance is common to all psychotherapies. However, therapeutic effects of the alliance are by no means incompatible with specific factors, and indeed, the two types of factors are likely to interact in psychotherapy (Tschacher et al., 2014a). Consistent with this, there is a growing consensus in clinical psychology that common and specific factors jointly shape therapeutic outcomes (Hofmann and Barlow, 2014; Laska et al., 2014).

Even though the therapeutic significance of the alliance has not been directly investigated by cognitive-behavioral psychologists, the cognitive-behavioral tradition has had a major influence on the conceptualization of the alliance. Most of this influence occurred indirectly, through the cognitive-behavioral psychologists' emphasis on objective empirical methods. Psychoanalytic and humanistic notions of the alliance were originally complex and hard to observe empirically. Under the influence of the cognitive-behavioral tradition, the empirically less tractable elements of the alliance have gradually shifted in to the background, whereas empirically observable aspects have been given more weight (for a conceptual geneology of the alliance, see Elvins and Green, 2008).

By becoming more empirically grounded, the alliance has become increasingly a trans-theoretical construct, whose meaning cuts across therapeutic traditions. This trans-theoretical orientation is clearly apparent in the work of Bordin (1979), who merged different theoretical contributions in his general concept of the working alliance, as (1) agreement of goals; (2) assignment of tasks; and (3) the development of a bond between patient and therapist. Bordin saw these features as central to all psychotherapies. The alliance is the most widely endorsed factor that is common among all psychotherapies (Grencavage and Norcross, 1990; Frank and Frank, 1993). Accordingly, the alliance has been a key interest within the psychotherapy integration movement, which seeks to draw together the different psychotherapy traditions (Grawe, 1997, 2007; Norcross and Goldfried, 2005; Stricker and Gold, 2013).

The modern notion of the alliance subsumes all collaborative elements within the therapeutic relationship (Horvath et al., 2011), regardless of how these elements are associated with the patients' prior interpersonal attachments. Most researchers distinguish between the personal/social-emotional aspects of the alliance and its task-related aspects (Bales, 1950; Bordin, 1979; Hougaard, 1994). Empirically, however, ratings of personal and task alliance tend to be highly correlated (Elvins and Green, 2008). Researchers from different therapeutic traditions have emphasized either the patient's or the therapist's contributions to the alliance. However, the latter may be mainly a matter of perspective, given that the alliance emerges from the mutual interactions between patient and therapist (Bordin, 1979; Hougaard, 1994; Tschacher et al., 2015).

Alliance Research

The alliance is one of the most frequently studied topics within contemporary clinical psychology (Elvins and Green, 2008; Horvath et al., 2011; Wampold and Imel, 2015). Nevertheless, the therapeutic significance of the alliance remains controversial. One important reason for this controversy is that alliance effects do not fit very well into the standard medical model, which has been widely applied to psychotherapy (for an extended discussion, see Wampold and Imel, 2015). In the medical model, the patient suffers from a physical condition that is treated with a cure that is specifically designed toward alleviating this condition. For instance, a patient suffering from a bacterial infection may be treated with antibiotics by her physician. A basic assumption of the medical model is that the effectiveness of a cure is largely independent of the relationship between the patient and the person providing the cure. After all, most bacteria get killed by antibiotics, regardless of who provides them. The medical model hence leaves little, if any, room for a potential curative role of the alliance.

The methodological gold standard of the medical model is the randomized controlled trial, in which patients are randomly assigned to either a treatment that is expected to be active or a control (placebo) treatment that is expected to be inactive (Danziger, 1994; Shapiro and Shapiro, 2000). To the extent that treated patients do better than patients who received the placebo, the treatment is considered effective. The major strength of the randomized controlled trial is that it allows one to determine if

a treatment causes patients' improvements. Unfortunately, the trial method does not easily lend itself to studying alliance effects. The effects of the alliance are typically very broad and cut across specific psychotherapies (Flückiger et al., 2012). This makes it difficult to determine what a plausible placebo treatment without a good alliance would look like. The alliance may even interact with the placebo, given that placebo effects may become enhanced when the treatment provider evokes a strong (rather than weak) alliance with the patient (Kaptchuk et al., 2008). The effects of the alliance thus go beyond the traditional logic of the randomized controlled trial.

Because of the difficulties in applying the trial method to the alliance, almost all research to date on the alliance has been correlational. In most studies, the patient and the therapist (or sometimes an external observer) rate the quality of the alliance on a questionnaire. Various standardized scales exist to this end (for overviews, see Elvins and Green, 2008; Ardito and Rabellino, 2011). For instance, the widely used Working Alliance Scale has items such as "[My therapist] and I understand each other" and "We agree on what is important for me to work on" (Horvath and Greenberg, 1989). A factor-analytic study of three widely used alliance scales found that the core of patients' view of the alliance consists of being confident in and committed to a process that feels promising and helpful (Hatcher and Barends, 1996). Items relating to goals and tasks emerged as a single factor, and tend to be correlated in other studies as well (Elvins and Green, 2008), suggesting Bordin's (1979) distinction between goals and tasks may be too strongly drawn.

The relation between the alliance and therapeutic outcomes has been extensively investigated. In a meta-analysis of 190 independent studies, Horvath et al. (2011) found an average correlation of the alliance and outcomes of individual psychotherapy of 0.275. Other meta-analyses have yielded similar correlations (e.g., Martin et al., 2000). It thus appears that prevailing measures of the alliance on average account for about 7% of psychotherapy outcomes. Although the latter relation is statistically modest, it is robust across different kinds of studies (randomized controlled trials or other), different types of psychotherapy (e.g., cognitive-behavior therapies or other), different alliance measures, and different types of outcomes (e.g., specific symptoms or general wellbeing). Moreover, the average effect of the alliance is larger than the effects of other treatment variables such as therapist adherence to treatment manual or therapist competence (Webb et al., 2010).

Because research on the alliance-outcome link has been correlational, the causal direction of this link remains uncertain (for an extended discussion of this point, see DeRubeis et al., 2005). It could be, for instance, that ratings of the alliance reflect how well the therapy has progressed. However, the alliance-outcome link is only slightly reduced (to $r = 0.25$), and still statistically significant, in studies that assessed the alliance during the first few sessions of psychotherapy (Flückiger et al., 2012). The latter pattern suggests that the alliance is more than just the result of therapeutic success.

Another possibility is that the alliance is linked to outcomes because "better" patients more easily form a strong alliance. However, variations in patients' contribution to the alliance are

not linked to better outcomes (Flückiger et al., 2012). By contrast, therapists who form stronger alliances tend to achieve better outcomes with their patients than therapists who form weaker alliances (Baldwin et al., 2007; Del Re et al., 2012). Therapists who achieve better therapeutic outcomes also score higher on a standardized measure of interpersonal skills such as empathy and warmth (Anderson et al., 2009). Overall, empirical findings are consistent with the idea that the alliance is an active ingredient of psychotherapy.

Taking Alliance Research Further

As we have seen, modern alliance research has achieved important theoretical and empirical progress. Even so, important aspects of the alliance remain incompletely understood and, in some cases, even hardly investigated. One of the greatest challenges is to understand the dynamic interpersonal nature of the alliance. The alliance is more than the sum of the individual contributions of the patient and therapist. Indeed, the alliance emerges from the mutual interactions between patient and therapist, that reciprocally influence each other as the actions of the patient influence the actions of the therapist, which then go on to influence the patient whose actions again influence the therapist, and so on. Theoretical accounts of the alliance should do justice to these interpersonal dynamics, which go the heart of the alliance as a trans-active, relational phenomenon (Bordin, 1979; Hougaard, 1994; Tschacher et al., 2015).

A second aspect that needs to be further developed is the methodology of alliance research. So far, most alliance research has relied on subjective ratings by the patient and the therapist, and sometimes external observers (Elvins and Green, 2008). When research has gone beyond rating scales, it has mainly examined the verbal-linguistic interactions during psychotherapy (e.g., Muntigl et al., 2013). Alliance research has thus focused almost exclusively on the subjective aspects of the alliance that can be directly explicated in the words of the patient and the therapist. However, there are also physical aspects of the alliance that can be observed objectively, such as patient and therapist's movements, along with their physiological responses (e.g., heart rates), and neurological activations. Measuring these objective, physical aspects of the alliance is often technically difficult, which may be why these kinds of measures have been understudied. Nevertheless, the scientific analysis of the alliance will not be complete until it addresses both the subjective-linguistic and the objective, physical aspects of the alliance (Tschacher et al., 2015).

A third and last aspect that needs to be developed lies in the connections between alliance research and other scientific disciplines. To date, research on the alliance has been essentially a mono-disciplinary enterprise that is conducted exclusively by clinical psychologists. This approach seems overly restrictive, given that the alliance is a multi-faceted phenomenon that has many meaningful relations with topics that are studied in other scientific disciplines. Indeed, several disciplines have made advances that seem potentially relevant to the scientific analysis of the alliance, including relationships science (e.g., Fitzsimons et al., 2015), social-cognitive neuroscience (e.g., Konvalinka and Roepstorff, 2012), cognitive linguistics (Fusaroli

et al., 2012), emotion science (Rimé, 2009), and dynamical systems theory (Tschacher et al., 2015). Consequently, alliance research would do well to nurture a more multidisciplinary orientation.

Outlook

Alliance research has achieved important progress, by conceiving of the alliance as the collaboration between patient and therapist, and by establishing that patients' and therapists' reports of the alliance can account for about 7% of psychotherapy outcomes. Still, many basic questions remain about the nature of the alliance. How does the alliance emerge from the mutual interactions between patient and therapist? How is the alliance manifested in body and brain? And what can disciplines outside clinical psychology tell us about the alliance? In what follows, we seek to derive some answers to these questions from the multidisciplinary area of synchrony research.

SYNCHRONY

The alliance is an interpersonal phenomenon. Principles that govern interpersonal relations are thus clearly relevant to understanding how the alliance works. Among the most basic of these principles is interpersonal synchrony. Whenever people interact, they are inclined to spontaneously synchronize their neural, perceptual, affective, physiological, and behavioral responses (Semin and Cacioppo, 2008; Wheatley et al., 2012; Repp and Su, 2013). This interpersonal synchrony is part of a broader family of synchrony phenomena that occur throughout the natural and life sciences (Pikovsky et al., 2003; Strogatz, 2003). The word "synchrony" derives from the Greek words *syn*, which means the same or common, and *chronos*, which means time. "Synchrony" thus literally means "occurring at the same time".

In this section, we selectively review synchrony theory and research. We begin by discussing how synchrony is a unifying principle that can explain many different kinds of complex, self-organizing systems, from pendulum clocks to the human brain. After this, we zoom in on interpersonal synchrony. We end this section with significance of interpersonal synchrony for emotion regulation, a topic that is particularly relevant for psychotherapy.

Synchrony and Self-Organization

Synchrony operates throughout many biological systems. Well-documented examples of synchrony can be found in cell assemblies, morphogenesis, and evolutionary mutation (Kauffman, 1993; Karsenti, 2008). Synchrony is further important in the functioning of neural networks (Haken, 2013). We consider neural synchronization in somewhat more detail because it illustrates how synchrony works in a biological system that is of central interest to psychologists.

The human brain consists of nearly 100 billion neurons that operate in assemblies of functionally specialized regions. The activities of these neural assemblies must somehow be integrated to yield coherent patterns of thoughts, feelings, and behaviors. This large-scale neural integration may be achieved

by synchronizing the activity of neural assemblies (Varela et al., 2001). More specifically, activated neural assemblies have the intrinsic property to oscillate electrically in certain rhythms (Herrmann et al., 2015). Because these oscillations modulate neural excitability, neural assemblies communicate most effectively when their oscillations are synchronized (Fries, 2005). Especially oscillatory rhythms in the beta/gamma range (20–80 Hz) may help facilitate communication between distributed neural functions (Varela et al., 2001; Fries et al., 2007; Uhlhaas et al., 2009). Neural synchrony thus appears to play a key role in coordinating brain functions.

Although synchrony is nowadays a major topic in the life sciences, research on synchrony started in the natural sciences. Indeed, first scientific description of synchrony was rendered by Dutch scientist and mathematician Christiaan Huygens in the 17th century (see Pikovsky et al., 2003). Having just patented the first pendulum clock, Huygens was working to adapt its design for ships on the open sea. During one sea trial, he suspended two pendulum clocks with hooks on a wooden beam (Huygens, 1673/1986). Huygens then observed that the motions of each clock became so much in agreement that that they never receded from another and their sounds were always heard simultaneously. He further noted that the agreement between the clocks became quickly reestablished if it was disturbed. Huygens carefully examined this "sympathy of two clocks" and discovered that the pendula communicated their oscillations onto the wooden beam to which they were suspended, which led the pendula to produce exactly contrary swings.

The development of electrical engineering in the 1920s provided a major impetus to synchrony research (Pikovsky et al., 2003). As it turned out, the frequency of a generator can be synchronized by a weak external signal of a slightly different frequency, a principle that became the basis of the modern radio. It gradually became clear that synchronization phenomena are part of a broader class of self-organizing systems, in which order arises from the non-linear interactions between individual parts. The basic principles of self-organization were formulated by Hermann Haken in the 1970s and 1980s, who was initially trying to understand laser light transitions. Haken's work led to synergetics theory, a mathematical approach to self-organizing systems that has been applied to both non-living and living systems (Haken, 2012).

Haken's (2012) synergetics theory shows how the unpredictability of complex systems is often greatly reduced by the emergence of order parameters. Notably, there is a circular causality between the order parameters and the individual components of the system: The individual components generate the order parameters that, in turn, determine the behavior of the individual components. Non-linear dynamics can thus explain how synchronous patterns can emerge 'spontaneously' (i.e., without a central coordinating agent) within a complex system. The latter has important implications for the study of human behavior, because there is a deeply engrained tendency among lay people and scientists to attribute coherent patterns in social behavior to the intentions or other qualities of the individual person. The emergence of synchronous behavior, however,

does not depend on intentions or any other quality of the individuals who are behaving in synchrony. Rather, synchrony arises as a self-organized behavioral pattern from people's mutual interactions.

Interpersonal Synchrony

Synchrony emerges in a wide range of social contexts. For instance, synchronous behavior often characterizes the behavior of large groups, ranging from termite nests and schools of fish (Camazine et al., 2001) to highway traffic (Lee et al., 1998). Moreover, synchrony in face-to-face interactions plays a key role in the formation of interpersonal bonds (Feldman, 2007; Wiltermuth and Heath, 2009; Vacharkulksemsuk and Fredrickson, 2012). The latter, interpersonal, forms of synchrony seem most relevant for psychotherapy.

In an early field study, independent judges observed more movement synchrony in videotaped interactions between high school students and their teachers, relative to control videos composed of randomly selected interactions (Bernieri, 1988). These field observations have been corroborated by the results of behavioral experiments using well-defined cognitive-motor tasks, in which participants can move more or less in synchrony with another. Research on interpersonal movement coordination developed out of studies of intrapersonal synchrony (bimanual finger movements), which resulted in the synergetic model of Haken et al. (1985). Across experiments, participants have been found to display a consistent tendency to synchronize their movements, even when they were previously unacquainted (e.g., Oullier et al., 2008; van Ulzen et al., 2008; Varlet et al., 2011).

Synchrony has further been documented in linguistic communication. For instance, people's breathing patterns during conversation are highly correlated, either negatively (out of phase) or positively (in phase) (Yang, 2007). Breathing is most closely synchronized near turn-taking and periods of simultaneous laughter or speech, indicating that breathing synchrony is closely tied to the communicative process (Warner, 1996; McFarland, 2001). Furthermore, conversants tend to have highly coordinated postural sway and match each other's eye gaze, even when they cannot see their partner (Shockley et al., 2003; Richardson D.C. et al., 2007; Brown-Schmidt and Tanenhaus, 2008). Finally, people are spontaneously inclined to synchronize their word use, a tendency that occurs not only for content words (what someone is saying) but also for function words (how someone is saying it) (Pickering and Garrod, 2004; Ireland and Pennebaker, 2010).

Though interpersonal synchrony is ubiquitous, it occurs more readily in the context of positive relationships. For example, in the aforementioned field study among teachers and students (Bernieri, 1988), significantly more movement synchrony was observed when teachers and students mutually trusted each other. Likewise, mothers synchronize their movements more with their own children than with unfamiliar children (Bernieri et al., 1988), and couples high on marital satisfaction synchronize more than couples low on marital satisfaction (Julien et al., 2000). In addition, people synchronize more with people with whom they wish to develop positive relationships (Miles et al.,

2011), and with people with whom they have self-disclosed (Vacharkulksemsuk and Fredrickson, 2012).

Once interpersonal synchrony emerges, it has important individual and social consequences. Several experiments have shown that leading people to move in synchrony promotes cooperation and helping behavior (Wiltermuth and Heath, 2009; Kirschner and Tomasello, 2010; Valdesolo and DeSteno, 2011). The behavioral effects of synchrony may be partly explained by increases in pro-social motivation, given that moving in synchrony has been found to increase liking, compassion, and rapport with partners (Hove and Risen, 2009; Valdesolo and DeSteno, 2011; Vacharkulksemsuk and Fredrickson, 2012). However, synchrony may do more than merely shift people's motivational state. A recent study showed that moving in synchrony led participants to display greater perceptual sensitivity to movements, which in turn was associated with greater success in a subsequent joint-action task (Valdesolo et al., 2010). Consequently, interpersonal synchrony may not only increase people's willingness to coordinate their actions with others, but also their capacity for doing so.

Research has further begun to illuminate the neural bases of interpersonal synchrony. In so-called hyper-scanning studies, researchers have used various techniques (such as electroencephalographs, magnetic resonance imaging, near infrared spectroscopy) to make simultaneous recordings of brain activities while participants are sharing a task (for reviews, see Konvalinka and Roepstorff, 2012; Babiloni and Astolfi, 2014; Hari et al., 2015). The types of shared tasks that so far have been investigated have ranged from simple button presses to interactive games and group discussions. Across studies, a consistent finding is that joint activities lead to interpersonal synchronization of neural activations. For instance, one experiment simultaneously recorded the brain actions of guitarists playing a short melody together (Lindenberger et al., 2009). The results showed that interpersonally coordinated actions (i.e., behavioral synchrony) are preceded and accompanied by interbrain oscillatory couplings in the prefrontal cortices. Other studies have shown that interpersonal neural synchrony is associated with better joint performance (Cui et al., 2012) and more effective communication (Jiang et al., 2015). Although more work is needed, the available findings suggest that interpersonal synchrony at the behavioral level gives rise to interpersonal neural synchronization.

Interpersonal Synchrony and Emotion Regulation

The term 'interpersonal synchrony' seems to suggest that what is synchronized happens entirely between persons, leaving unchanged what happens within the person. In reality, however, interpersonal synchrony continually interacts with the person's inner regulatory resources. The boundaries between internal and external regulation thus become blurred. Indeed, synchronous activity may actually lead people's perceptions of the self and the synchronous other to become merged, both at the level of the body and at the conceptual level (Paladino et al., 2010; Mazzurega et al., 2011). Nevertheless, for analytic purposes, it remains useful

to distinguish between internal and external regulation, as long as their mutual dependencies are acknowledged.

During early developmental stages, interaction patterns between the child and caregivers set the stage for interpersonal synchrony (see Feldman, 2007, for an overview). Already within the first hours after birth, mothers strategically initiate vocal and tactile stimulation when the child displays an alert state, establishing the first contingency between the infant's internal state and the caregiver's behavior. Such maternal stimulation is associated with the onset of non-verbal synchrony between child and mother, and between child and father (Feldman and Eidelman, 2007). Developmentally primary forms of interpersonal synchrony are thus closely coordinated with systems that self-regulate arousal and attention within the child (Feldman, 2006).

By the age of 9 months, the child's ability to respond to changes in caregiver's affect results in mutually synchronous affective exchanges in brief episodes of about 10 s (Feldman, 2007). These micro-level affective exchanges play an important role in the development of the child's capacity for self-regulation, particularly in regulating own emotional states (Tronick, 1989; Hofer, 1995). For instance, one study showed that mutual affect synchrony with the mother when the child was 9 months predicted self-control abilities at age 2 years, even after statistically controlling for temperament, IQ, and maternal style (Feldman et al., 1999). In a related vein, another study found that greater parent–child synchrony predicted better emotion regulation skills at a later point in time over a period of 10 years (Feldman, 2015). The later findings are consistent with the idea that interpersonal synchrony enhances the capacity for emotional self-regulation.

It seems straightforward that interpersonal synchrony regulates children's emotions during interactions with their caregivers. After all, synchronous interaction is associated with emotional security (Feldman, 2007), which should down-regulate emotional distress. However, interpersonal synchrony also enhances children's capacity for emotion regulation when their caregivers are physically absent (Feldman, 2015). The latter may occur because interpersonal synchrony leads the self to become more involved in the interaction (Paladino et al., 2010; Pinel et al., 2015). People's memory for what is associated with the self is considerably better than people's memory for what is dissociated with the self (Symons and Johnson, 1997). Moreover, affect-regulatory processes may become associated with the self (Kuhl, 2000; Koole and Coenen, 2007). Consequently, interpersonal synchrony may help children to internalize the emotional security that is associated with the relationship with their caregiver.

Although the links between interpersonal synchrony and emotion regulation have been mostly investigated among children, these links are likely to remain important in adulthood. The clearest support for this notion has been found in the domain of close relationships (Butler and Randall, 2013; Ferrer and Helm, 2013; Timmons et al., 2015). People in close relationships are usually attuned to their partner's emotions, leading to synchronization of emotional responses between relationship partners, or 'co-regulation' (Butler and Randall,

2013). Co-regulation is linked to synchronization of non-verbal behavior (Marci and Orr, 2006; Feldman et al., 2011). Synchrony of emotional processes may thus transfer to close relationships in adulthood. Notably, co-regulation entails more than merely matching of each other's emotional responses, because this may easily lead to escalating arousal levels, or 'codysregulation' (Reed et al., 2015). Instead, co-regulation maintains emotional arousal of the dyad around a healthy homeostatic balance (Timmons et al., 2015).

Outlook

Synchrony, or the temporal coordination of interacting parts, can be observed in complex self-organizing systems throughout the natural and life sciences. A growing number of studies have examined interpersonal synchrony in neural, perceptual-motor, emotional, social, and behavioral processes. This research has achieved important progress, for instance, by showing that interpersonal synchrony may facilitate positive exchanges and enhance adaptive emotion regulation. Nevertheless, the field has remained somewhat scattered. Neural, perceptual-motor, emotional, social, and behavioral forms of synchrony have been studied separately, without considering how they relate to each other and function together in an interpersonal relationship. We consider a potential integration of these sub-processes in the next section, on synchrony in psychotherapy.

SYNCHRONY IN PSYCHOTHERAPY

As we have seen, synchrony plays a pervasive role in interpersonal relationships. It thus seems likely that interpersonal synchrony extends to the patient-therapist relationship during psychotherapy. To analyze how this may occur, we present the Interpersonal Synchrony (In-Sync) model of psychotherapy, a new framework that combines insights from various literatures, including social-cognitive neuroscience, cognitive linguistics, psychophysiology, developmental science, relationship science, and emotion science. After laying out the In-Sync model, we discuss the empirical assessment of interpersonal synchrony. Finally, we review the available literature on synchrony in psychotherapy on the basis of the In-Sync model.

## Interpersonal Synchrony Model of Psychotherapy

The core idea of the In-Sync model is that the alliance emerges from the coupling of the neural activity of the brains of the patient and therapist. The more tightly patient and therapist's brains are coupled, the better the alliance. Of course, patient and therapist's brains do not communicate directly. Their coupling can thus be achieved only indirectly, through the mutual coordination of the patient and therapist's behavior and experiences. This mutual coordination is achieved through synchronous activities of the patient and therapist. Synchrony thus helps to establish the alliance, which in turn promotes adaptive emotion regulation in the patient, and thereby good therapeutic outcomes.

As can be seen in **Figure 1**, the In-Sync model distinguishes three levels of processing. The different levels are descending in terms of their processing speed and ascending in terms of the complexity of cognitive inferences that are involved. Processes at Level 1 operate on a *phasic* time-scale, which runs from a few hundred milliseconds to about 10 s, and involves the simplest forms of cognitive inferences, namely, automatic associations between perceptions and action. Processes at Level 2 operate on a *tonic* time-scale, which runs from 10 s to about an hour, and involves more complex forms of social cognition, such as language and reasoning. Finally, processes at Level 3 operate on a *chronic* time-scale, which runs from several weeks to years, and involves the development of complex emotion-regulatory abilities. In what follows, we discuss each level in more detail. Notably, there are likely to exist multiple feedback loops between levels, represented in **Figure 1** as double-sided arrows.

Level 1 of the In-Sync model (perceptual-motor processes) starts with movement synchrony, the most basic form of interpersonal synchrony in psychotherapy. Movement synchrony may occur in any perceptual-motor system that can operate automatically, such as facial expressions (Feldman, 2007), eye gaze (Richardson D.C. et al., 2007), breathing patterns (Yang, 2007), or whole-body movements (Ramseyer and Tschacher, 2011). Movement synchrony presumably promotes inter-brain coupling between patient and therapist. The synchronization of motor movements is ideally suited for this purpose because the link between perception and motor action is highly automatic (Prinz, 1990; Dijksterhuis and Bargh, 2001; Wheatley et al., 2012). Motor movements thus provide a continuous stream of behavior that can be rapidly and effortlessly synchronized, even when patient and therapist's conscious attention is directed elsewhere (Oullier et al., 2008; Varlet et al., 2011).

At Level 2 of the In-Sync model, inter-brain coupling facilitates more complex social-cognitive processes that together constitute the alliance. The key distinction with Level 1 is that cognitive representations at Level 2 no longer have a direct connection with motor systems. Consequently, Level 2 cognition is capable of forming goals and intentions that are maintained over longer periods of time (Goschke and Kuhl, 1993). In addition, Level 2 cognition is capable of retrieving prior autobiographical experiences and connecting these with new experiences in a coherent self-memory system (Conway and Pleydell-Pearce, 2000; Kuhl et al., 2015). Traditionally, the higher cognitions of Level 2 are conceived as separate from the more elementary perceptual-motor processes of Level 1. However, research has shown that complex forms of information processing build upon and extend basic perceptual-motor processes (Barsalou, 2008; Williams et al., 2009; IJzerman and Koole, 2011). In a similar vein, the In-Sync model assumes that the complex cognitions that form the alliance are grounded in elementary perceptual-motor processes.

For analytic purposes, the In-Sync model breaks the alliance down into three different –but closely interacting– component processes. The first component of the alliance is the development of shared mental representations of meanings, that is, a *common language*. The development of a common language occurs through mutual adaptation to another's linguistic behaviors, a

FIGURE 1 | The Interpersonal Synchrony (In-Sync) model of psychotherapy.
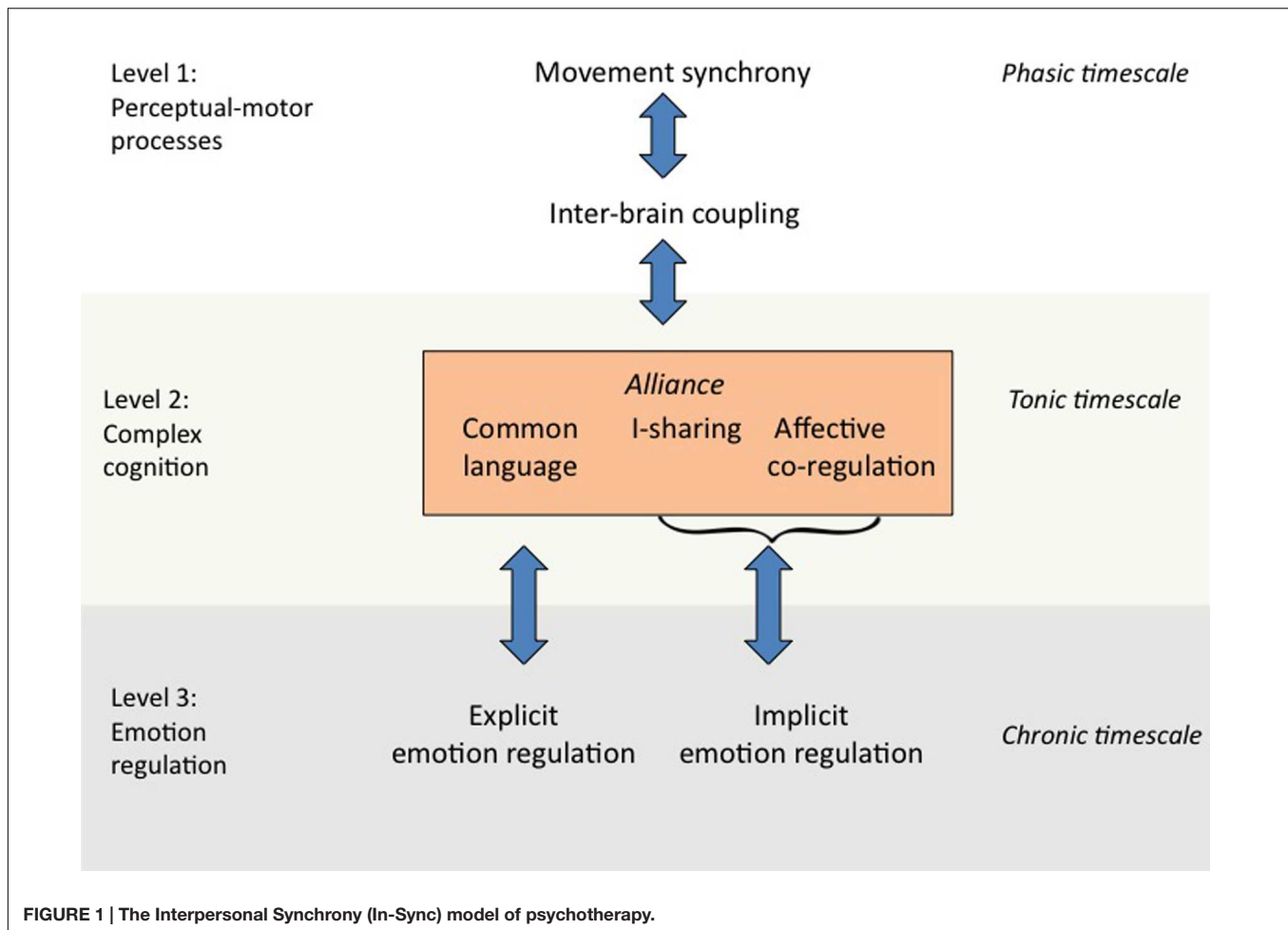
process that is also known as linguistic alignment. Research within cognitive linguistics has shown that more abstract forms of linguistic alignment build upon more basic perceptual-motor processes during face-to-face interaction –the elementary synchronization processes of Level 1 (Pickering and Garrod, 2004). Having a common language facilitates joint problem solving and coordination (Fusaroli et al., 2012). Common language is thus particularly relevant to the task- and goal-related aspects of the alliance (Bordin, 1979).

The second component of the alliance consists of patient and therapist's mutual sharing of subjective experiences. This process is also known as *I-sharing* (Pinel et al., 2015), after William James' classic term for the subjective self, the "I". Experiments have shown that I-sharing promotes social bonding and works as a powerful antidote to feelings of existential isolation (Pinel et al., 2004). I-sharing is therefore most relevant to the personal aspects of the alliance (Bordin, 1979). Synchrony is likely to promote I-sharing, by reinforcing the impression that patient and therapist are undergoing similar experiences (Paladino et al., 2010). Furthermore, to the extent that synchrony fosters the coupling of patient and therapist's brain states, synchrony may allow patient and therapist to share each other's experiences (Semin and Cacioppo, 2008).

The third and last component of the alliance is *affective co-regulation* (Butler and Randall, 2013), and consists of the joint regulation of affective responses and their physiological correlates. Co-regulation will often be achieved automatically, through the synchronization of patient and therapist's motor actions. For instance, when patient and therapist are talking with each other, their breathing patterns will often become synchronized (Warner, 1996; McFarland, 2001), which in turn may synchronize their heart rates and their associated levels of physiological arousal (Hirsch and Bishop, 1981). However, co-regulation entails more than automatic physiological matching. For instance, when a patient gets upset during psychotherapy, it will not be helpful if the therapist becomes similarly upset. Instead, it will be more beneficial if the therapist finds complementary ways of responding to the patient so that they both return to their homeostatic balance. The latter form of co-regulation requires more active regulation, especially on the part of the therapist. Presumably, effective therapists know how to keep the physiological variations during the therapy within healthy homeostatic limits (for a description of experiential-dynamic techniques for co-regulation, see Grecucci et al., 2015). Co-regulation thus appears to be a vital, though largely uncharted, aspect of the alliance.

At Level 3, the therapeutic effects of the alliance lead to improvements in the patient's self-regulatory capacities. These self-regulatory improvements are likely to apply particularly to the patient's ability to deal with her or his emotions. The alliance is intimately tied to emotional processes (Greenberg and Safran, 1989). Furthermore, over 75% of the categories of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013) are characterized by problems with emotion regulation. Emotion dysregulation thus underlies many of the most common forms of psychopathology, including anxiety and mood disorders (Barlow et al., 2004; Kring and Sloan, 2009; Gratz et al., 2015; Grecucci et al., 2015). The In-Sync model therefore assumes that the therapeutic effects of the alliance are achieved by improving the patient's capacity for emotion regulation. Notably, the In-Sync model does not rule out that the alliance may also have beneficial effects for the therapist. However, because of the model's clinical focus, our theoretical emphasis is on the patient's outcomes.

The In-Sync model further distinguishes between explicit and implicit emotion regulation. *Explicit emotion regulation* is based on self-insight and conscious emotion-regulatory strategies and techniques. Because explicit emotion regulation is mediated by language, it may benefit most from the common language (goal-related) component of the alliance. *Implicit emotion regulation*, by contrast, does not require conscious intentions (Gyurak et al., 2011; Koole and Rothermund, 2011; Koole et al., 2015). The In-Sync model assumes that skills at implicit emotion regulation derive from the combined effects of co-regulation and I-sharing. Through co-regulation, the patient's physiological arousal becomes stabilized around a healthy homeostatic balance. When co-regulation occurs together with I-sharing, the patient's self-involvement will be high, which allows the patient to internalize the calming effects of co-regulation. This internalization makes it possible for the patient to implicitly self-regulate similar affective states on subsequent occasions (Kuhl et al., 2015).

Empirical Assessment of Interpersonal Synchrony

The study of interpersonal synchrony, whether in psychotherapy or other settings, involves a unique set of challenges (see also Delaherche et al., 2012). The first major challenge is to specify in concrete terms what interpersonal synchrony is and what it is not, so that it can be distinguished from other phenomena. Interpersonal synchrony refers to the temporal coordination of behavior between interaction partners. When interaction partners become synchronized, they become adapted to each other's rhythms and cycles of activity, like people who are dancing together. This mutual adaptation may mean that interaction partners come to display similar behaviors. However, interpersonal synchrony does not always involve imitation or mimicry (Chartrand and Lakin, 2013). For instance, if one interaction partner nods her head in response to another's hand movements, this still qualifies as interpersonal synchrony. Interpersonal synchrony thus depends on the mutual timing of responses, regardless of the precise form of these responses.

The most commonly used statistical method for assessing interpersonal synchrony relies on determining the correlations between the activities of interaction partners. Researchers first record the activities of each of the interaction partners over time. Most studies of interpersonal synchrony to date have examined movement dynamics, which may be recorded by means of video images or dedicated motion-tracking devices (Delaherche et al., 2012). However, there is growing interest in interpersonal synchrony in physiological responses (Butler and Randall, 2013), and neurological responses (Hari et al., 2015). After the responses have been recorded, their relevant features are extracted and subjected to statistical analysis. Typically, the time series of the interaction partners are analyzed by computing a time-lagged cross-correlation within brief time windows.

The duration of these time windows is a critical factor and may be determined theoretically or through empirical means. Adopting an empirical approach to this matter, one study analyzed videos of 51 same-sex dyads from Stanford University who were engaged in several conversation tasks (e.g., planning a meal together, finding out what they had in common) (Tschacher et al., 2013). The results showed that the dyads' body movements were significantly associated within time windows of about 6 s. Beyond this time window, the associations between the dyads' movements were at chance levels. The time window of non-verbal synchrony may represent the 'social present', that is, the time duration that interaction partners subjectively experience their togetherness in the here and now. The social present may be akin to the individual present, the time window that people subjectively experience as 'now' (Pöppel, 2009).

To determine the time window of interpersonal synchrony, the aforementioned study had to separate genuine synchrony from randomly coinciding movements. This problem applies more generally to synchrony research. Let us say that a patient and a therapist just moved their arm within a second of each other. This could mean that patient and therapist's movements are indeed synchronized. However, it could also be that patient and therapist independently decided to move their arm and, by a mere stroke of fortune, their individual movements occurred simultaneously. How can we separate synchrony from such chance events? A sophisticated solution to this problem is to construct 'pseudo-interactions', that is, artificial datasets of behavior of individuals who did not really interact with each other (Bernieri, 1988). This approach has recently been implemented in automated computer algorithms that can generate pseudo-interactions by randomly sampling from actual interpersonal interactions at very brief time intervals (Ramseyer and Tschacher, 2010). Such stringent statistical controls are necessary to conclude whether interpersonal synchrony has occurred or not.

A final set of challenges derives from the need to record and process activities that become synchronized during interpersonal interactions. Interpersonal synchrony involves a variety of non-verbal responses such as bodily movements, shifts in intonation, or changes in heart rate. Because these non-verbal responses are often subtle and may occur within seconds or mere fractions of seconds, registering them often requires specialized

equipment. Fortunately, technological developments have greatly improved the user-friendliness and affordability of the relevant measurement devices. Physiological variables such as heart rate and electrodermal responses can be assessed with ever lighter and smaller devices at increasingly affordable prices (Cacioppo et al., 2007). Likewise, neurological measures have become increasingly non-invasive and adaptable to the investigation of interpersonal dynamics (Hari et al., 2015). These and other technologies have helped to make the assessment of interpersonal synchrony at once more efficient, more accurate, and more comprehensive.

After the data have been recorded, researchers have to extract the relevant features from people's activities. For instance, in one classic study, judges coded the amount of movement synchrony between students and teachers in frame-by-frame video recordings (Bernieri, 1988). Such manual coding is time-consuming, and typically takes up more time than actual data collection. Again, technological innovation has gone a long way toward addressing this problem. The costs of coding may be considerably reduced if the process can be automated. For instance, researchers at the University of Bern, Switzerland, have developed Motion Energy Analysis (MEA), a software package for automated coding of whole body movements from video images. MEA has become a useful tool for investigating interpersonal synchrony in clinical and non-clinical contexts (e.g., Ramseyer and Tschacher, 2011; Paxton and Dale, 2013). An added advantage is that MEA eliminates the subjectivity of human observers, and thus provides more objective coding. In future years, comparable software will likely become available for the coding of non-verbal affect (e.g., Huis in 't Veld et al., 2014; Lewinski, 2015) and vocalizations (e.g., Lee et al., 2014), modalities that currently still rely on manual coding.

Research on Synchrony in Psychotherapy

Building on the aforementioned technological and methodological advances, recent research has begun to systematically address the role of synchrony in psychotherapy. In the following paragraphs, we review this emerging area. In so doing, we use the In-Sync model as a framework of organizing and interpreting the available findings. For each level of the model, we discuss the extent to which key predictions of the In-Sync model have been supported by empirical findings, have remained unexamined, or when findings appear inconsistent with the model. For each topic, we also note which kinds of research are still needed to fill the gaps in our scientific understanding of synchrony in psychotherapy.

Level 1: Movement Synchrony

The first major prediction of the In-Sync model is that patient and therapist should be inclined to synchronize their movements during psychotherapy. A relevant study that examined this issue selected 104 sessions from an archive of videotaped psychotherapies at the outpatient psychotherapy clinic of the University of Bern in Switzerland (Ramseyer and Tschacher, 2011). Patients suffered from a wide range of problems, including anxiety disorders, affective disorders, and other diagnoses except for psychotic disorders and substance dependency. The

sessions were analyzed using the automated movement algorithm MEA. The results showed that non-verbal synchrony between patient and therapist was significantly higher than would be expected by chance (i.e., a baseline of pseudo-interactions). Moreover, a reanalysis of a subset of the sample showed that the patient-therapist synchrony occurred both for movements of the head and of the rest of the body, (Ramseyer and Tschacher, 2014). Thus, synchrony in psychotherapy was not only driven by speech activity. Taken together, these findings provide convincing evidence for movement synchrony during psychotherapy.

The In-Sync model further predicts that movement synchrony should facilitate inter-brain coupling between patient and therapist. As far as we know, there have been no studies on this topic. Nevertheless, the link between movement synchrony and inter-brain coupling has been confirmed in motor tasks (Lindenberger et al., 2009). Moreover, inter-brain coupling is higher when conversations partners are facing each other than when they are sitting back-to-back (Jiang et al., 2012), presumably because face-to-face communication allows more movement synchrony. Though research in psychotherapy settings is needed, the available evidence is consistent with the notion that movement synchrony fosters inter-brain coupling.

Level 2: The Alliance

The second major prediction of the In-Sync model is that movement synchrony will improve the quality of the alliance. Consistent with this, several experiments that examined simulated psychotherapy sessions have shown that therapists are rated more favorably and as more empathic when they are instructed to make their movements more (rather than less) synchronized with the patient (Trout and Rosenfeld, 1980; Maurer and Tindall, 1983; Sharpley et al., 2001). In addition, the previously discussed clinical study by Ramseyer and Tschacher (2011) found that movement synchrony between patient and therapist, assessed at the start of the psychotherapy, was predictive of the quality of alliance, as rated by the patient at the end of each session. Thus, converging findings support the idea that movement synchrony fosters the alliance.

The aforementioned studies assessed the alliance via subjective reports. However, the In-Sync model also distinguishes objective components of the alliance. These objective components have so far received only little research attention. Nevertheless, we discuss some preliminary work on this topic. The first objective component of the alliance is the emergence of a common language between patient and therapist. One pioneering study of language use during psychotherapy examined 122 sessions by 122 therapists in the USA (Lord et al., 2015). Using written transcripts of the sessions, the study assessed linguistic style synchrony, that is, whether patient and therapist used the same function words (e.g., personal pronouns, prepositions) at each conversational turn. Linguistic style synchrony was significantly correlated with empathy of the therapist, as rated by trained observers in a standardized test. Though preliminary, these findings fit with the In-Sync model's proposed link between common language and the alliance.

The second objective component of the alliance is I-sharing, or the sharing of subjective experiences between patient and therapist. Given that I-sharing is based on shared subjective experiences, it may not be considered an objective component of the alliance. From the perspective of the In-Sync model, however, shared experiences are closely tied to the interpersonal synchrony. Thus, even though the phenomenological contents of a person's experience may be subjective, the degree to which the experience is shared can be determined through objective means. Interpersonal synchrony can be assessed with neuro-imaging methods, or inferred from synchrony in movements, language use, or physiological activations. These various forms of interpersonal synchrony are necessary, but not sufficient to conclude that I-sharing has taken place. I-sharing means that the person's self has become involved in the interpersonal interaction. This self-involvement may be verified by assessing the accessibility of self-related knowledge (Koole and Jostmann, 2004) or memory for self-related material (Baumann and Kuhl, 2003). At present, we are not aware of any research that has used this methodology to examine I-sharing in psychotherapy. The role of I-sharing in the alliance must therefore await future research (see also Pinel et al., 2015).

The third objective component of the alliance is affective co-regulation. To study co-regulation in psychotherapy, researchers need to assess the inter-relations between patient and therapist's affective responses while they are interacting (Ferrer and Helm, 2013). One study that meets these criteria examined patient-therapist concordance in skin conductance, assessed among 20 patient-therapist dyads in 15-s windows during a 45 min session of psychodynamic therapy (Marci et al., 2007). Skin conductance concordance was associated with higher patient ratings of therapist empathy, and more positive social-emotional interactions for both patients and therapists, as rated by independent observers. These findings suggest that skin conductance concordance may tap into co-regulation processes within the alliance.

Two other studies measured the relation between therapist empathy and patient-therapist synchrony in vocal pitch (Imel et al., 2014; Reich et al., 2014). Vocal pitch synchrony is relevant to affective co-regulation because vocal pitch is associated with emotional arousal (Scherer et al., 2003). One study found that vocal pitch synchrony was positively associated with therapist empathy (Imel et al., 2014). However, the other study found that vocal pitch synchrony was negatively associated with therapist empathy and therapeutic outcomes (Reich et al., 2014). The latter may mean that effective therapists sometimes dampen the patient's emotions to prevent emotional escalation. Such would be in line with the close relationships literature, where some forms of physiological linkage between partners (e.g., in cortisol levels) are negatively correlated with relationship satisfaction (Timmons et al., 2015). Though more research is needed, these preliminary findings suggest that patient and therapist coordinate their affective responding within psychotherapy. This is consistent with the affective co-regulation within the alliance that is presumed by the In-Sync model.

Level 3: Emotion Regulation

The third and last major prediction of the In-Sync model is that patient-therapist synchrony, through its beneficial effects on the alliance, should foster adaptive emotion regulation. The link between movement synchrony and emotion is well-established in parent–child interactions (Feldman, 2007), but has been less investigated in the adult literature. Nevertheless, there are indications that the synchrony-emotion link emerges among adults. One study (Tschacher et al., 2014b) examined the synchrony-emotion link during conversations, a setting that has some similarity with psychotherapy. Specifically, this study recorded movement synchrony and affective changes among 84 previously unacquainted dyads while they were conversing about various pre-selected topics (e.g., tuition fees at the university). The results showed that movement synchrony was associated with increases in positive affect and decreases in negative affect. Moreover, this association was only found after a conversation, consistent with the notion that movement synchrony caused the affective change, rather than the other way around.

Additional findings suggest that synchrony may also foster emotion regulation in clinical settings. In the aforementioned clinical study by Ramseyer and Tschacher (2011), movement synchrony between patient and therapist was a longitudinal predictor of symptom reduction at the end of psychotherapy. Because the majority of patients in this sample suffered from emotional disorders, this finding fits the idea that patient-therapist synchrony fosters emotion regulation. Nevertheless, the evidence is indirect, because psychological symptoms may also become reduced though non-emotion related processes (e.g., more regular sleeping hours, better nutrition). Future work on synchrony in psychotherapy should therefore include more direct measures of patients' emotion-regulatory skills. In addition, it would be important to assess both implicit and explicit measures of emotion regulation, and to investigate if these show the relations with the different components of the alliance that are proposed by the In-Sync model.

Taken together, research has supported several important aspects of the In-Sync model, particularly for movement synchrony between patient and therapist. At the same time, research on synchrony in psychotherapy is still in an early stage. More well-controlled studies are needed to study the role of synchrony in psychotherapy and to test various predictions of the In-Sync model. In particular, future research should address the effects of synchrony on inter-brain coupling within psychotherapy and on the three objective components of the alliance, common language, I-sharing, and affective co-regulation. Moreover, research should be aimed at the transitions between the different levels of the In-Sync model, to understand how the movement synchrony and inter-brain coupling may become translated into improvements in the alliance and how the alliance may facilitate emotion regulation.

Outlook

According to the Interpersonal Synchrony (In-Sync) model, movement synchrony supports the alliance –common language, I-sharing, and affective co-regulation between patient and therapist– and thereby facilitates adaptive emotion regulation in

the patient. Though research on synchrony in psychotherapy is challenging, recent innovations have enabled rigorous research in this domain. Initial findings are supportive of the In-Sync model, but more research is needed to fully assess the validity of the model.

CONCLUSION

In the present article, we have highlighted the role of synchrony in the therapeutic alliance. As the term is used here, synchrony refers to the temporal coordination of the activities of patient and therapist. After reviewing the alliance and synchrony literatures, we integrated both literatures in the Interpersonal Synchrony (In-Sync) model. According to the In-Sync model, synchrony facilitates the alliance, which in turn promotes the patient's emotion-regulatory skills. Consistent with this, research has shown that patient and therapist synchronize their movements during psychotherapy and that such movement synchrony is positively associated with the alliance and therapeutic outcomes. Moreover, there is suggestive evidence that synchrony plays a role in establishing a common language and affective co-regulation between patient and therapist. The In-Sync model is thus a promising framework for understanding the alliance and its role in psychotherapy.

The In-Sync model builds on and complements prior theory and research on the therapeutic alliance (Horvath and Luborsky, 1993; Elvins and Green, 2008; Wampold and Imel, 2015). In line with this work, the In-Sync model regards the alliance as a collaborative relation between patient and therapist that is important in shaping therapeutic outcomes. The In-Sync model adds a number of new elements, however, including the idea that movement synchrony and inter-brain coupling are foundational to the alliance; a specification of objective components of the alliance, common language, I-sharing, and affective co-regulation; and an emphasis on emotion regulation as a major outcome of alliance effects. Moreover, the In-Sync model introduces a highly multidisciplinary perspective to the alliance, by including insights from social-cognitive neuroscience, cognitive linguistics, psychophysiology, developmental science, relationship science, and emotion science.

More generally, the In-Sync model treats psychotherapy as the product of two interacting brains. This is a fundamentally new perspective because psychotherapy research to date has only considered the patient's brain as the locus of therapeutic effects (Etkin et al., 2005; Beauregard, 2014; Weingarten and Strauman, 2015). Although the single-brain approach has generated important insights, we believe that it falls short of explaining the dynamic interpersonal aspects of psychotherapy. Ignoring these dynamics denies the inherent interpersonal nature of the alliance, including those aspects of the alliance that are most likely to bring relief from psychological suffering. To fully understand how psychotherapy works, researchers should therefore adopt an inter-brain perspective, by unraveling the interactions between the patient's and the therapist's brains.

The In-Sync model further contributes to the interpersonal synchrony literature (Semin and Cacioppo, 2008; Wheatley et al.,

2012; Repp and Su, 2013). Because interpersonal synchrony has been studied in various disciplines, findings and paradigms have tended to remain somewhat isolated from each other. For instance, adult research on motor synchrony (Repp and Su, 2013) has so far made little contact with developmental research on synchrony in facial affect (Feldman, 2007), and both lines of research have just started to connect with research on inter-brain coupling (Konvalinka and Roepstorff, 2012) and research on affective co-regulation in close relationships (Butler and Randall, 2013). The In-Sync model helps to draw together these and other lines of research, by using them jointly to analyze the nature of the alliance. In this manner, the alliance may form a center of gravity for interpersonal synchrony researchers, where they can develop and test ideas about the interplay of various forms of synchrony. The resulting insights into the alliance may subsequently be used to understand other kinds of interpersonal exchanges.

The In-Sync model inevitably has limitations. A first limitation is that the In-Sync model assumes the alliance has therapeutic benefits. This assumption seems reasonable given the current state of the psychotherapy literature (Horvath et al., 2011; Wampold and Imel, 2015). Nevertheless, in cases where the alliance has no or only limited benefits, the In-Sync model is not or only partly applicable. A second limitation is the In-Sync model does not include patient expectancies that may give rise to placebo effects, which are part of some models of the alliance (e.g., Wampold and Imel, 2015). Expectancies derive from relatively stable individual beliefs, which are relatively independent from the moment-to-moment synchrony between patient and therapist. Synchrony may influence the patient's beliefs indirectly, by increasing receptiveness to the therapist's suggestions (Tanner and Chartrand, 2008; Kelley et al., 2009). However, direct benefits of positive expectancies –placebo effects– cannot be explained by the In-Sync model.

Finally, a third limitation is that the In-Sync model, like all models, is a simplified version of reality. In years to come, research is likely to uncover new factors that shape the effects of synchrony in psychotherapy. For instance, the In-Sync model does not differentiate between whether the therapist is leading or following the patient in their synchronous behavior. Nevertheless, there are preliminary indications that leading versus following in synchrony may have different therapeutic effects (Ramseyer and Tschacher, 2011). If these findings are empirically confirmed, the In-Sync model will have to be extended. In a related vein, models of self-organized systems predict that synchronous actions may fall into one of only two dynamically stable states: inphase or antiphase (Haken et al., 1985). This prediction has been amply confirmed for joint movement coordination (Richardson M.J. et al., 2007; Schmidt and Richardson, 2008). These two modes of behaving in synchrony (Beauregard, 2014) could have differential effects in psychotherapy, but this remains to be investigated in future research. The In-Sync model thus represents a work in progress, which is to be elaborated and revised on the basis of new empirical findings.

Despite these caveats, the In-Sync model has great potential for clinical applications. One possible application lies in improving clinical training programs. Therapists vary

substantially in clinical effectiveness, and at least some of these variations are due to their different abilities in forming a strong alliance (Del Re et al., 2012). Improving one's alliance-building abilities requires accurate feedback, but such feedback is difficult to provide using subjective ratings of the alliance, which are currently standard in the field. The In-Sync model could fill this gap, by fostering the development of objective, standardized measures (e.g., movement synchrony, common language) that can provide valid feedback for therapists regarding their ability to form an alliance with patients. In this manner, the In-Sync model could help therapists to build and strengthen their clinical expertise.

Another possible application of the In-Sync model is in the domain of online psychotherapy. Because the traditional format of face-to-face psychotherapy is time-consuming and expensive, clinicians are increasingly turning to online modes of delivery (Kazdin and Blase, 2011). Online psychotherapy can be effective, especially when it is guided by a trained professional (Andersson and Titov, 2014). However, field studies have shown dropout rates in the range of 75 to 95% (Fleming et al., 2016). One reason for this high dropout may be the reduced physical contact with the therapist during online psychotherapy. From the perspective of the In-Sync model, patient commitment to the therapy and therapeutic effectiveness, may be improved by adding non-verbal modalities to online interventions. For instance, patient and therapist could hold videoconferences. A related option would be to add non-verbal synchronizing modalities to a virtual psychotherapist. There already exist virtual agents with therapist-like functionalities that are capable of responding to people's non-verbal behavior (DeVault et al., 2014). The In-Sync model could provide a systematic theoretical framework for guiding these developments.

To many, the idea that patients could form a genuine therapeutic relationship with a virtual agent may sound far-fetched. Nevertheless, underneath this heretical idea lies a deeper theoretical insight. As we have seen throughout this article, people appear to be biologically prepared to respond to synchrony in positive, relational terms. This response was already apparent in Huygens's (1673/1986) description of this synchronized pendulum clocks as having "sympathy" for each other. Consequently, if a virtual therapist can be made to behave in synchrony with patients, patients are likely to respond positively, and may even become attached to it in ways that parallel what clinicians have traditionally called "the alliance". These notions must currently remain speculative. Nevertheless, we hope that they invite readers to consider the fundamental significance of synchrony in psychotherapy.

AUTHOR CONTRIBUTIONS

SK and WT together conceived of the article. SK wrote the first draft and WT made critical revisions. After receiving the reviews, SK drafted the revision and WT made critical revisions.

FUNDING

ACKNOWLEDGMENTS

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Tuned In Emotion Regulation Program Using Music Listening: Effectiveness for Adolescents in Educational Settings

Genevieve A. Dingle*, Joseph Hodges and Ashleigh Kunde

School of Psychology, The University of Queensland, Brisbane, QLD, Australia

This paper presents an effectiveness study of *Tuned In*, a novel emotion regulation intervention that uses participant selected music to evoke emotions in session and teaches participants emotional awareness and regulation skills. The group program content is informed by a two dimensional model of emotion (arousal, valence), along with music psychology theories about how music evokes emotional responses. The program has been evaluated in two samples of adolescents: 41 "at risk" adolescents (76% males; M_{age} = 14.8 years) attending an educational re-engagement program and 216 students (100% females; M_{age} = 13.6 years) attending a mainstream secondary school. Results showed significant pre- to post-program improvements in measures of emotion awareness, identification, and regulation (p < 0.01 to p = 0.06 in the smaller "at risk" sample and all p < 0.001 in the mainstream school sample). Participant ratings of engagement and likelihood of using the strategies learned in the program were high. *Tuned In* shows promise as a brief emotion regulation intervention for adolescents, and these findings extend an earlier study with young adults. *Tuned In* is a-theoretical in regard to psychotherapeutic approach and could be integrated with other program components as required.

Keywords: emotion regulation, emotion awareness, music, engagement, adolescents

INTRODUCTION

Effective emotion regulation relies on an individual's awareness of their own and others' emotions, the development of a lexicon to label a range of emotional states, and strategies to modulate emotions to suit the context. These abilities develop throughout childhood and adolescence, although the rate of acquisition varies across emotions and stimuli. There is some evidence that the development of emotional skills slows down during the onset of puberty – at a time when young people typically experience intense emotions and when their regulatory skills are not yet fully developed. The *Tuned In* program was designed to train young people in emotion awareness, labeling, and regulation, using music listening as an engaging and meaningful way of evoking emotions during sessions. An early trial of the program found it to enhance emotional clarity and regulation among young adults (Dingle and Fay, under review), and the current study extends on this work with an investigation of the effectiveness of *Tuned In* for enhancing emotion awareness and regulation of healthy and at-risk adolescents in educational contexts.

Most pre-school children (aged 3 to 5 years) are able to correctly identify primary emotions in facial expressions, body postures and a combination of cues (Nelson and Russell, 2011). Studies of older children and adolescents suggest that the development of facial emotion recognition may slow down in early puberty. For example, in one study participants were asked to decide if happy, sad, angry or neutral faces matched with one of four emotion words. Compared to 10 year old participants, reaction times were significantly slower for making a correct decision at 11 and 12 years of age (the approximate ages of puberty onset), then stabilized by 15 years of age (McGivern et al., 2002). Other studies have found that sensitivity to anger expressions remained relatively stable between upper childhood and puberty and then increased from middle to late puberty (Thomas et al., 2007; Lawrence et al., 2015).

Recognition of one's own emotions doesn't necessarily develop at the same rate as recognition of emotions in others. The development of a lexicon for affect labeling has long been considered a precursor for emotion regulation – particularly the regulation of negative emotions (Lieberman et al., 2007). The recognition of emotion words doubles in size every two years between 4 and 11 years old, but plateaus between 12 and 16 years old (Baron-Cohen et al., 2010). Adolescence and the onset of puberty is a time of great physical, social and emotional change, and the findings summarized here suggest that adolescents may find the processing and regulation of their own emotions particularly challenging.

Emotion regulation can be conceptualized as the ability to modify emotion in flexible and adaptive ways in response to social context (Campos et al., 2011). Those with better emotion regulation skills are more socially competent, have better quality friendships and show more prosocial behaviors than those with poor emotion regulation capacity (Eisenberg et al., 2007; Wranik et al., 2007). Adolescents commonly experience intense emotional states during puberty and the transition from childhood to adulthood (Casey and Caudle, 2013). At the same time, their full regulation capacity is still developing (Hannesdottir and Ollendick, 2007; Beauchaine, 2015). Emotion dysregulation is considered an important trans-diagnostic risk factor for mental disorders in adolescents (McLaughlin et al., 2011).

There are currently no interventions designed to specifically address emotion dysregulation in adolescents. Cognitive behavior therapy (CBT) is an evidence based treatment for a range of emotional disorders in children and adolescents (Weisz and Gray, 2008). However, strong emotions are rarely evoked during cognitive restructuring, and CBT has been criticized for lacking a focus on emotion dysregulation (Hannesdottir and Ollendick, 2007). Several other psychotherapy programs include emotion regulation components, such as: dialectical behavior therapy (DBT; Linehan, 1993), acceptance and commitment therapy (ACT; Hayes et al., 1999), emotion focused therapy (EFT; Greenberg and Bolger, 2001), and mindfulness based cognitive therapy (MBCT; Segal et al., 2002). These treatments seek to increase clients' awareness and attention to their internal emotional states, and to build their tolerance of these states. The research evidence in support of these therapies with adolescents

is still developing (Ritschel et al., 2015). Some of these treatments (e.g., DBT) are intensive and long term; designed to treat diagnosed personality disorders. It is unlikely that all adolescents with emotion regulation difficulties require this level of treatment or indeed can access a specialist DBT program. There is clearly room for a brief and engaging emotion regulation program for enhancing emotional skills in adolescents.

In the *Tuned In* program, music listening is used as the method for evoking and experiencing emotions in session for the purpose of emotion psycho-education and skills building. Personalized music listening has been consistently listed by 18–25 year old Australians as their number one emotion management strategy in the annual national survey of Australians Stress and Wellbeing (Australian Psychological Society, 2015). Adolescents and young adults are the biggest consumers of music, with one study reporting that young people listened with intention to an average of 18 h of music per week (Papinczak et al., 2015). Furthermore, music psychology research attests to the influence music listening has over emotional states captured in subjective ratings (Hunter et al., 2011), physiological responses like skin conductance and heart rate (Krumhansl, 2002; Sharman and Dingle, 2015), and imaging studies showing that the brain's emotion centers are activated while listening to either pleasant and unpleasant music (Salimpoor et al., 2011; Hodges and Wilkins, 2015). Experience sampling and mobile application research shows that music-based emotion regulation differs from non-music emotion regulation in several key ways, and is a strategy that allows listeners to reach specific emotional goals (Randall and Rickard, 2014; Hides et al., 2015). Due to individual variations in musical preference, research indicates that personally selected music is more effective at evoking emotional responses than music selected by experimenters (Chafin et al., 2004; Weth et al., 2015). Therefore, participants' own music selections are used in the *Tuned In* program.

The *Tuned In* program was designed to enhance participants' emotional awareness, identification of emotions, and emotion regulation skills. Participants are introduced to a two dimensional model of emotion consistent with Hevner's (1936) taxonomy of emotional adjectives in music, and most closely aligned with Russell's (1980) circumplex model of emotion, in which the full gamut of emotions can be located in relation to two dimensions: valence (from pleasant to unpleasant) and arousal (from high to low energy). Studies using music stimuli have reliably mapped emotional responses onto this two dimensional model (Schubert, 1999; Eerola and Vuoskoski, 2013). The model provides a visual psycho-educational tool assisting participants to become proficient in identifying their current and desired state. Each *Tuned In* session is based on a different emotion, taking participants to a different co-ordinate on Russell's model. **Table 1** shows the content of the 8 session version of the program.

Prior to each session, participants are asked to select a song that makes them feel the focal emotion for the next session and bring it along on their portable music device. An emotional "Tune In" procedure is conducted at the start of each session, in which participants are asked to indicate their current emotional state on the two dimensional model, and their desired emotional state (either the same or different), and what type of music

TABLE 1 | The Eight Session Version of *Tuned In* Used with the At-Risk Adolescent Sample.

Session	Content	Activities	Homework
(1) Welcome to *Tuned In*	Building group alliance, establishing group guidelines, brief program overview, Introduction to Russell's Circumplex model of emotion.	Completion of pre-program surveys Place the emotion on the model.	Find a low energy, pleasant song to share for next week.
(2) Music to calm you down.	Positive valence, low arousal music. Review of Russell's Circumplex model of emotion. Discussion of music characteristics (tempo, voice, instruments) and when to use calming music.	Imagery task Body scan Lyric analysis	Find a high energy, pleasant song to share next week.
(3) Music to power you up.	Positive valence, high arousal music. Discussion of musical characteristics and when energizing music may be helpful.	Imagery task Body scan Lyric analysis	Find a medium-to-high energy, pleasant song to share next week.
(4) Music to make you happier.	Positive valence, medium to high arousal. Discussion on extending/intensifying happy emotions through music.	Imagery task Body scan Lyric analysis	Find a low energy, unpleasant song to share next week.
(5) Music to be sad to.	Negative valence, Low arousal. Listening to music to explore feelings of sadness. Discussion on knowing when enough is enough and strategies to use when feeling sad.	Imagery task Body scan Lyric analysis	Find a high energy, unpleasant song to share next week.
(6) Music to shout to!	Negative valence, high arousal. Discussion on current strategies for coping with anger, shame, jealously and positives/negatives of these.	Imagery task Body scan Lyric analysis	Find a low to high energy, pleasant song to share next week.
(7) Music that inspires you.	Positive Valence, low to high arousal, discussion on what is inspiring and future directions.	Imagery task Body scan Lyric analysis	Continue to compile your emotion playlists!
(8) Keep on Groovin'.	Concluding comments and group discussion. Review of Russell's Circumplex model of emotion and strategies to change mood states through music listening.	Post program surveys	Review booklets as needed.

listening or other emotion regulation strategy would help them to reach their desired emotional state. For example, if a participant felt flat and unmotivated at the start of the session, they would locate this emotional state as low on the arousal dimension and on the negative side of the valence dimension. They might want to feel more energized, so they would indicate a spot higher in arousal and on the positive side for valence. The participant would be asked to nominate some music that would help them to achieve this energized state, and some other strategies they could use (such as exercise) if music listening was not suitable.

Several participants' songs are played in each session, and participants engage in three activities designed to focus their attention on the music in order to enhance their emotional responses. The first is an imagery task in which participants are instructed to draw any images that come to mind while they listen to the music. According to Holmes et al. (2008) and Holmes and Mathews (2010), imagery plays a role in many mental disorders, with cognitions in the form of mental images reported to have a greater impact on emotions than verbal representations alone. In the second task, participants are provided with an outline of a human body and instructed to illustrate where they experienced any physiological sensations in response to the music. This task is based on research suggesting that paying mindful attention to the physical sensations of emotions, without trying to change or alter them, can assist individual's to build awareness and tolerance of their emotional experiences (Chambers et al., 2010).

The third task is a lyric analysis with participants asked to listen to a piece of music while reading the lyrics in their manuals, circling or underlining any lyrics that are particularly emotionally moving for them. Participants are then invited to discuss what the lyrics meant to them, along with sharing any emotional responses they evoked. According to McFerran (2010, p. 89–92), analyzing the lyrics of a meaningful song can assist young people to explore difficult feelings and experiences. Furthermore, Juslin et al. (2008, 2010) purported that imagery and lyrics are two of the psychological mechanisms by which music is related to emotional responses (Juslin and Västfjäll, 2008; Juslin et al., 2010). Thus, the music listening and concurrent activities were designed to enhance participants' emotional experience during listening in order to increase their skills in recognition of their own emotions and their ability to label and tolerate these emotions.

A pilot study of a 6 h version of *Tuned In* was conducted amongst 50 dysphoric university students aged 18–25 years (67% female). Participants were randomly assigned to *Tuned In* or a wait-list control. *Tuned In* involved groups of around eight participants with two psychologist facilitators. Mixed repeated measures ANOVA results showed that *Tuned In* participants experienced greater improvement in emotional awareness and clarity and total emotion regulation scores than controls. Weekly ratings also indicated significant improvements in emotional awareness, ability to name emotions, and ability to regulate emotions. Ratings of engagement were high and the overall

attendance rate was 98% (Dingle and Fay, under review). As such, preliminary data supports the efficacy of this program amongst a non-clinical sample of university students.

The aim of this study was to investigate the effectiveness of *Tuned In* among two adolescent samples in real world educational contexts: a sample of adolescents who had disengaged from school due to learning and psychosocial problems and were enrolled in an experiential learning program run by the non-Government organization BoysTown; and a sample of students at a mainstream girls secondary school in a suburb of a metropolitan city in Australia. It was hypothesized that:

(1) Participants' ratings of emotional awareness, ability to name emotions, strategies for regulation and confidence in using their strategies would increase from pre to post intervention;

(2) Participants would show improvements from pre to post intervention on validated measures of emotion regulation; and

(3) Participants would find *Tuned In* to be an engaging program, as indicated by their ratings of interest and enjoyment in the program collected at the end of the program.

(4) That the program could be scaled up from the original small group size of around 8 participants to an en masse school group of over 100 students while remaining effective and engaging.

MATERIALS AND METHODS

Sample 1 – At-Risk Adolescents
Participants

Forty-one participants (76% males), aged between 14 and 17 years old ($M_{age} = 14.83$) were recruited from the BoysTown experiential learning program in a regional city in Australia. All consenting members of the program during the study period were recruited to the study. A majority of the sample was born in Australia (88%), with five participants identifying as Aboriginal and Torres Strait Islander and the remaining 12% hailing from New Zealand, the Philippines and Liberia. Participants in this sample experienced multiple barriers to learning and social inclusion resulting in their drop out or exclusion from formal secondary schooling. Furthermore, 18% were reportedly undergoing treatment for a psychological disorder at the time of this study. The sample mean on the K6 (see Measures) was 5.7 ($SD = 4.9$), which is in the normal range, with no participants falling over the cut off of 13 indicative of mental health problems. So although this was not a clinical sample of adolescents, they could be characterized as "at risk" of mental health problems. Less than a quarter of the sample (24.3%) had received a year or more of formal musical training.

Measures
Demographic Information

Participants were asked to report their age in years, sex, ethnicity, and country of origin, and their highest grade completed at school. Musical involvement was assessed with items about music listening engagement, music education and playing.

Emotion Variables

At pre- and post-program, participants were asked to rate the extent to which five purpose-written emotion statements were true of them over the past week, on a 7-point Likert type scale from 1 = *Never True*, to 7 = *Always True*. The statements were: *I was aware of what happened in my body when I felt strong emotions*; *I was able to name these feelings (e.g., I'm happy, sad, anxious, etc)*; *I felt confident that I could manage my strong emotions*, *I used music as a way of managing my emotions*, and *I have a range of healthy ways of managing my emotions*. The internal consistency of the emotion variables in sample 1 was $\alpha = 0.83$ at pre-program and $\alpha = 0.90$ at post-program.

Emotion Regulation Questionnaire

The ERQ (Gross and John, 2003) is a widely used 10-item emotion regulation scale measuring use of cognitive reappraisal (e.g., *When I want to feel more positive emotion (such as joy or amusement), I change what I'm thinking about*); and suppression (e.g., *I keep my emotions to myself*). Longitudinal research indicates that use of emotional suppression is related to negative social connectedness and wellbeing while cognitive reappraisal is associated with positive social connectedness and wellbeing among young people (English et al., 2012). Participants provided a rating for each item on a 7-point Likert type scale ranging from 1 = *Strongly disagree* to 7 = *Strongly agree*. The internal consistency for the two subscales in the current sample was $\alpha = 0.72$ and $\alpha = 0.61$ (for reappraisal and suppression, respectively). As the internal consistency for suppression was low in this sample, the results should be interpreted cautiously.

Kessler-6

The K6 is a widely used six-item screen for mental illness designed by Furukawa et al. (2003). The K6 asks respondents to rate how often in the past 30 days they have experienced three symptoms of depression and three symptoms of anxiety. Participants rated their experience of each on a 5-point Likert type scale from 0 = *None of the time* to 4 = *All of the time*, which are summed to a total score in the range of 0 to 24. A cut off score 13 and above is interpreted as indicating a clinical level of distress. The internal consistency of the K6 in sample 1 was $\alpha = 0.87$.

Program Evaluation

Upon completion of the program, three additional items were included to assess responses to the program overall: how helpful participants found the program in helping them to regulate mood; how enjoyable and interesting they found *Tuned In*; and the likelihood they will continue to use music to regulate their emotion. These were rated on a 7 point Likert type scale from 1 = *Never True* to 7 = *Always True*.

Procedure

Participants took part in the *Tuned In* program as a component of their 2-days a week BoysTown experiential learning program. Participants from five different cohorts were recruited across three terms, with data collection spanning an 8-month period in 2014. Participants completed the online surveys prior to the *Tuned In* program and immediately following the completion

of the program. Participants in the BoysTown program did not receive any other psychological intervention during this time, with the curriculum focused solely on literacy, numeracy and life skills. There was a 29% attrition rate during the 10 weeks term, with 29 participants completing the post-program survey (and some measures not being completed accurately). Attrition was due to a range of factors including that the young person started a vocational training program, had to appear in court, or experienced an increase in family difficulties that was associated with their disengagement with the learning program. The *Tuned In* program was facilitated by provisional psychologists enrolled in postgraduate clinical psychology internships at the University of Queensland under the supervision of the first author. Participants received $20 in vouchers for each completed survey as compensation for their time.

Sample 2 – Mainstream Adolescents
Participants
Comprised of 216 female students aged 12 to 15 years (M_{age} = 13.6 years) attending an independent school. There were 117 year eight girls and 99 year nine girls. This was a convenience sample in which participants were given a brief survey to complete before and after an en-masse half day *Tuned In* workshop, so only a small selection of variables was assessed. No information was collected on psychological problems or musical training.

Emotion Variables
The same emotion variables as collected from Sample 1 were collected at pre- and post-program, with some additional confidence items: *I am confident that I can regulate my anger, I am confident that I can regulate my sadness, I am confident that I can regulate my anxiety*, and *I am confident that I can be happy without negative consequences*. The internal consistency of these emotion variables in sample 2 was α = 0.75 at pre-program and α = 0.89 at post-program.

Program Evaluation
Participants were asked to rate three statements at the end of the program on a 7 point Likert type scale from 1 = *Never True* to 7 = *Always True*: *I enjoyed the Tuned In program*; *I would recommend this program to other students in my year at school*, and *I am likely to continue to use the music emotion regulation strategies learnt in the program*.

Procedure
The mainstream school study was conducted in two half-day workshops, with all of the year nine girls and then all of the year eight girls together in the school auditorium. The students' usual teachers were present although they were not directly involved in running the program. Facilitators were the three authors and two other provisionally registered psychologists. This en masse version of the program included key components of the program content such as the two dimensional model of emotion, identifying current and desired emotion on this model, and sharing participants' music while completing body scan, imagery and lyric analysis activities. On the request of

the School leaders, emotions related to three specific themes were emphasized: academic anxiety, relationship problems, and enhancing wellbeing. This was done through the use of age appropriate scenarios asking the students to imagine themselves in the scenario, and how it would make them feel. Data were collected by means of a short pre- and post-program survey completed on paper. Participants were given confectionary as a token of appreciation for their involvement in the study. Methods and procedures were approved by the University Human Research Ethics Committee (approval #2009001748).

RESULTS

Sample 1 means on the emotion variables at pre- and post-program are shown in **Figure 1**. Repeated measures analysis of variance results showed a significant increase in participant's self-reported emotional awareness from pre to post, M_{pre} = 4.03, SD = 1.59; M_{post} = 4.83, SD = 1.26; $F(1,28)$ = 5.28, p = 0.029, η^2 = 0.16. There was also significant increase in their ability to name their emotions: M_{pre} = 4.25, SD = 1.35; M_{post} = 5.00, SD = 1.39; $F(1,27)$ = 6.32, p = 0.018, η^2 = 0.19. Furthermore, a significant increase in participants' confidence to manage their emotions was observed from pre to post, M_{pre} = 3.61, SD = 1.64; M_{post} = 4.75, SD = 1.11; $F(1,27)$ = 12.43, p = 0.002, η^2 = 0.32. The use of music to regulate emotions did not change significantly: M_{pre} = 4.84, SD = 1.90, and M_{post} = 4.90, SD = 1.60. Finally, self-reported range of healthy strategies to regulate emotions improved from M_{pre} = 3.74, SD = 1.74 to M_{post} = 4.56, SD = 1.53, however, this change did not quite reach significance: $F(1,26)$ = 3.882, p = 0.06 (see **Figure 1**). According to scores on the Emotion Regulation Questionnaire, there was a significant decrease in the use of emotional suppression as a regulation strategy from pre- to post-program, M_{pre} = 4.53, SD = 1.02; M_{post} = 3.88, SD = 0.97; $F(1,24)$ = 6.44, p = 0.018, η^2 = 0.21. No significant difference was found for the use of reappraisal, M_{pre} = 4.27, SD = 0.86; M_{post} = 3.77, SD = 1.1; $F(1,24)$ = 3.35, p = 0.08, see **Figure 2**.

Depression and anxiety symptoms on the K6 were in the normal range for the majority of participants and although the sample mean increased slightly from pre- to post-program this did not reach significance, M_{pre} = 5.64, SD = 4.92; M_{post} = 7.56, SD = 4.06; $F(1,24)$ = 4.16, p = 0.053. Participants rated *Tuned In* to be helpful in managing their emotions (M = 5.00, SD = 1.6), they found *Tuned In* interesting and enjoyable (M = 5.87, SD = 1.4) and reported that they were likely to continue to use music to manage their emotions (M = 5.45, SD = 1.76).

The mainstream secondary school sample means on the emotion variables at pre- and post-program are shown in **Figures 3** and **4**. Repeated measures analysis of variance results showed a significant increase in participants' emotional awareness from M_{pre} = 4.59, SD = 1.44 to M_{post} = 5.59, SD = 1.23; $F(1,213)$ = 103.13, p < 0.001, η^2 = 0.326. There was also a significant increase participants' affective labeling of their emotions, M_{pre} = 5.70, SD = 1.10; M_{post} = 6.11, SD = 1.02; $F(1,214)$ = 27.33, p < 0.001, η^2 = 0.113. The use of music to regulate emotions increased from M_{pre} = 4.97, SD = 1.83 to
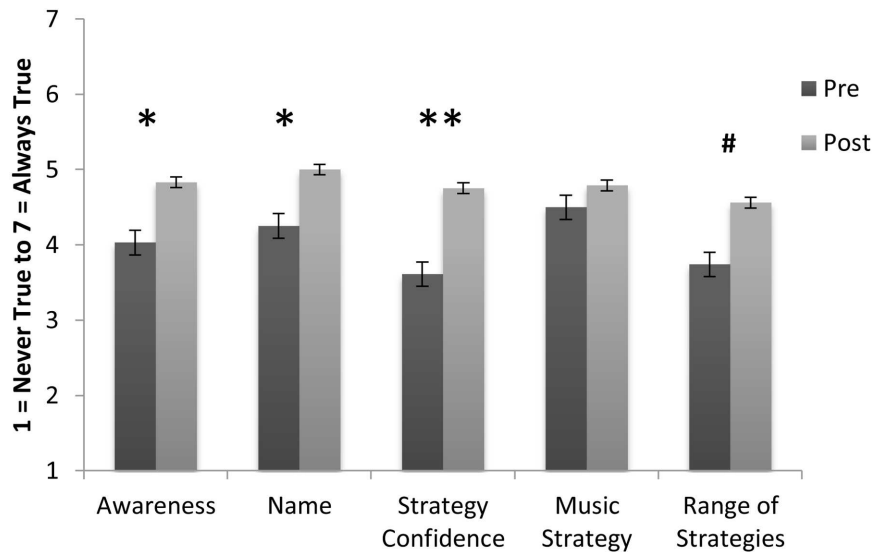
FIGURE 1 | Sample means from 41 at-risk adolescents on the emotion variables at pre- and post-program. (Bars are standard errors; significance *$p < 0.05$, **$p < 0.01$, #$0.10 > p > 0.05$).
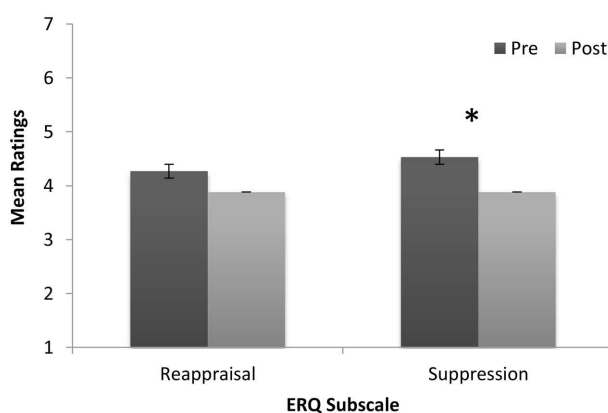

FIGURE 2 | Sample means for 41 at-risk adolescents on the emotion regulation questionnaire cognitive reappraisal and suppression subscales at pre- and post-program. (Bars are standard errors; significance *$p < 0.05$).

$M_{post} = 5.76$, $SD = 1.43$; $F(1,212) = 43.655$, $p < 0.001$, $\eta^2 = 0.171$. Furthermore, participants' range of healthy strategies to regulate emotions improved from $M_{pre} = 4.89$, $SD = 1.46$ to $M_{post} = 5.68$, $SD = 1.31$, $F(1,213) = 63.52$, $p < 0.001$, $\eta^2 = 0.230$. Confidence in regulating anger increased from $M_{pre} = 4.97$, $SD = 1.55$ to $M_{post} = 5.50$, $SD = 1.42$, $F(1,210) = 30.76$, $p < 0.001$, $\eta^2 = 0.128$. Confidence in regulating sadness improved from $M_{pre} = 4.73$, $SD = 1.52$ to $M_{post} = 5.39$, $SD = 1.46$, $F(1,215) = 55.187$, $p < 0.001$, $\eta^2 = 0.204$. Anxiety regulation confidence increased from $M_{pre} = 4.55$, $SD = 1.79$ to $M_{post} = 5.31$, $SD = 1.49$, $F(1,211) = 52.36$, $p < 0.001$, $\eta^2 = 0.199$. Finally, confidence that they could be happy without negative consequences was rated $M_{pre} = 5.37$, $SD = 1.52$, and $M_{post} = 5.78$, $SD = 1.21$,

$F(1,212) = 22.067$, $p < 0.001$, $\eta^2 = 0.094$. The program was rated an average of 5.85 ($SD = 1.26$) out of 7 for enjoyment, 5.61 ($SD = 1.42$) for recommended to other students, and 5.86 ($SD = 1.27$) for likelihood of continuing to use the emotion regulation strategies learned.

DISCUSSION

The aim of this study was to assess the effectiveness of the group program *Tuned In* to enhance emotion awareness and regulation skills of at-risk and mainstream adolescents in educational settings. The at-risk adolescents were offered an eight session version of the program in groups of around eight participants and showed significant improvements in self-reported emotional awareness, affective labeling of their own emotions, and confidence in using a range of emotion regulation strategies. Interestingly, the use of music as a strategy for regulating emotions did not increase from pre- to post-program, however, scores were highest at pre-program for this variable. This finding is consistent with previous research showing that adolescents are high consumers of music and use music listening naturally as a way of managing their emotions (Saarikallio and Erkkilä, 2007; Australian Psychological Society, 2015; Papinczak et al., 2015).

Further supporting these improvements in emotion variables, scores on the validated emotion regulation questionnaire showed that participants used the maladaptive strategy of emotional suppression significantly less at post-intervention. No significant change was observed in the use of adaptive, cognitive reappraisal. This pattern of results made sense given that the *Tuned In* program did not provide participants with cognitive-based strategies for emotion regulation, instead encouraging participants to explore emotional experiences using music. With
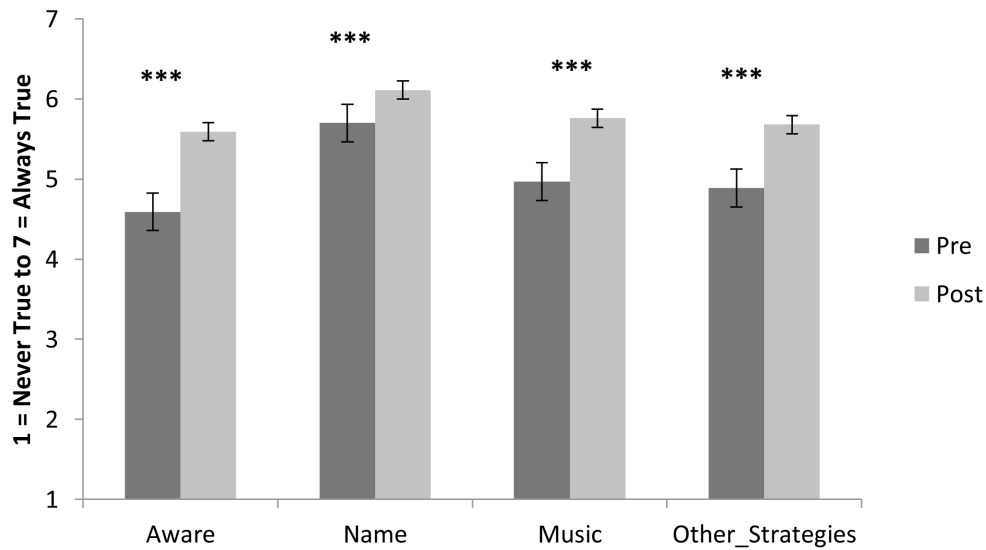
FIGURE 3 | Sample means for 216 mainstream adolescents on emotion variables at pre- and post-program. (Bars are standard errors; significance ***$p < 0.001$).
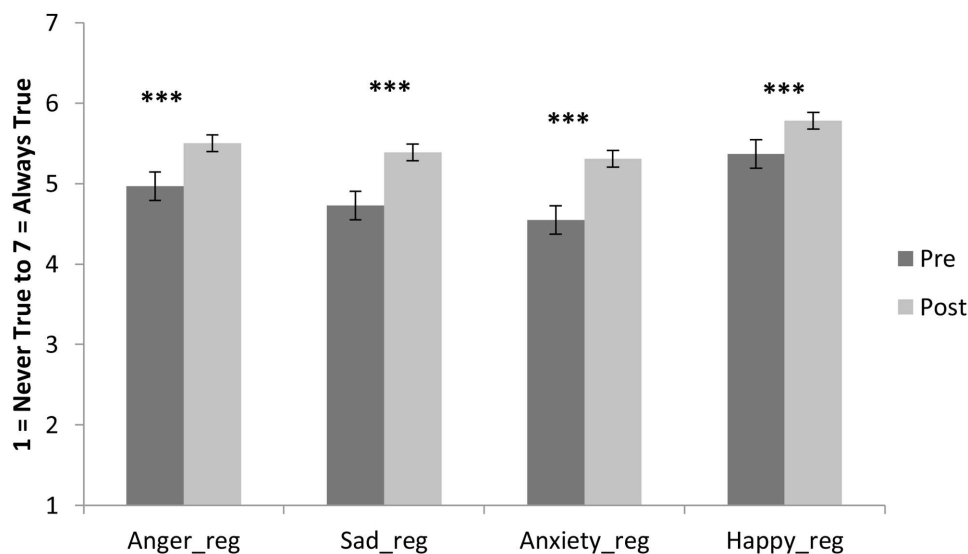

FIGURE 4 | Sample means for 216 mainstream adolescents on confidence in regulating primary emotions at pre- and post-program. (Bars are standard errors; significance ***$p < 0.001$).

participants encouraged to notice and then share the physical sensations and imagery that arose during the course of a song, they were being exposed to their emotions in a safe environment (Baker et al., 2007). It follows that scores on emotional suppression, a strategy aimed at preventing emotional expression, decreased at post-intervention as the expression of participant's emotional experiences had been normalized and validated through the *Tuned In* program. Research suggests that ongoing emotional suppression plays a central role in the development of social problems (English et al., 2012) and psychopathology (Aldao and Nolen-Hoeksema, 2012), with the

use of maladaptive strategies proposed to be more harmful than the absence of adaptive strategies. These results are encouraging as they lend support to the effectiveness of the program as a preventative intervention.

The improvement in measures of emotion awareness and regulation did not translate to symptom change on the K6, although there was limited room for improvement as the mean was in the normal range at pre-program. In fact, there was a slight increase in the K6 mean from pre- to post-program although this could be accounted for by the usual fluctuations over time within the non-clinical range on this measure. It

failed to reach statistical significance or move into the clinical range (of 13 or above using the suggested cut off score given in Kessler et al., 2003). Further research with adolescents who experience clinical levels of depression and anxiety is necessary to test whether the emotion regulation training translates to mood symptom improvement. Further research is also necessary to establish whether the emotional skills learned in the program generalized to the home or other environments and were sustained over time – questions which were unfortunately beyond the scope of the current study. Importantly, given that these adolescents were disengaged from mainstream school and many experienced social disadvantage and exclusion, they rated the *Tuned In* program as interesting and enjoyable, and that they were likely to continue to use the strategies taught in the program. This indication that a music based program was engaging to young people has been found in other research, for instance, in educational contexts (Cheong-Clinch, 2009) and in clinical contexts (Dingle et al., 2008). Taken together, this pattern of results for the emotion variables provides proof of concept that the *Tuned In* program enhances at-risk adolescents' emotional skills.

In the mainstream school sample, despite the limited opportunity for individual participants to share their music and to discuss their emotional experiences in this en masse format, results indicated that *Tuned In* was effective at improving adolescents' confidence in regulating a range of emotions, and enhanced their self-reported emotional awareness and regulation strategies. Although the emotion variable means were higher at pre-program in the mainstream sample (around 4.5 to 5.5 out of 7, see **Figures 3** and **4**) than in the at-risk sample (around 4, see **Figure 1**), a significant improvement was also seen across all emotion measures in the mainstream sample. Of all of the primary emotions assessed, students reported the lowest confidence in regulating their anxiety at pre-program, and this was one theme that the program particularly attended to. Further research is required to ascertain whether this increase in anxiety regulation confidence at post-program might translate to decreases in academic anxiety around assignment and exam time, and improvements in performance across academic, sporting, and music domains where anxiety can be a barrier to performance (Osborne, 2012; Ringeisen and Raufelder, 2015).

The program ratings indicated that participants in the mainstream school found it to be an interesting and engaging program that they would recommend to same age peers. Furthermore, they rated their likelihood to continue to use the strategies learned in the program as high, although because the workshops were conducted in the final week of the school year, we were unable to conduct a follow up assessment to confirm this. The effectiveness on emotion variables and the program ratings lend support for the fourth hypothesis that the program can be scaled up to large school groups, which makes it a cost effective intervention.

Overall, the findings of this study indicate support for the four hypotheses and provide a proof of concept that the *Tuned In* program enhances emotion awareness and regulation of adolescents in educational settings. However, there were a number of limitations to the study. Due to practical and resource limitations there were no control groups so our conclusions are based on within group changes only. The lack of follow up means we can't account for whether any gains were maintained over time. The Emotion Regulation Questionnaire subscale scores used in sample 1 had low to moderate internal consistency reliability values. Further analysis indicated that participants did not respond especially differently to any one item on the subscales (that is, item deletion did not significantly improve the Cronbach's alpha values). However, the participants may have found the scale difficult to understand due to the meta-cognitive nature of the items, e.g., "when I want to feel more positive emotion, I change what I am thinking about". It would therefore be recommended that future research with at-risk adolescents use a different measure of emotion regulation that is less reliant on meta-cognitive awareness. Alongside of the measure of emotion regulation, future research would need to include broader measures of social and academic functioning – potentially including teacher and parent reports to address the issue of demand characteristics on participants' self-reports.

Questions that remain to be investigated include: what are the moderators and mediators of the effectiveness of *Tuned In*? Other research shows that individual factors such as reward sensitivity, emotional sensitivity to music and absorption in music contribute to its effect on listeners (Sandstrom and Russo, 2011; Loxton et al., 2016). Several recent studies have found that a tendency to ruminate or brood influences whether people listen to music in ways that are helpful or unhelpful to their mood (McFerran and Saarikallio, 2013; Garrido and Schubert, 2015; McFerran, 2016). Music with lyrics may have a particularly powerful influence on the mood of adolescents who score more highly in ruminative thoughts than adults of older age groups (Sütterlin et al., 2012). In respect to sad music in particular, variations in the ways people conceptualize sadness and music lead to differences in the emotion regulation processes at play (Peltola and Eerola, 2016). It would be interesting to investigate the mechanisms through which music influenced participants' emotions in *Tuned In* beyond those specifically targeted in the program (appraisal of lyrics, imagery, and bodily sensations). Other mechanisms have been described in work by Juslin et al. (2008, 2010) such as emotional contagion and evaluative conditioning to the music.

CONCLUSION

The findings of this study show evidence that *Tuned In* helps build emotional awareness and regulation amongst at-risk and mainstream adolescents, and results are consistent with previous findings in a young adult sample (Dingle and Fay, under review). Adolescence is a time of growth, change, and emotional upheaval during which individuals' capacity for self-regulation of emotion is still developing. The *Tuned In* program is engaging and effective at enhancing participants' emotional skills in small and large groups.

AUTHOR CONTRIBUTIONS

GD developed the intervention program, designed the study, set up the collaboration with the stakeholders of Sample 1, and took overall responsibility for the manuscript. JH set up the collaboration with the stakeholders of Sample 2 and was involved in facilitating the program with both Samples, data collection, and input into the written manuscript. AK was involved with facilitating the program with both Samples, data collection and analysis of Sample 1 data, and input into the written manuscript.

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