THE INFLUENCE OF POSITIVE MEMORIES ON STRESS RESILIENCE: AN EXPERIMENTAL INVESTIGATION OF NEUROBIOLOGICAL AND COGNITIVE MECHANISMS

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The influence of positive memories on stress resilience: An experimental investigation of neurobiological and cognitive mechanisms

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CONTENTS

GENERAL INTRODUCTION

The past decades have witnessed a fast increase in the prevalence of mental illness. Studies show stunningly high prevalence rates, especially for mood disorders such as depression (e,g. Wittchen & Jacobi, 2005). Moreover, major depressive disorder is high up in the list of 25 diseases that globally cause the most Disability Adjusted Life Years (i.e. years lost and years lived with disability due to the condition) (Murray & Lopez, 2013). Depression is a mental disorder not only affecting our feelings, but also the way we perceive and think about ourselves and our environment. A major depressive episode is characterized by the experience of negative mood and/or the loss of interest and pleasure in (almost) all activities most of the day and nearly every day, according to the Diagnostic and Statistical Manual of Mental Disorders (4th ed., text rev.; DSM–IV–TR; American Psychiatric Association, 2000). Additional symptoms can be categorized as somatic, affective, and cognitive, including changes in sleeping and eating patterns, psychomotor agitation or retardation, fatigue or loss of energy, self-criticism, feelings of worthlessness, excessive or inappropriate guilt, concentration problems, indecisiveness, and recurrent thoughts of death or suicidal ideation (DSM–IV–TR; American Psychiatric Association, 2000).

Epidemiological data suggests that a major depressive disorder is among the most common mental disorders (Wittchen et al., 2011) with population estimates indicating a life-time prevalence around 19% in the United States (Kessler et al., 2009) and similar rates in Europe (Wittchen et al., 2011). This makes depression not only a severe psychiatric illness with detrimental consequences for the individual, but also a mental disorder causing high societal costs (e.g. treatment costs, decreased work performance) (e.g. Kessler et al., 2006).

Although a wide variety of pharmacological and psychological interventions are available that are effective in the short term (e.g. Hollon & Ponniah, 2010), relapse rates show that up to 85% of people who recovered from a depression relapse over a period of 15 years (Mueller et al., 1999). Research has shown that the presence of residual symptoms predict faster relapse (Keller, 2003). Moreover, it has been shown

that there is an association between a history of previous depressive episodes and an increased risk of relapse or recurrence, with the risk of recurrence increasing with each successive episode (Keller, 2003) and successive depressive episodes are triggered by progressively milder stressors *(*Monroe & Harkness, 2005). This points out the great importance of prevention of recurrence in depression.

Given the personal consequences, societal costs, and the high relapse rates it is not surprising that a wealth of research has focused on studying risk factors associated with the development, maintenance, and recurrence of depression. However, research on factors related to adaptive responding to stress and the protection against more maladaptive, depressive responding is still limited. That is, only recently research started to shift its focus to also investigating resilience factors, even though understanding resilience seems essential in understanding recurrence of depression and its prevention. Therefore, we aimed at improving our understanding of resilience, starting from an emotion regulation perspective by studying the role of the recall of positive memories, influencing positive emotions, and how its cognitive and neurobiological effects may work as a mechanism underlying resilience. We start by giving a brief overview of research on biological and cognitive risk factors in depression, as our hypotheses on the mechanisms underlying the relationship between positive emotions and resilience are based on this literature.

Vulnerability For Depression

During the past decades, a wealth of research has studied both biological and cognitive risk factors associated with the development, maintenance, and recurrence of depression. An enhanced emotional reactivity in response to stress, or disrupted emotion regulation has been observed at the level of different biological systems. It has been shown that a genetic risk – biological diathesis - in interaction with stressful life events can lead to enhanced emotional reactivity to stress (Caspi et al., 2003; Caspi, Hariri, Holmes, Uher, & Moffitt, 2010). At the neurotransmitter level, a relation between depression and problems with serotonin transport and re-uptake has been observed (reviewed in, Southwick, Vythilingam, Charney, 2005). On the hormonal level, depression has been related to hyperactivity of the hypothalamic-pituitary-adrenal (HPA) axis reflected in an increased secretion of cortisol or actually hyper secretion of

corticotrophin-releasing hormone, and a disrupted down regulation (i.e. disrupted feedback inhibition) of HPA axis activity by glucocorticoids (for review, see Pariante & Miller, 2001). At the neural systems level, research has shown evidence for abnormalities in the emotion regulation circuitry (for review, see Davidson, Pizzagalli, Nitschke, & Putnam, 2002). Depression has been linked to hyperactivation of the amygdala, a subcortical region implied in directing attention to affectively salient stimuli. This enhanced amygdala activity is related to impaired regulatory (or cognitive) control by prefrontal regions such as the dorsolateral prefrontal cortex, the ventromedial prefrontal cortex, and the anterior cingulate cortex, reflected in reduced activity in these areas and reduced connectivity between frontal regions and the amygdala during emotion processing (Davidson et al., 2002).

The dysregulation in biological processes in depression does not stand on its own, but relates to cognitive risk factors in depression. Recent research aims at integrating biological and cognitive processes involved in depression, resulting in an integrative framework linking biological and cognitive vulnerability for depression through diminished attentional control (De Raedt & Koster, 2010). Previous studies have linked depression to difficulties in disengaging from negative, self-relevant material once its captures attention (for review, see De Raedt & Koster, 2010; Gotlib & Joormann, 2010). However, it is likely that cognitive biases in different aspects of information processing interact in the vulnerability and maintenance of a mental disorder (Hirsch, Clark, & Mathews, 2006), or depression specifically (Everaert, Koster, & Derakshan, 2012). Next to biases in attention, depression is also characterized by cognitive biases in memory and interpretation. Several studies have found evidence for an increased accessibility of negative material in explicit memory, overgeneral memory recall which is likely to reduce emotionality (for review, see Williams et al., 2007), and the tendency to negatively interpret ambiguous stimuli (Gotlib & Joormann, 2010).

This extensive elaboration on and impaired disengagement from negative, stressful material is likely to reflect problems with cognitive control (for emotional material) which also expresses itself in a ruminative thinking style. That is, repetitive, perseverative thinking on negative (self-related) information. Empirical evidence supports this by showing that depression is characterized by impaired (internal) cognitive control which has been related to rumination (De Lissnyder, Derakshan, De

Raedt, & Koster, 2011; De Lissnyder, Koster, Everaert, Schacht, Van den Abeele, & De Raedt, 2012), a cognitive symptom and vulnerability factor for depression (Nolen-Hoeksema, 2000). Moreover, both biological and cognitive factors related to these processes seem to remain present after remission (Joormann & Gotlib, 2007; Nolen-Hoeksema, 2000; Vanderhasselt et al., 2012). These biases in processing emotional information and impairments in cognitive control are likely to affect one's ability to regulate emotions, as it has been proposed that cognitive control and flexibility is important for emotion regulation (Ochsner & Gross, 2007). Emotion regulation entails a set of processes in order to redirect the spontaneous flow of emotions (Koole, 2009), so normal emotion regulation should allow adaptive coping with situations by down-regulating or up-regulating negative or positive emotions. A division can be made between strategies of emotion regulation, with antecedent-focused strategies modifying the likelihood of encountering distress and having an impact early (and continuously) in the process of emotion generation, and response-focused strategies modulating the emotional response to a stressor once the emotion has been elicited (Gross, 1998; 2002).

It is believed that emotion regulation is an essential component of mental health (Gross, 1998; Gross & Munoz, 1995), with problems in regulation being related to depression. Studies show a relation between depression and increased use of maladaptive cognitive emotion regulation strategies like self-blame, rumination, and catastropizing, while the use of more adaptive strategies like positive reappraisal is decreased, (Garnefski & Kraaij, 2006; 2007). Also depressive symptoms have shown to be related to a self-appraised ineffectiveness of coping potentials and this dysfunctional appraisal of one's coping potentials might mediate vulnerability to depression (Dixon, Heppner, Burnett, Anderson, & Wood, 1993). This dysfunctional emotion regulation also seems apparent in recovered depressed people (Ehring, Fischer, Schnülle, Bösterling, & Tuschen-Caffier, 2008; Ehring, Tuschen-Caffier, Schnülle, Fischer, & Gross, 2010; Joormann, Siemer, & Gotlib, 2007).

Although most research on dysfunctional emotion regulation in depression has focused on regulation of negative emotions, research has begun to investigate impaired regulation of positive emotions in depression, which is relevant as depression is not only characterized by negative mood but also by the loss of interest and pleasure.

Several studies have shown that cognitive biases and impaired cognitive control may also impact positive emotion regulation in depression (for review, see Carl, Soskin, Kerns, Barlow, 2013). Depression has been associated with dysregulated processes of positive emotion regulation in categories of antecedent-focused strategies such as situation selection/modification (e.g. decreased reward sensitivity), attentional deployment (e.g. biases away from positive stimuli, problems disengaging from negative stimuli), and cognitive change or positive reappraisal (e.g. negative interpretive biases, positive imagery deficits, fewer positive recollections) (Carl et al., 2013). But also processes of positive emotion regulation regarding response-focused strategies such as response modulation (e.g. cognitive dampening of positive emotions) seem dysregulated (Carl et al., 2013).

Provided that disrupted emotion regulation in depression seems related to abnormalities in the emotion regulation circuitry at the neurobiological level (Davidson et al., 2002) and biases in cognitive processing and impaired cognitive control at the cognitive level (e.g. Carl et al., 2013), it seems probable that resilience also depends on such neurobiological and cognitive mechanisms. Furthermore, there are reasons to believe that processing of positive information is crucial for psychological resilience.

Resilience

Psychological resilience can be defined as "the effective coping and adaptation although faced with loss, hardship, or adversity" (Tugade & Fredrickson, 2004, p. 320). This captures the idea that although exposure to stressors can lead to a wide range of negative outcomes such as decreased well-being or even psychopathology, some individuals are able to resist to the psychological stress associated with negative experiences. There is a history of research on psychosocial factors associated with resilience which has also pointed out the role of positive emotions. Studies have shown that resilient individuals are optimistic and marked by high positive emotionality (Block, & Kremen, 1996; Klohnen, 1996). Positive emotions can co-occur with negative emotions during periods of stress and seem to have an adaptive value in the context of stress (Folkman & Moskowitz, 2000). Optimism, positive emotionality, and openness to new experiences have also been associated with increased psychological well-being

when faced with distress related to medical illness such as chronic pain (Affleck & Tennen, 1996) and early stage breast cancer (Carver et al, 1993).

These findings indicate that positive emotions appear to play an important role in coping and adaptation when faced with distress. A more recent, influential theory on the relationship between positive emotions and resilience, the broaden-and-build theory (Fredrickson, 1998; 2001; 2004), proposes positive emotions not to be merely a by-product of resilience and well-being, but to play an active role in the ability of resilient people to cope with stress.

The broaden-and-build theory

A central theory on the relationship between positive emotions and resilience is the broaden-and-build theory (Fredrickson, 1998; 2001; 2004), which starts from the idea that positive emotions do not only serve as markers of resilience and well-being, but also contribute to the development of resilience and improved well-being over time. The theory describes that positive and negative emotions have distinct functions as well as cognitive and physiological effects. Negative emotions are associated with narrowed thought-action repertoires and specific action tendencies, which has an adaptive function when confronted with a threatening situation requiring direct action. Positive emotions on the other hand, are proposed to be related to a broadening of momentary thought-action repertoires, which has an adaptive function in other ways. The broadened thought-action repertoires are believed to contribute to building both psychological, physical, intellectual, and social resources. Moreover, these personal resources gained during momentary experiences of positive emotions are believed to be lasting and can be drawn upon in future (stressful) situations, so through the experience of positive emotions individuals can become more resilient. The broaden-and-build theory thus states that positive emotions *broaden* one's thought-action repertoire which serves an adaptive purpose by contributing to *building* personal resources.

Positive emotions and broadened cognition

The idea that positive emotions broaden one's thought-action repertoire does not stem from the broaden-and-build theory. Isen and colleagues already investigated the effects of positive emotions on broadened cognition in the eighties of the 20th

century. Several of their studies have shown that people experiencing positive emotions are more flexible in their cognitive categorization, process material in a more integrated manner (e.g. Isen & Daubman, 1984), and are more creative (Isen, Daubman, & Nowicki, 1987; for review, see Baas, De Dreu, & Nijstad, 2008). Furthermore, the experience of positive emotions has also been associated with more openness to new experiences and increased variety-seeking (Kahn & Isen, 1993), increased repertoires of desired actions (Fredrickson & Branigan, 2005), and a positive emotional context has been shown to influence decision-making and to reduce loss aversion (Cassotti et al., 2012).

Although these studies involve a wide range of conceptualizations of broadened thought-action repertoires, mostly targeting higher-level cognition, several studies have also investigated the effects of positive emotions on visual attention. Visual attentional breadth, or the attentional scope, has mostly been measured using global-local visual processing and attention selection tasks. Global-local processing tasks measure the extent to which individuals attend to global features (the whole) and local features (parts) of a composite stimulus (Kimchi & Palmer, 1982; Navon, 1977). To measure selective attention, the Eriksen flanker task has often been used (Eriksen & Eriksen, 1974). In this task, a central target stimulus that has to be identified, is flanked by non-target stimuli which consist either of response-compatible stimuli or response-incompatible stimuli. Rowe, Hirsh and Anderson (2007) examined effects on the scope of attentional selectivity by presenting the non-target stimuli at three different distances, allowing investigation of interference of non-target stimuli on the response to the central target at close to further distances.

Early studies using global-local processing tasks suggest that positive emotional states are associated with a global bias, consistent with a more broadened attentional scope (Derryberry & Tucker, 1994). Also more recent studies have found that positive affective states, as compared to negative or neutral states, are associated with a more broadened attentional scope, as reflected by relatively more classifications of geometric figures on the basis of their global (versus local) features (Fredrickson & Branigan, 2005; Gasper, 2002; Gasper & Clore, 2004). Studies using attention selection tasks have also found an influence of positive mood, compared to negative and neutral mood, on attentional broadening or reduced visual selective attention. This was indicated by an

increased interference of response-incompatible compared to response-compatible non-target stimuli, when non-target stimuli were presented further from the central target stimulus (Rowe et al., 2007). An event-related potentials study found similar behavior results, showing that whereas in neutral and negative mood states the interference of response-incompatible compared to response-compatible non-target stimuli decreases as spacing between the stimuli increases, this decrease was not found under positive mood (Moriya, & Nittono, 2011). Furthermore, event-related potential data suggest that this broadening of the focus of attention may already occur early on in attention, during the visual input stage (Moriya, & Nittono, 2011). Interestingly, an eye-tracking study revealed that induced positive mood was related to a broadening of visual attention but only when positive stimuli were presented as compared to neutral and negative stimuli (Wadlinger & Isaacowitz, 2006).

Although there is a great amount of evidence supporting the idea that positive and negative emotional states have distinct effects on attentional broadening/narrowing, some alternative accounts have been proposed. In their line of research, Gable and Harmon-Jones (e.g. 2008; 2010) have argued that not only affective valence should be taken into account but also motivational direction. They argue that most used positive mood manipulations induce positive affective states low in approach motivation, which could explain the relation with attentional broadening (Gable & Harmon-Jones 2008). However, positive affective states high in approach motivation, for example, pre-goal positive affective states directing behavior towards a desired object, should be more likely to result in attentional narrowing (Gable & Harmon-Jones, 2008). Indeed, they found that induced positive affective states high in approach motivation, using appetitive stimuli, narrowed the breadth of attention using a global-local processing task (Gable & Harmon-Jones, 2008).

Recently, a more flexible link between affect and attentional breadth has been proposed (Huntsinger, 2012; 2013; Huntsinger, Clore, & Bar-Anan, 2010), based on the idea that affect can have an informative function and influence judgment (Schwarz & Clore, 1983). Instead of having fixed effects on cognition, affect is proposed to provide information about the attentional orientation that is most dominant or accessible at that moment (Clore & Huntsinger, 2007; Clore & Huntsinger, 2009; Huntsinger, 2013). Whereas negative affect acts as a “stop signal” inhibiting the use of the currently

available or dominant mode of processing, positive affect is believed to act as a "go signal" (Huntsinger, 2012; 2013). Recent research provides evidence in support of this view, showing that positive mood was associated with either a global or local attentional focus, depending on which focus was made momentarily dominant via a priming procedure (Huntsinger, 2012; Huntsinger et al., 2010).

These alternative accounts reveal the complexity of the effects on broadened attention and highlight the need for further research on the broadening effects of positive emotions and under which conditions this occurs. However, despite possible conditional factors and the idea that mood is probably not the only variable influencing attentional breadth, there is a wide range of studies that observed fluctuations in attentional breadth depending on affective valence. To summarize, research on the effects of positive affective states on a broadening of one's thought-action repertoire seems to show that positive affect has an influence on higher-level cognition such as creativity and cognitive categorization of information, but also on earlier visual attention processes. These results suggest that in a positive mood state, individuals attend to a larger distribution of the visual field including more surrounding information. However, not only (positive and negative) affective states relate to fluctuations in visual attentional breadth, also trait-like positive emotionality and optimism are related to broader attention in general (Basso, Schefft, & Dember, 1996). In contrast, measures of depression and trait anxiety have been related to more narrowed attention (Basso et al., 1996). A recent model on the cognitive processes that influence the likelihood of ruminative thinking to occur, a feature of depression and related to vulnerability for depression, also suggest the attentional scope to play a role (Whitmer & Gotlib, 2013). The attentional scope model (Whitmer & Gotlib, 2013) describes that negative mood, by narrowing the attentional scope, will limit the momentary thought-action repertoire, increasing the likelihood that thoughts will repetitively focus on the same (negative, self-focused) topic, which in turn could increase negative mood leading to more attentional narrowing and more ruminative thinking (Whitmer & Gotlib, 2013).

Although attention could be considered as the start of information processing, it is likely to influence further information processing (e.g. memory and interpretation). More narrowed attention, as a result of (chronic) negative mood, allows more

elaborate and deep encoding of information at the center of attention; however, it will also make it more difficult to disengage from or forget this information. This is in line with studies associating depression with increased difficulties in disengaging attention from negative information, increased accessibility of (mood-congruent) negative material in memory (for reviews, see De Raedt & Koster, 2010; Gotlib & Joormann, 2010), and impaired cognitive control which seems related to ruminative thinking (De Lissnyder et al., 2011; De Lissnyder et al., 2012). So while threatening situations that require quick and decisive action (Fredrickson, 1998) might benefit from more narrowed thought-action repertoires as it will reduce distractibility from irrelevant information (Friedman & Förster, 2010), this may become dysfunctional when situational demands change. Positive emotions on the other hand, broaden the thought-action repertoire, decreasing the likelihood that thoughts will continue to focus on the same topic and allow more flexible processing of a wider range of information (Fredrickson, 1998; 2001; 2004; Whitmer & Gotlib, 2013). This more broadened and flexible cognitive processing style could (over time) counteract these cognitive impairments related to depression and protect against a depressive responding to stress.

Positive emotions and resilience

The effects of positive emotions on broadening attention and cognition are believed to facilitate coping with distress and in turn this improved coping should predict future experiences of positive emotions, thereby further building psychological resilience and increasing emotional well-being (Fredrickson, 2001). The broaden-and-build theory proposes that positive emotions could work as an antidote for the effects of negative emotions (Fredrickson, 1998; 2001). This *undoing hypothesis* (Fredrickson & Levenson, 1998) predicts positive emotions to undo the effects of negative emotions, not only on a cognitive level but also by undoing physiological preparation for specific action. More specifically, the broadening of one's thought-action repertoire may actually work as the mechanism in undoing the effects of negative emotions on one's mind and body by undoing the preparation for specific action (Fredrickson, 2004). Previous studies have showed that people who are exposed to positive video clips after a negative mood induction (Fredrickson & Levenson, 1998, study 1; Fredrickson, Mancuso, Branigan, & Tugade, 2000, study 1) or people who spontaneously smile

during viewing a sad-inducing video clip (Fredrickson & Levenson, 1998, study 2) show faster cardiovascular recovery afterwards. More recent studies have showed that especially among high-resilient people, the experience of positive emotions facilitated physiological stress recovery after a negative mood induction (Tugade & Fredrickson, 2004) and emotional stress recovery in response to naturally occuring stressors (Ong, Bergeman, Bisconti, & Wallace, 2006). Also positive emotional style, reflecting trait positive emotionality, has been shown to be related to more adaptive recovery from induced stress, as indicated by lower reported feelings of tension, a lower acute cortisol response to stress, and more complete blood pressure recovery (Bostock, Hamer, Wawrzyniak, Mitchell, & Steptoe, 2011).

The experience of positive emotions is not only proposed to undo the acute response to stress or to merely reflect resilience, but positive emotions are also believed to contribute to building psychological resilience over time and counteract the effects of chronic negative mood as observed in depression. The experience of positive emotions is believed to contribute to building lasting personal resources that can be called upon in future situations (Fredrickson, 1998; 2001). This idea that positive emotions build enduring personal resources and thereby increase well-being has been supported by research investigating the links between the daily experience of positive emotions, ego resiliency, and life satisfaction (Cohn, Fredrickson, Brown, Mikels, & Conway, 2009). The daily experience of positive emotions (averaged over a 1-month period) predicted the change in ego resiliency across a 1-month period. Moreover, the relation between positive emotions and a change in life satisfaction across the 1-month period was fully mediated by the change in ego resiliency, indicating that the increase in life satisfaction was not just caused by feeling better or happier, but because they developed more personal resources (Cohn et al., 2009).

Positive and negative emotions, through reciprocal links between cognitive, behavioral, and somatic processes, are thought to trigger different self-perpetuating cycles (Burns et al., 2008; Fredrickson & Joiner, 2002; Garland et al., 2010). Depression research describes the reciprocal relations between negative mood, narrowed and pessimistic thinking, a ruminative self-focus, and rigid defensive behavior which in turn trigger negative emotions, and these “downward spirals” over time exacerbate negative moods to even clinical levels. On the other hand, positive emotions trigger “upward

spirals" by broadening cognition and increasing social openness which in turn may result in an increase in positive emotions, engendering resilience over time. Support for these self-perpetuating upward spirals comes from prospective correlational studies showing that positive affect and broad-minded coping (i.e. generating multiple solutions for problems and taking a broader perspective on problems) are reciprocally related (Fredrickson & Joiner, 2002). Changes in positive affect over a 5-week period were partly mediated by broad-minded coping and similarly, changes in the use of broad-minded coping over a 5-week period were partly mediated by positive affect. Thus, positive emotions and broad-minded coping reciprocally influenced each other, creating an upward spiral and thereby increasing emotional well-being (Fredrickson & Joiner, 2002). Building upon this study, Burns et al. (2008) conducted a study in which changes in positive affect over a 2-month period were partly mediated by positive, broad-minded coping and interpersonal trust, while changes in the use of positive, broad-minded coping and interpersonal trust over a 2-month period were also partly mediated by positive affect. In a recent study by Kok and Fredrickson (2010) they investigated the reciprocal relations between positive emotions, social connectedness, and vagal tone, used as an index of autonomic flexibility and adaptability representing physical health. Vagal tone reflects the functioning of the vagus nerve, which is a key component of the parasympathetic nervous system. The vagus nerve can actively inhibit the influence of the sympathetic nervous system on the heart and dampen HPA axis activity (Porges, 2007). High vagal tone is considered as a marker of physiological and psychological flexibility (Friedman & Thayer, 1998). In this study, vagal tone was measured via respiratory sinus arrhythmia, which can be defined as the change in heart period corresponding with inspiration and expiration (Thayer, Ahs, Fredrickson, Sollers III, & Wager, 2012). Vagal tone at baseline actually predicted a faster increase in positive emotions and feelings of social connectedness over a period of nine weeks. In turn, the increase in positive emotions and social connectedness predicted vagal tone at the end of the 9-week period, independent of baseline vagal tone. This is in line with the idea of reciprocal relations in an upward spiral, where autonomic flexibility is related to increased positive emotions and social connectedness which in turn resulted in greater autonomic flexibility (Kok & Fredrickson, 2010). Similarly, another study by Kok et al. (2013) showed that individuals with a higher baseline vagal tone reported a

significantly greater increase in positive emotions in response to a 6-week loving-kindness meditation intervention, in turn predicting a greater increase in feelings of social connectedness, which then predicted a larger increase in vagal tone. In this study vagal tone was assessed using heart rate variability data which reflects the variability in interbeat interval time and provides an indication of modulations in parasympathetic outflow as the sympathetic influence on the heart is too slow to cause beat to beat changes (Thayer et al., 2012). This shows that feelings of social connectedness is one mechanism through which positive emotions and physical health (i.e. vagal tone) influence one another in a self-perpetuating upward cycle (Kok et al., 2013).

To summarize, based on decades of research a distinction has been made between negative emotions and positive emotions in the effect they have on cognitive processing. Negative emotions have been related to more narrowed (and rigid) thought-action repertoires, which is also reflected in depression being associated with a ruminative self-focus and difficulties with disengaging from negative information. Positive emotions, on the other hand, have been associated with a more broadened and flexible cognitive processing style. Positive emotions have been associated with, amongst others, increased creativity, social openness, and increased visual attentional breadth. There are reasons to believe that the processing of positive information is important for resilience and research on psychosocial factors related to resilience, has associated optimism and high positive emotionality with resilience and well-being. The broaden-and-build theory (Fredrickson 1998; 2001) brings together these lines of research by proposing the effect of positive emotions on broadening the thought-action repertoire (*broaden hypothesis*) to be a mechanism in the relation between positive emotions and resilience (*build hypothesis*). Positive emotions are believed not to merely reflect resilience and well-being but to contribute to the development of resilience over time; by broadening cognition, positive emotions contribute to building lasting personal resources that can be called upon in the future and thereby increase well-being. Thus, negative emotions are thought to trigger self-perpetuating downward spirals in which reciprocal relations between negative emotions and biases in cognition, ruminative self-focus, and rigid defensive behavior can exacerbate negative emotions even to clinical levels. On the contrary, positive emotions are thought to trigger upward spirals by

broadening cognition and increasing social openness which in turn result in an increase in positive emotions, engendering resilience over time and increasing well-being. Studies have showed that the experience of positive emotions can be beneficial when confronted with a negative or stressful situation and is a contributor to developing adaptive ways of responding to stress. Positive emotions have shown to build social resources (e.g. interpersonal trust and social connectedness) which in turn increase positive emotions and could thereby work as one way through which positive emotions in an upward spiral increase well-being. Experimental testing of the proposition that effects of positive emotions on more broadened and flexible cognitive processing could contribute to developing resilience and protect against a depressive responding to stress is, however, scarce. Therefore, we aimed to experimentally investigate how the cognitive and neurobiological effects of positive emotions, as evoked by positive memory recall, may work as a mechanism underlying resilience.

Research Objectives Of The Dissertation

Despite the high recurrence of depression, still little is known about the core psychological and neurobiological mechanisms of resilience to depression. However, in depression research, the study of psychological resilience to stress can be important to understand why some individuals are protected against the development of (new) depressive episodes. There is clearly a need for further systematic research on resilience and the beneficial effect of positive affect, in such a way to better account for the inherent variability across individuals in their ability to become resilient to stress over time. The broaden-and-build theory (Fredrickson 1998; 2001) provides an interesting theoretical framework for studying mechanisms of resilience. We therefore aimed to further investigate the core principles derived from this theory in the context of depression, to better understand mechanisms of resilience to stress which seems essential in understanding recurrence of depression and its prevention.

In this dissertation we investigate the mechanisms underlying the relation between positive emotions and resilience, starting from an emotion regulation perspective by studying the role of the recall of positive memories as a way to cultivate positive emotions. Activation of positive emotional memories has been shown to play a role in the self-generation of positive emotions when people face a stressful situation

(Phillippe, Lecours, & Beaulieu-Pelletier, 2009). Previous studies have shown that in healthy participants the recall of positive memories resulted in improved mood after a negative mood induction (Joormann & Siemer, 2004; Joormann et al., 2007). Furthermore, in a study on affect laden autobiographic memory in healthy people, the retrieval of happy memories was related to activation in the left hippocampal region, medial brain areas, and the dorsolateral prefrontal cortex, which are areas also involved in the circuitry of emotion regulation (Markowitsch, Vandekerckhove, Lanfermann, & Russ, 2003). However, research has also shown evidence for abnormalities in this emotion regulation circuitry in depression (Davidson et al., 2002) and it has been shown that dysphoric-, formerly depressed-, and depressed individuals show an impaired ability to use mood incongruent memories to overcome sad mood (Joormann & Siemer, 2004; Joormann et al., 2007). A possible explanation for this finding, is that recalling a positive event may negatively influence (sub-clinically) depressed individuals' mood through a contrast effect (Joormann et al., 2007). Literature on the relation between mental imagery and emotion may provide further explanation for this contrast effect. Research on imagining positive information suggests that using a verbal processing mode or imagery from an observer perspective (i.e. looking at oneself from outside) may lead to a reduction of positive affect but that a field perspective (i.e. looking through your own eyes) is crucial in producing positive emotion (Holmes, Coughtrey, & Connor, 2008). This may be explained by a verbal processing mode or taking an observer perspective promoting evaluative thinking and increasing the likelihood that the self is compared to a more ideal standard that may reduce positive mood (Holmes et al., 2008; Holmes, Lang, & Shah, 2009; Kuyken & Howell, 2006). Depression is related to verbal processing in the form of rumination which is associated with evaluative thinking about the self (e.g. Holmes et al., 2009). In this dissertation we therefore used a procedure involving the recall of positive autobiographical memories, but promoting individuals to take a field perspective and to imagine specific memories (based on Holmes et al., 2008; Watkins & Moberly, 2009) to avoid the recall of overgeneral memories, a bias often observed in depression (Williams et al. 2007).

In a *first research line* we experimentally investigated the effects of positive emotions on visuospatial attentional breadth. Given the role attentional broadening could play in the relation between positive emotions and resilience against depressive

responding to stress, we should consider that cognitive processes in depression are often affected depending on the processing of specific types of information (e.g. self-relevant, emotionally valenced). However, to date only a few studies have examined the effects of positive emotions on attentional breadth taking into account the value of the presented information. Therefore, we investigated whether the relation between positive mood and visuospatial attentional breadth was influenced by the self-relatedness of the presented stimuli (chapter 2), the emotional valence of presented stimuli (chapter 3), and whether the attended stimuli can influence attentional breadth in itself, depending on affective stimulus evaluation (chapter 4). In chapter 3 and 4 we further investigated whether individual differences in the presence of depressive symptoms and trait resilience respectively, qualified the effect of positive mood on attentional breadth. Finally, we also investigated how rumination, a maladaptive way of responding to stress, influenced attentional breadth for self-related information and how individual differences in trait rumination, trait resilience, or depressive symptoms might qualify this relation (chapter 5).

In a *second research line* we more directly tested the hypothesis based on the broaden-and-build theory, that the effects of positive emotions on cognitive processing could work as a mechanism in the relation between positive emotions and resilience. In a healthy sample we investigated the effects of positive mood on flexible attentional processing of emotional material and tested how these effects of positive mood on cognitive processing were underlying stress reactivity (chapter 6). We then extended our research to a formerly depressed sample as these individuals are especially at risk of developing new episodes of depression and it is therefore essential to investigate mechanisms of resilience in this vulnerable group of people. We examined the effect of positive mood on availability of positive information in mind and how the presence of residual depressive symptoms influenced this effect. Additionally we tested how this effect of positive mood on availability of positive information in mind was underlying stress reactivity (chapter 7).

In a final, *third research line*, we sought to investigate the neurobiological underpinnings of (positive) autobiographical memory recall, as this may shed further light on the mechanisms of this emotion regulation strategy to overcome stress and negative mood. Given that mental imagery has strong effects on emotion, we used field

perspective imagery of positive autobiographical memories to self-generate positive emotions. Behavioral research suggests that vantage perspective in mental imagery (i.e. field perspective vs. observer perspective) influences the intensity of the emotional response in reaction to mental imagery, which may therefore also have implications for using this emotion regulation strategy to overcome stress and negative mood. However, little is known about underlying neurobiological differences between adopting a field- or observer perspective, while this could provide further knowledge on factors that may influence the effectiveness of using positive memory recall in the context of cultivating positive emotions and emotion regulation. Therefore we investigated the underlying neurobiological differences between imagining autobiographical memories from a field perspective versus an observer perspective, using functional Magnetic Resonance Imaging (fMRI) (chapter 8).

Overview Of The Chapters

As our research is placed in the context of depression, we first tested in **chapter 1** whether the effectiveness to self-generate positive emotions through imagining specific, positive autobiographical memories would be influenced by the presence of sub-clinical depression (dysphoria). The aim was to investigate whether instructing people to use field perspective imagery of specific positive memories would result in a similar emotional response in healthy and dysphoric people. A second aim was to compare the effects of positive memory recall between dysphoric people who received instructions and practice in field perspective imagery and dysphoric people who did not receive these instructions or practice, allowing a more spontaneous or automatic way of processing the positive memory.

In **chapter 2**, we aimed to experimentally test the broadening hypothesis by investigating the effects of induced positive mood on visuospatial attentional breadth, taking into account the value of the presented information. Given the relation between self-focused attention and negative mood (for review, see Mor & Winquist, 2002), we tested the effect of induced positive mood on visuospatial attention for self-related information, using a performance-based measure to assess fluctuations in attentional broadening from self-related contrasted to not-self-related information. Experiment 1 served to control that the used self-related versus not-self-related stimuli in the

attentional breadth paradigm, did not evoke differential attention effects in general. In the main experiment 2, we manipulated mood and investigated whether effects of induced positive mood on attentional breadth interacted with the value of the presented stimuli, that is, self- versus not-self-related stimuli.

In **Chapter 3**, we further elaborated on the attentional broadening effects of induced positive mood, taking into account characteristics of the presented information. As attentional processes in mood disorders are often affected depending on the processing of emotional information, the aim of this study was to investigate the effects of a positive mood induction on visuospatial attentional breadth and test whether this interacted with the emotional valence of the information presented. Besides stimuli characteristics, we also tested the influence of individual differences on the broadening effects of positive emotions. Previous findings associating depressive symptoms with more narrowed attentional breadth (Basso et al., 1996) suggest that the presence of depressive symptoms might hamper the effects of positive emotions on attentional broadening. An additional aim of the study was therefore to explore how the presence of depressive symptoms, in an unselected sample, might qualify the relationship between positive mood and attentional breadth for emotional information.

Chapter 4 continued on previous research (Wadlinger & Isaacowitz, 2006) and findings of chapter 3, indicating that the broadening effects of positive emotions interact with the affective valence of the presented information and that this effect may further be qualified by individual differences. The stimulus in the target of attention may also influence visuospatial attentional breadth in itself, depending on affective evaluation. Therefore, we investigated the relation between affective evaluation and visuospatial attentional breadth for surprised faces. Surprised faces were used as stimuli as they are valence ambiguous, thus people vary in their affective evaluation of surprised faces as more negative or positive. The broaden-and-build theory (Fredrickson, 1998; 2001) was developed from a resilience perspective, proposing attentional broadening effects to underlie the relation between positive emotions and resilience, which suggests that especially high resilient people seem to benefit from positive emotions at the cognitive level. Additionally, we therefore investigated whether individual differences in trait resilience qualified the effect of stimulus evaluation on attentional breadth.

In **chapter 5**, we investigated how rumination, a maladaptive way of responding to stress, influenced attentional breadth for self-related contrasted to not-self-related information. The attentional scope model of rumination (Whitmer & Gotlib, 2013) postulates that more narrowed attention increases the likelihood of thoughts becoming repetitive on the same topic, which in turn could exacerbate negative mood and lead to more attentional narrowing. In a first study we experimentally tested this model by examining the effects of a rumination- versus problem-solving induction on attentional breadth for self-related information, and how individual differences in trait rumination, trait resilience, or depressive symptoms might qualify this effect. Based on predictions from the attentional scope model of rumination, we also investigated the relation between trait rumination and attentional breadth for self-related information in a second study.

In **chapter 6**, we expanded on the current literature investigating the mechanisms of the relation between positive emotions and resilience, by more directly testing whether effects of positive mood on cognitive processing are underlying the relation between positive mood and stress reactivity. We investigated the effects of positive memory recall on the flexible attentional processing of emotional material (affective flexibility). We then further investigated whether effects of induced positive mood on affective flexibility were underlying the relation between positive mood and (emotional and physical) stress reactivity.

Chapter 7, extended our investigation of whether effects of positive mood on cognitive processing are underlying the relation between positive mood and stress reactivity, to a formerly depressed sample. We first investigated the effects of positive memory recall on the availability of positive information in mind, resulting in a more positive processing bias, and tested whether the presence of residual depressive symptoms qualified this effect. We then investigated whether the effect of induced positive mood on the availability of positive information was underlying the relation between positive mood and (emotional and physical) stress reactivity.

In **chapter 8**, we investigated the neurobiological underpinnings of positive and neutral memory recall, using fMRI. We contrasted field perspective imagery and observer perspective imagery when imagining both positive and neutral autobiographical memories. This may provide further information about how positive

memory recall could contribute to resilience. Furthermore, underlying neurobiological differences between a field- and observer perspective could further elucidate whether differences in imagery perspective can be considered to have an influence on the effectiveness of positive memory recall as an emotion regulation strategy to cultivate positive emotions.

The **general discussion**, provides an overview of the most important results of this dissertation and theoretical as well as clinical implications will be discussed. In addition, limitations of our research and directions for future research are outlined.

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CHAPTER 1

The influence of dysphoria on the effectiveness of mood induction using mental imagery of positive autobiographical memories[1]

Abstract

Vantage perspective in mental imagery has shown to influence the emotional response, with an observer perspective reducing emotionality. This is important given that positive imagery is used in clinical settings and can be applied in the study of resilience. Indeed, (sub-clinical) depressed individuals tend to automatically adopt an observer perspective. We aimed to investigate whether instructing non-dysphoric and dysphoric people to use field perspective imagery of positive memories would result in a different emotional response. Additionally we compared dysphoric people receiving instructions on field perspective imagery with dysphoric people who did not, allowing a more automatic way of processing the positive memory. When receiving instructions and practice in field perspective imagery, no differences were found in adopting a field and observer perspective or the positive emotional response between dysphoric and non-dysphoric individuals. However, when dysphoric individuals did not receive specific instructions, they reported to adopt a field perspective to a similar extent, but an observer perspective to a higher extent. Moreover, there were indications that dysphoric individuals receiving instructions on field perspective imagery, as compared to those who did not, reported higher levels of positive affect. These findings indicated that instructions and practice on field perspective imagery could be important when using positive imagery in psychotherapy, and in the context of studying mechanisms of resilience.

[1] Based on Grol, M., Vanlessen, N., & De Raedt, R. (2014). The influence of dysphoria on the effectiveness of mood induction using mental imagery of positive autobiographical memories. Manuscript submitted for publication.

Introduction

Mental imagery has been used by researchers for a long time, but in recent years there has been a renewed growth of interest in the use and applications of this technique. Mental imagery, which does not only involve visual images but also other sensory modalities, can have an important influence on emotion (Holmes & Mathews, 2005; 2010). It is therefore not surprising that mental images are believed to be involved in both the development and maintenance of different forms of psychopathology, clearly in posttraumatic stress disorder (Ehlers & Clark, 2000), but also in other emotional disorders like depression (Holmes & Mathews, 2010). Although mental imagery has been used in psychotherapeutic interventions for a very long time, the last decades have witnessed an increase in the use of mental imagery (e.g. imagery rescripting) for clinical purposes (Holmes, Arntz, & Smucker, 2007).

Research investigating the effects of mental imagery has generally made a distinction between imagery from a field perspective and observer perspective. Field perspective is described as when "people re-experience the event through their own eyes, as if they were looking outward, perceiving the situation now much as they did before", while observer perspective is described as when people "take the perspective of an autonomous observer or spectator, so that they see themselves as actors in the remembered scene" (McIsaac & Eich, 2002, p. 146). Importantly, both perspectives can be experienced during the retrieval of a memory (Rice & Rubin, 2009). In previous research it has been observed that memories imagined from a field perspective include more statements concerning affective reactions, physical sensations, and psychological states, whereas memories imagined from an observer perspective include more information concerning how the person looked, physical actions, or spatial relations (McIsaac & Eich, 2002). Studies in healthy samples show that perspective, or vantage point, may not only influence the kind of information that is recalled, but that imagery from a field perspective, as compared to an observer perspective and/or verbal processing, is also related to a greater emotional response (Holmes, Coughtrey, & Connor, 2008; Holmes, Lang, & Shah, 2009; Holmes & Mathews, 2005; Holmes, Mathews, Dalgleish, & Machintosh, 2006). However, a recent study in a healthy sample showed a greater change in positive affect after imagery of positive descriptions

compared to verbal processing, but did not find a differential effect due to the adopted perspective (Nelis, Vanbrabant, Holmes, & Raes, 2012).

Interestingly, vantage point in mental imagery does not only seem to influence the intensity of the emotional response, but the different perspectives may even play a role in emotional disorders such as depression (Kuyken & Howell, 2006, Lemogne et al., 2009; Williams & Moulds, 2007). Some studies have shown that depression and dysphoria are related to a higher proportion of retrieving memories from an observer perspective (Kuyken & Howell, 2006; Nelis, Debeer, Holmes, & Raes, 2013), though this may be specific for positive memories (Lemogne et al., 2006; Nelis et al., 2013). Furthermore, dysphoria has been related to more difficulties vividly imagining positive future events and lower positive ratings of visual images generated in response to positively interpreted homographs (Holmes, Lang, Moulds, & Steele, 2008). Possible explanations for these findings are that a verbal processing mode or an observer perspective promote evaluative thinking and increase the likelihood that the self is compared to a more ideal standard which may promote unfavorable self-comparisons reducing the positive affective response (Holmes, Coughtrey et al., 2008; Kuyken & Howell, 2006).

Depression is characterized by verbal processing in the form of rumination which is associated with reduced imagery and has been related to evaluative thinking about the self (e.g. Holmes et al., 2009). Furthermore, a higher occurrence of observer memories in depression has been linked to greater negative self-evaluation, greater use of avoidance, and dissonance between the current self and ideal self (Kuyken & Howell, 2006; Kuyken & Moulds, 2009).

The finding that vantage perspective can influence the emotionality of mental images and can even play a role in depression is important if we want to study the possibilities for positive mental imagery in treatment but also in relapse prevention, as research suggests that positive emotions play an important role in (developing) psychological resilience (e.g. the broaden-and-build theory; Fredrickson, 1998; 2001). Mental imagery of positive memories can be used to investigate the effects of positive emotions and how this relates to psychological resilience. Former research suggests that depression and dysphoria are related to the increased use of an observer perspective which seems to reduce the emotionality of mental images (Holmes &

Mathews, 2010). It remains unclear however, what the effects of positive mental imagery of emotional memories are in a depressed or dysphoric sample, when people receive explicit instructions and practice in imagery from a field perspective.

The main aim of the current study is to investigate whether the effectiveness of a positive mood induction using mental imagery of positive autobiographical memories, specifically giving instructions and practice in the use of field perspective imagery, would be influenced by the presence of dysphoria. When dysphoric people receive explicit instructions and practice in field perspective imagery, do they still report to imagine their positive memory less from a field perspective and/or more from an observer perspective compared to non-dysphoric people? And is the positive emotional response to the imagined positive event lower compared to non-dysphoric people? Our second aim was to investigate (or replicate) the effects when dysphoric people recall a positive memory without receiving instructions or practice in the use of imagery, which would allow a more spontaneous or automatic way of processing the positive memory. Based on former research (e.g. Nelis et al., 2013) we expected dysphoric people who do not receive explicit instructions, compared to dysphoric people receiving instructions, to adopt a field perspective to a lesser extent and/or an observer perspective to a greater extent, which might influence the emotional response (e.g. Holmes, Coughtrey, et al., 2008).

Method

Participants

The data in this study was based on data from several studies using the mood induction procedure as described below. The data from these studies were collected in two phases. Thirty-four dysphoric participants who reported a score of 14 or higher on the BDI-II at time of testing were included in the first phase. From all participants who reported a score of less than 7 on the BDI-II we randomly selected 34 persons. Twenty-eight participants who had been invited based on BDI-II scores in a previous survey screening were tested in an extra control condition. Eighteen of these participants were included in the analyses, as ten participants did not report a score on the BDI-II ≥ 14 at time of testing and were therefore not considered to be dysphoric at time of testing. In total 86 cases were analyzed (78 females), who were aged between 17 and 30 years (*M*

= 19.84, *SD* = 2.48). All data was collected during studies approved by the local ethical committee of the Faculty of Psychology at Ghent University.

Materials

Questionnaire measures. We used the self-report Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996; Dutch translation: Van der Does, 2002) to measure presence and severity of depressive symptoms during the past two weeks.

Mood state was measured using the state version of the 20 item Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Participants rated the degree to which they felt different emotions "*at this moment*" on a 5-point Likert scale ranging from 1 "very slightly" to 5 "very much".

The tendency to use mental imagery in daily life was assessed using the Spontaneous Use of Imagery Scale (SUIS; Nelis, Holmes, Griffith, & Raes, 2014; Reisberg, Pearson, & Kosslyn, 2003). The questionnaire consists of 12 descriptions about using mental imagery in daily life. Participants were asked to rate the degree to which each description is appropriate for them on a 5-point scale ranging from 1 "never appropriate" to 5 "always completely appropriate", resulting in a total score ranging from 12 to 60.

As a manipulation check during the mood induction procedure, participants were asked to rate the extent to which they adopted a field perspective and an observer perspective. Participants were asked to make their rating on a 5-point Likert scale ranging from 1 "not at all" to 5 "extremely". Both types of vantage perspective were assessed as previous research has shown that both perspectives can be experienced during the retrieval of a memory (Rice & Rubin, 2009), even though instructions on using a field perspective are given in this study.

Mood induction procedure (MIP). An imagery procedure was used to manipulate mood in which participants were instructed to vividly imagine either a neutral- or happy-inducing autobiographical memory. Field perspective was first practiced using a mental imagery task of cutting a lemon (Holmes, Coughtrey, & Connor, 2008). Following this practice task, participants were instructed to recall a memory of an event that happened on a specific day, more than one week ago. Participants in the positive MIP condition were instructed to recall an event that made them feel very happy at the time and happy as they think back to it, while participants

in the neutral MIP condition were instructed to recall a memory that did not elicit strong negative or positive emotions when the event occurred. Participants were asked to close their eyes while imagining and describing what they remembered in detail. Participants were given instructions (based on Holmes et al., 2008; Watkins & Moberly, 2009) to promote taking a field perspective while imagining the situation (e.g. "see it through your own eyes, from your own perspective") and to promote concreteness (e.g. "focus on how the event happened and imagine in your mind as vividly and concretely as possible a 'movie' of how the event unfolded"). Participants imagined the event for 30 seconds after which they were asked to focus on what they could see, hear, and feel (e.g. "What can you see?", "What physical or bodily sensations do you feel?") (based on Watkins & Moberly, 2009). Furthermore, they were asked to rate the manipulation check on adopting a field perspective and observer perspective and participants were told that we are interested in the extent to which they experienced both of these perspectives during recall. Following these questions, participants continued imagining the event for another 30 seconds without speaking up aloud about what they remembered. At the end, participants were asked again to rate the manipulation checks on adopting a field and observer perspective. During the mood induction music was played to strengthen the induction. Across the experiments, different types of music had been used in the positive mood condition; either Mike Oldfield's "Music of the spheres" (track 2, 3, 5, and 6), or Chopin's "Waltzes Nos. 11 and 12", or Tchaikovsky's "Waltz of the flowers" and Mozart's "Eine kleine Nachtmusik". However, the different types of 'positive music' were balanced across dysphoric and non-dysphoric participants[2]. For the neutral MIP condition Chopin's "Waltzes Nos. 11 and 12" were always used, which have been used before in a neutral mood induction (Startup & Davey, 2001; Heene, De Raedt, Buysse, & Van Oost, 2007).

In an extra control condition we used a similar positive mood induction procedure in which participants were instructed to recall a happy mood-inducing

[2] In the positive MIP with dysphoric participants: 12 participants listened to Mike Oldfield, 4 participants listened to Chopin, and 2 participants listened to Tchaikovsky and Mozart. In the positive MIP with non-dysphoric participants: 11 participants listened to Mike Oldfield, 4 participants listened to Chopin, and 1 participant listened to Tchaikovsky and Mozart. Moreover, data from a control pilot study in an unselected sample (N = 15) showed that the different types of music (Tchaikovsky and Mozart versus Chopin) by itself did not cause mood changes or differentially influenced a subsequent attentional task, only in combination with the imagery mood induction procedure (mentioned in Vanlessen, Rossi, De Raedt, & Pourtois, 2013).

autobiographical memory of an event that happened on a specific day, more than one week ago. However, participants were not instructed to close their eyes, nor given instructions to promote taking a field perspective and to promote concreteness. Furthermore, the use of mental imagery was not practiced. Participants described the event for 30 seconds after which they were asked to rate the manipulation checks on adopting a field and observer perspective. After these checks, participants continued describing the event for another 30 seconds. At the end, participants were asked again to rate the manipulation checks. Similarly as during the mood induction using mental imagery, music was played during the induction procedure. The different types of music used in the control positive mood induction were matched with the different types of music used in the positive imagery condition with dysphoric participants.

Procedure

Participants in the mental imagery conditions were randomized to receive either the neutral or positive MIP. After informed consent, baseline mood levels were measured with the PANAS. Following this, participants completed the MIP and at the end mood was measured again with the PANAS. At the end of the experiment the BDI-II and SUIS were administered. In the extra control condition everyone received the positive MIP without instructions on the use of mental imagery. Participants filled out the BDI-II, SUIS, and baseline mood levels were measured with the PANAS. This was followed by the MIP and after the MIP, the PANAS was administered again.

Results

Group Characteristics

Thirty-four dysphoric and 34 non-dysphoric participants were randomized to receive the happy or neutral mood induction. Furthermore, 18 dysphoric participants were assigned to the extra control condition receiving a positive MIP without imagery instructions. Table 1 gives an overview of the means and standard deviations for the baseline variables. To test for baseline differences we performed a univariate ANOVA on the SUIS scale with the five groups as between-subjects factor, but this analyses showed no group differences, $F(4,76) = 0.36$, $p = .838$, $\eta_p^2 = .02$. To test for baseline differences in BDI-II scores between the five groups we performed a nonparametric

Table 1.

Group Characteristics

	Dysphoric students *M* (*SD*)			Non-dysphoric students *M* (*SD*)	
	Neutral MIP (n = 16)	Positive MIP (n = 18)	Positive control MIP (n = 18)	Neutral MIP (n = 18)	Positive MIP (n = 16)
Age	21.19 (3.94)	19.17 (2.31)	18.89 (1.75)	19.78 (1.77)	20.38 (1.54)
Gender	15 females	18 females	13 females	17 females	15 females
BDI-II	22.38 (6.59)	19.28 (5.63)	22.50 (6.81)	2.06 (2.01)	2.38 (2.31)
SUIS	43.87 (6.77)	44.20 (9.05)	42.06 (6.95)	42.71 (8.90)	41.31 (8.24)
PANAS positive baseline	27.63 (4.77)	28.67 (5.213)	26.00 (5.93)	35.78 (3.39)	33.87 (3.48)
Scale field perspective	4.16 (0.79)	4.14 (0.66)	3.97 (0.74)	4.44 (0.64)	4.20 (0.56)
Scale observer perspective	2.06 (0.95)	2.11 (1.06)	3.08 (1.06)	1.67 (0.77)	1.73 (0.56)

Kruskal-Wallis test as the assumption of normality was violated even after log transformation of the data. This analysis yielded a significant group effect, $H(4) = 62,43$, $p < .001$. To follow-up this significant group effect we performed nonparametric Mann-Whitney tests. Follow-up analyses revealed that non-dysphoric participants in the neutral MIP group reported significantly lower levels on the BDI-II compared to dysphoric participants in the neutral MIP group, $U = 0.00$, $p < .001$, $r = -.86$, lower levels compared to dysphoric participants in the positive MIP group, $U = 0.00$, $p < .001$, $r = -.86$, and lower levels compared to dysphoric participants in the positive control MIP group, $U = 0.00$, $p < .001$, $r = -.86$. Furthermore, we found that non-dysphoric participants in the positive MIP group reported significantly lower levels on the BDI-II compared to dysphoric participants in the neutral MIP group, $U = 0.00$, $p < .001$, $r = -.86$, lower levels compared to dysphoric participants in the positive MIP group, $U = 0.00$, $p < .001$, $r = -.86$, and lower levels compared to dysphoric participants in the positive control MIP group, $U = 0.00$, $p < .001$, $r = -.85$. All other Mann-Whitney tests were not significant, $p > .10$. This shows that, by design, non-dysphoric participants scored significantly lower on the BDI-II than dysphoric participants, regardless of the mood manipulation condition they were in.

Manipulation Check MIP

Participants rated on a 5-point Likert scale the extent to which they adopted a field perspective and observer perspective during the MIP (see also Table 1). As data from this manipulation check was not normally distributed, even after transformation of the data, we performed nonparametric Kruskal-Wallis tests to check for differences between the five groups. These analyses yielded no significant group effect for the field perspective ratings, $H(4) = 5,471$, $p = .242$; however, for the observer perspective ratings a significant group effect was found, $H(4) = 18.54$, $p = .001$. Follow-up analyses revealed that dysphoric participants in the positive control MIP group reported higher levels of adopting an observer perspective compared to all other groups, all ps $< .050$. This shows that there were no significant differences between groups in the self-reported adopting of a field perspective during the MIP. However, dysphoric participants in the positive control MIP group who received no instructions, reported significantly higher levels of adopting an observer perspective compared to all other groups who received instructions on the use of field perspective imagery. The groups

receiving instructions on field perspective imagery did not differ from each other in adopting an observer perspective. Across all participants, the BDI was significantly related to the ratings for an observer perspective, r = .34, p = .002, but not to the ratings for a field perspective, r = .10, p = .360, suggesting that across all participants an increase in severity of depressive symptoms was related to higher reported rates of adopting an observer perspective.

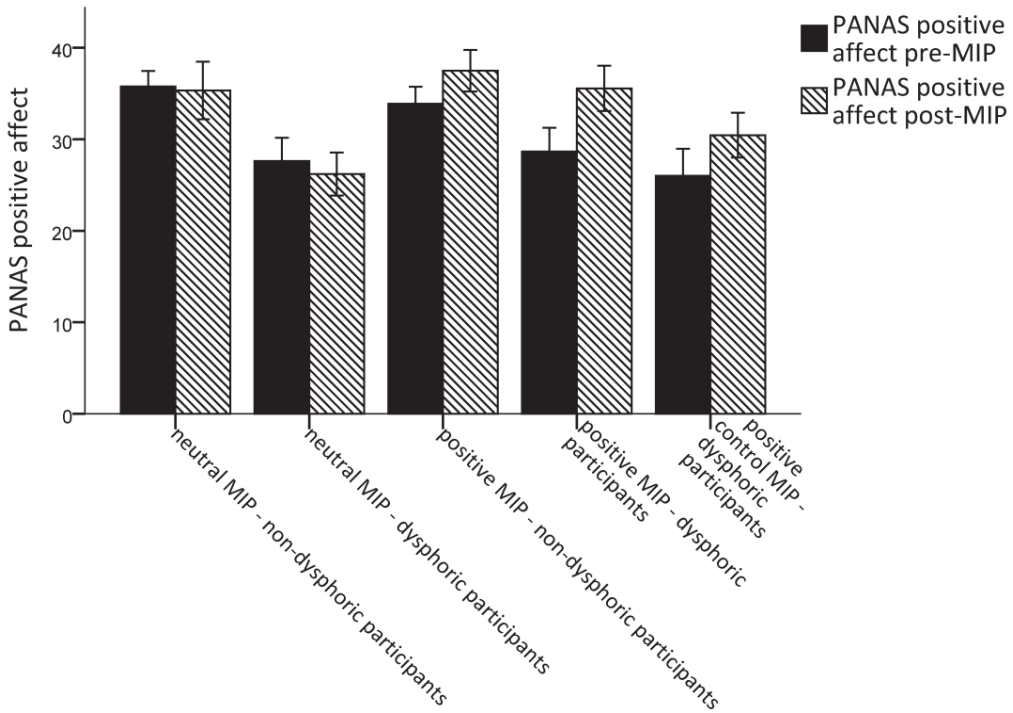

Figure 1. *Mean scores on the PANAS positive affect subscale before and after the mood induction, depicted per group.*

Effect of Mood Manipulation using Mental Imagery

The main aim of this study was to investigate the influence of dysphoria on the effectiveness of the positive mood induction using mental imagery when participants were stimulated and trained to adopt a field perspective. To assess the effect of the MIP on positive mood (see also Figure 1), we performed a mixed ANOVA with Time (before versus after the MIP) as within-subject factor and MIP group (neutral versus positive with imagery) and Dysphoria (dysphoric versus non-dysphoric) as between subject factors on the PANAS positive affect subscale. This revealed a significant main effect of Time, $F(1,64) = 13.48$, $p < .001$, $\eta_p^2 = .17$ and a Time x MIP group interaction, $F(1,64) = 27.81$, $p < .001$, $\eta_p^2 = .30$, indicating a difference between MIP conditions in

the change in positive mood but regardless of the presence of dysphoria. The Time x MIP group interaction for the positive affect subscale was driven by a significant increase in levels of positive affect in participants in the positive MIP group, $t(33) = 5.60$, $p < .001$, while participants from the neutral MIP group did not show such an increase, $t(33) = 1.28$, $p = .211$.

Positive MIP using Imagery instructions versus Positive MIP without Imagery instructions

A second aim within this study was to compare dysphoric participants who receive instructions and practice in the use of field perspective imagery, with dysphoric participants not receiving any instructions, allowing a more spontaneous or automatic way of processing the positive memory. We investigated whether dysphoric participants not receiving any instructions would adopt a field perspective to a significantly lesser extent and/or an observer perspective to a greater extent, and whether this would actually influence the effectiveness of the positive mood induction.

A mixed ANOVA was performed with Time (before versus after the MIP) as within-subjects factor and MIP group (positive with imagery versus positive control) as between-subjects factor on the PANAS positive affect subscale. This analysis yielded only a significant main effect of Time, $F(1,34) = 30.61$, $p < .001$, $\eta_p^2 = .47$. Results remained similar for the mixed ANOVA when controlling for (as a covariate) the group differences in ratings on adopting an observer perspective. Paired samples t-tests showed that the dysphoric participants who received the positive MIP with imagery reported a significant increase in positive affect from baseline ($M = 28.67$) to post-induction ($M = 35.56$), $t(17) = 4.13$, $p = .001$, as well as the dysphoric participants who received the positive control MIP without imagery instructions who also reported a significant increase in positive affect from baseline ($M = 26$) to post-induction ($M = 30.44$), $t(17) = 3.73$, $p = .002$, in line with the result from the mixed ANOVA. However, although the change in positive affect did not significantly differ between these two groups, the dysphoric participants who received the positive MIP with imagery did report higher levels of positive affect after the induction, $F(1,34) = 9.58$, $p = .004$, $\eta_p^2 = .22$, even though the groups did not significantly differ in positive affect at baseline, $F(1,34) = 2.05$, $p = .161$, $\eta_p^2 = .06$. The difference in positive affect between the two groups at post-induction also remained significant when taking into account (as a

covariate) variability in positive affect at baseline, $F(1,33) = 7.07$, $p = .012$, $\eta_p^2 = .18$. Again, these results remained similar when also controlling for the group differences in ratings on adopting an observer perspective (as a covariate). This discrepancy in results from the mixed ANOVA – indicating no group differences in the change in positive mood – and results from the ANCOVA – indicating that the group receiving instructions on field perspective imagery reported higher levels of positive affect after the MIP – may be explained by statistical issues. In randomized studies any pre-test group differences or variability is assumed to be due to sampling error. Using an ANCOVA (with the pretest measure as the covariate) minimizes the residual posttest variance, thereby minimizing the standard error of the group effect estimate, which increases power compared to an ANOVA on the change (i.e. the mixed ANOVA) (Van Breukelen, 2006). Therefore, the ANCOVA analysis may have had more power to detect group differences at post-MIP controlling for pre-MIP variability in positive affect, as compared to a mixed ANOVA on group differences in the change in positive affect from pre- to post-MIP.

Discussion

The main aim of this study was to investigate whether the effectiveness of a procedure inducing positive mood through mental imagery of positive autobiographical memories would be influenced by the presence of dysphoria. Specifically, we investigated whether under conditions in which explicit instructions and practice in field perspective imagery are given, dysphoric participants, compared to non-dysphoric participants, would report imagining the memory less from a field perspective and/or more from an observer perspective and whether this would influence the emotional response.

Compared to non-dysphoric individuals, dysphoric individuals have been shown to use an observer perspective for positive memories to a greater extent (Nelis et al., 2013), report less vivid imagery of positive future events, and give lower positive ratings of visual images generated in response to positively interpreted homographs (Holmes, Lang, Moulds, & Steele, 2008). The current results however, did not show a significant difference between dysphoric and non-dysphoric participants in adopting a field or observer perspective when imagining the autobiographical event when instructions and practice were given in adopting a field perspective. This finding suggests that dysphoric

individuals are not incapable to imagine (positive) memories from a field perspective to the same extent as healthy individuals, but this may be a less automatic way of processing as previous studies without explicit instructions about field perspective imagery showed a higher proportion of using an observer perspective with positive memories (Lemogne et al., 2006; Nelis et al., 2013).

Furthermore, we also studied whether the emotional response to the imagined positive event would be smaller in dysphoric individuals compared to non-dyshporic individuals. The results showed no difference in the change in positive affect between dysphoric and non-dysphoric individuals and after the mood induction dysphoric and non-dysphoric individuals who imagined a positive memory no longer differed in levels of positive affect despite of baseline differences. This could indicate that when dysphoric people imagine their positive autobiographical memories from a field and observer perspective to the same extent as non-dysphoric controls, there are also no differences in the emotional response following imagery of their specific positive memories.

A second aim in this study was to check whether not giving instructions to dysphoric individuals regarding using a field perspective when imagining positive autobiographical memories would indeed lead to different results compared to when dysphoric individuals are given these instructions. Previous research shows that depression is related to verbal processing in the form of rumination which is associated with reduced imagery (e.g. Holmes et al., 2009) and that dysphoria is related to less field and more observer perspective when recalling positive memories (Lemogne et al., 2006; Nelis et al., 2013) which may hamper the positive emotional response. Results of the current study showed that the dysphoric individuals who did not receive instructions and practice in field perspective imagery reported to adopt an observer perspective to a significantly higher extent than the dysphoric individuals who did receive these instructions, but there were no significant differences in the reported use of a field perspective. Although the group who did not receive instructions on mental imagery reported higher rates of using an observer perspective and similar rates of using a field perspective, these individuals did seem to report to have mental images - regardless of perspective - to the same extent as individuals who received instructions about imagery when processing their specific positive memory. This finding is in line

with previous research showing that recalling specific memories is much more associated with mental images than general memories (Mansell & Lam, 2004). Given that the dysphoric individuals in the control MIP did receive instructions to recall a specific memory this may have increased the likelihood of mental images coming up during recall of the memory.

Despite the group differences in the rates of adopting an observer perspective, this did not seem to directly influence the emotional response as reflected in the effect on positive affect. Results revealed no differences in the change in positive affect across the mood induction between dysphoric individuals receiving instructions and practice in using field perspective imagery when recalling a positive memory and dysphoric individuals not receiving such instructions. However, results did show that the group receiving instructions on field perspective imagery reported higher levels of positive affect after the induction when statistically controlling for variability in positive affect at baseline, which might be because the last analysis had more statistical power to detect a group effect. This could indicate that the difference between the two groups is not big, but that the effect on positive affect was slightly greater in the dysphoric individuals who received the instructions and practice in field perspective imagery when recalling their positive autobiographical memory.

A possible limitation to this study is that we investigated a dysphoric sample instead of a depressed sample as results could be different in a clinical sample. However, dysphoric people have shown to be at risk for developing a depression and previous studies have shown similar results with regard to the higher occurrence of observer memories in both depressed and dysphoric samples (Kuyken & Howell, 2006; Nelis et al., 2013). Moreover, investigating sub-clinical populations is relevant as applications of mental imagery in relapse prevention and research on mechanisms of resilience, aiming at increasing positive affect as this is believed to play a role in developing resilience (Fredrickson, 1998; 2001), would most likely target remitted- or sub-clinical populations.

A second limitation in this study may have been the measurement scale to assess the extent to which participants adopted a field and observer perspective during imagery. The 5-point Likert scale may not have allowed for enough variance in reports on adopting a field and observer perspective to detect possible subtle differences

between non-dysphoric and dysphoric participants or participants receiving imagery instructions and those not. Future research could use a 9-point Likert scale to allow for more subtle variance in reports on adopting a field and observer perspective. Furthermore, future research could also include manipulation checks assessing effort to adopt each perspective as it may be possible that dysphoric/ depressed people, when instructed, adopt a field perspective to the same extent as healthy controls, but that this is more effortful for them.

To summarize, results showed that when dysphoric and non-dysphoric individuals received instructions and practice in using field perspective imagery when recalling positive autobiographical memories, dysphoric people imagined their positive autobiographical memories from a field and observer perspective to the same extent as non-dysphoric controls. Moreover this resulted in a similar positive emotional response following imagery of their specific positive memories. When dysphoric individuals did not receive such instructions, allowing for a more automatic way of processing their memory, they did report to adopt a field perspective to the same extent as dysphoric individuals receiving instructions, but also reported to adopt an observer perspective to a higher extent. Although the change in positive mood did not differ between these groups as shown by the repeated measures ANOVA, indications were found with the ANCOVA for a greater effect on positive affect after recalling a specific positive memory for the dysphoric individuals receiving instructions and practice on using field perspective imagery. Results from the current study are promising as they show that instructing and practicing field perspective imagery when recalling a specific positive memory in individuals at risk for developing depression, leads to a similar positive emotional response as compared to healthy individuals. This makes the use of field perspective imagery an interesting tool not only in psychotherapy, but also for inducing positive affect in the context of studying mechanisms of psychological resilience.

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CHAPTER 2

Effects of positive mood on attention broadening for self-related information[1]

Abstract

Studies on cognitive effects of positive emotions have associated positive emotions to broadened attention. Given the widely investigated relationship between self-focused attention and mood, it is important to investigate the effect of positive mood on visuospatial attention for self-related information. We used a performance-based measure to assess fluctuations in attentional broadening from self-related contrasted to not-self-related information. In Experiment 1, we checked that the self-related versus not-self-related stimuli did not evoke differential attention effects in general. In Experiment 2, we manipulated mood and found that an increase in positive mood was associated with a relative broadening of attention for self-related information. These results suggest that the meaning of the target of attention provides an interesting dimension for further investigation into the relation between positive emotions and attentional broadening.

[1] Based on Grol, M., Koster, E.H.W., Bruyneel, L., & De Raedt, R. (2014). Effects of positive mood on attention broadening for self-related information. *Psychological Research, 78*, 566-573. doi: 10.1007/s00426-013-0508-6

Introduction

Considerable research has focused on how emotion influences cognition, in relation to different functions of positive and negative emotions. Within the field of positive psychology, the broaden-and-build theory (Fredrickson, 1998; 2001) proposes qualitatively distinct functions for negative and positive emotions. This theory proposes that positive emotions, as opposed to negative emotions, broaden people's repertoire of thoughts and actions that come to mind. Research has supported this theory by linking positive emotions to broadened cognition; positive emotions have been shown to increase creativity, social openness, and visual attentional breadth (e.g. Fredrickson & Branigan, 2005; Garland et al., 2010; Isen, Daubman, & Nowicki, 1987; Rowe, Hirsh, & Anderson, 2007). These prior studies have also stimulated research into the conditions under which these broadening effects of positive emotions occur.

Research by Gable and Harmon-Jones (2008; 2011) suggests that the effect of positive emotions on visuospatial attentional breadth may depend on motivational factors. While positive affective states low in approach motivation broaden attention, which is in line with previous work (e.g. Fredrickson & Branigan, 2005), they found that positive affective states high in approach motivation were actually related to a relative decrease in global attentional focus (Gable & Harmon-Jones, 2008; 2011). Moreover, Förster and Dannenberg (2010) describe in their global versus local processing model (GLOMO^{sys}) the effects of mood on global and local processing. They mention that although explicit mood and approach/avoidance motivational factors may underlie effects on processing, these cannot explain all broadening effects (Förster & Dannenberg, 2010). They suggest that additional psychological factors (e.g. regulatory focus) may underlie the effects on processing, and their overview reveals the complexity of the effects on broadened attention or global processing.

Research on the attentional broadening effects of positive emotions has shown a sharp increase after Fredrickson (1998; 2001) elaborated on the cognitive broadening function of positive emotions. Interestingly, it is proposed that these broadening effects play an important role in the relation between positive emotions and resilience against stressful events and potentially against emotional disorders. Given the potential role of these attentional broadening effects, it is important to consider that in emotional disorders, cognitive processes are often affected depending on the processing of

specific types of information (e.g. emotional valence of presented stimuli). There is an expansive literature relating emotional disorders to self-focused attention (e.g. Mor & Winquist, 2002). This literature indicates that (chronic) negative mood is related to a heightened focus on self-relevant information. In line with this, it has recently been proposed that rumination, a style of persistent negative thought, is associated with attentional narrowing on self-related information (Whitmer & Gotlib, 2012). On the other hand, research also shows that adopting a self-distanced perspective, allowing a focus on the broader context, is related to reduced distress and less rumination after recall of a negative event (Kross & Ayduk, 2011).

If we want to further investigate the attentional broadening effects of positive emotions, as these may be important in explaining the relation between positive emotions and psychological resilience, we need to consider the possible influence of the value of the presented information when measuring the attentional effects of positive emotions. Earlier research already suggested that the broadening effects of positive emotions may be influenced by characteristics of the presented information, such as emotional valence (Wadlinger & Isaacowitz, 2006). However, although it might be specifically relevant in the context of emotional disorders, to our best knowledge, no research so far has investigated how the attentional broadening effects of positive emotions may interact with the presence (or processing) of self-related information.

Former research has not yet focused on the value or meaning of the target of attention when investigating the broadening effects of positive emotions. That is, most studies examined visuospatial attentional broadening effect in relation to manipulations of mood or emotions (e.g. Fredrickson & Branigan, 2005; Gable & Harmon-Jones, 2008) but did not manipulate the content or meaning of the target of attention. Importantly, attentional broadening effects may occur because of the nature of a positive mood induction, but also because of the meaning or value of the attentional target. Therefore, it is important to examine whether broadening effects by positive emotions can be influenced on a trial-by-trial basis, due to the nature of the target in focal attention. In the current study we were interested in broadening in function of self-relevant information. Based on previous research on the relation between negative mood and self-focused attention and the effects of self-distancing, it can be expected that positive mood would be related to a broadening of attention (or

loosening of attentional focus) for self-related information. In our study, this broadening of attention is operationalized at the level of visuospatial attention. Furthermore, in line with the observation that mood induction procedures (MIP) that elicit positive mood with low approach motivation tend to broaden attention, we used a MIP based on the recollection of positive autobiographical memories, and not a MIP using appetitive stimuli or approach motivating positive cues, which may be more likely to induce high approach positive mood (Gable & Harmon-Jones, 2008; 2011).

The present study examines the effects of positive mood on attention for self-related information using a performance-based measure of visual attentional breadth. The task is based on an attentional breadth task that has been successfully used before to measure fluctuations in attentional broadening/narrowing related to centrally presented, personally relevant information (Bosmans, Braet, Koster, & De Raedt, 2009). This task allows us to explore how the presentation of self-related information influences the broadening effect of positive emotions contrasted to a comparison condition, that is, relative to effects for not-self-related information.

Given the previously shown association of positive emotions with visual attentional breadth and the relation between negative mood and a heightened self-focus, we hypothesized positive emotions to be associated with broadened attention for self-related information.

Experiment 1

To measure attention for self-related information we used a paradigm based on a task developed by Bosmans et al. (2009). This task was adjusted to measure attentional narrowing/broadening in relation to self-related as compared to not-self-related stimuli. Based on previous criticism about the use of "self" versus general "other" categories in implicit measures (e.g. Karpinski & Steinman, 2006), we used self-related stimuli in contrast to a non-defined but specific not-self category: "ME" (self-related) versus the name initials of an unknown other participant ("LR") who was said to have already taken part in this study.[2] The problem with self-related versus general other stimuli (e.g. ME, THEM) is that it is difficult to infer whether the effect is driven by self-related stimuli, or by the fact that other people in general (as a category) evoke

[2] We checked that none of the participants' name initials was LR.

attentional processes. However, a possible confound in the use of "ME" and "LR" as stimuli could be that the self category and not-self category are a word versus non-word respectively.[3] This problem is impossible to prevent because there are no suitable real two-letter words that can be used as a contrast category for "ME". Therefore, in experiment 1, under conditions without any mood manipulation we first investigated whether our self-related and not-self-related stimuli evoked differences in attentional broadening in general (i.e. due to other factors than mood manipulation). Across the literature a quite consistent relation is found between negative affect and self-focused attention, notwithstanding the multifaceted nature of this concept (Mor & Winquist, 2002). Across the literature, results are however mixed with regard to whether self-related stimuli automatically capture attention in studies without any manipulation of mood. There are studies finding that self-related stimuli do automatically capture attention (Alexopoulos, Muller, Ric, & Marenda, 2012); however, other studies did not confirm this finding or suggest this appears only under specific conditions (Bundesen, Kyllingsbaek, Houmann, & Jensen, 1997; Devue & Brédart, 2008; Devue, Van der Stigchel, Brédart, & Theeuwes, 2009; Harris & Pashler, 2004). Given the mixed findings across the literature we would not necessarily expect differences evoked by self-related and not-self-related stimuli in general (in a healthy population).

Method

Participants. Thirty-five undergraduate students (24 females) aged between 18 and 25 years (M = 19.97, SD = 2.04) volunteered to participate in this experiment in partial fulfilment of undergraduate course requirements or were paid €6 for their participation. This experiment was approved by the local ethical committee of the Faculty of Psychology at Ghent University.

Materials. In each trial of the experimental task a word appeared in the center of the screen; this word was either "ME" (Dutch = IK) or "LR". Simultaneously with presentation of the central word, 16 gray dots with a diameter of 2 cm appeared around the word in two concentric circles (see Figure 1). One circle appeared at 4.5 cm

[3] We considered using participants' own initials, but this is problematic as this introduces perceptual variance across participants. Moreover, some letters may be more familiar or form a word which could cause differences in attentional breadth for reasons other than mood. Finally, some name initials will consist of more than two letters and because the control initials have to match the length of the experimental stimulus, using stimuli of different length across participants, would again introduce perceptual variance across participants.

from the central word at 10° of the visual angle, the other circle appeared at 11.2 cm from the central word at 25° of the visual angle. The gray dots were arranged in pairs of two, one close and one far, situated on one of eight imperceptible axes. Simultaneously with the presentation of the word and gray dots, a smaller, black circle with a diameter of 1.3 cm appeared in one of the gray dots, either close or far. The smaller circle that could appear in one of the 16 gray dots was the target stimulus participants had to identify.

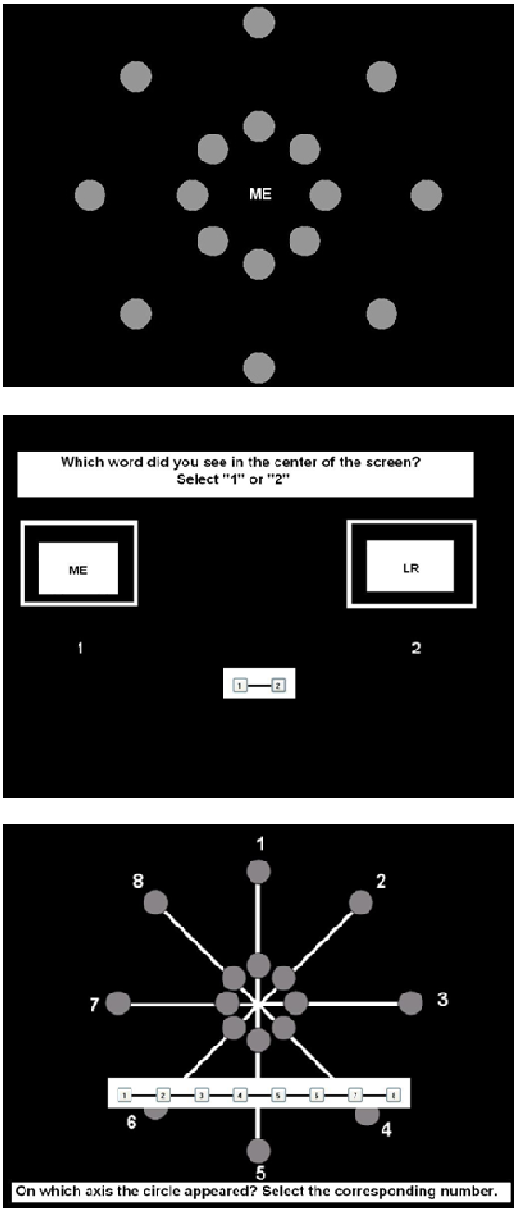

Figure 1. *Stimulus presentation of the Attentional Breadth Task. The gray dots are presented in pairs of two, simultaneously with the central word and the target stimulus. The first response screen asks participants which word they have seen. The second response screen asks participants on which of eight axes the target stimulus was presented.*

After the simultaneous presentation of the stimuli, participants were asked to identify the central stimulus. After their response, they were asked to identify the axis on which the target stimulus (i.e. the smaller black circle) had appeared. The main dependent variable was the accuracy rate on the peripheral task (i.e. the proportion of correctly localized target stimuli) on trials in which participants also correctly identified the central word to make sure participants maintained attention to the center of the screen during the task. Because we were merely interested in early, automatic attentional processes, and in order to prevent confounds of saccadic eye movements in search of the peripheral target, all stimuli were presented for 68 msec (Ball, Beard, Roenker, Miller, & Griggs, 1988).

Experimental Design and Procedure. All participants were seated at a distance of 27 cm from a 19" CRT-computer screen, using a chin rest to ensure correct positioning. The task consisted of 16 practice trials with a presentation time of 250 msec to allow participants to get acquainted with the task, followed by 16 practice trials with a presentation time of 68 msec. The test phase consisted of 128 trials, with four types of trials: "ME" close, "ME" far, "LR" close, and "LR" far which were randomly presented in two blocks consisting of 64 trials each.

Results and Discussion

In order to ensure that participants were focusing on the center of the screen during the task we deleted all trials in which the central word was incorrectly identified. This resulted in deleting an average of 1.58% of the trials.

Attention for self-related information. We performed a 2 Word (ME versus LR) x 2 Distance (far versus close) ANOVA with accuracy rates on the peripheral task as dependent variable, that is, the proportions of correctly localized target stimuli. Table 1 shows the means and standard deviations for the proportions of correctly localized target stimuli for each type of trial. This analysis yielded only a significant main effect of distance, $F(1,34) = 127.16$, $p < .001$, $\eta_p^2 = .79$, indicating that in general the accuracy for localizing the peripheral target when it is close to the word ($M = .93$) is higher than when it appears further away ($M = .60$). No other effects were significant (Fs < 1.85).

These results indicate that when mood was not manipulated, participants did not show differences in attentional broadening between the self and not-self trials; that

is, the presentation of a word versus non-word did not evoke differences in attentional broadening in general.

Table 1.

Experiment 1: Proportion of correctly localized target stimuli for each type of trial

M (*SD)*	Word: "ME"	Word: "LR"
Distance: close	0.94 (0.08)	0.93 (0.08)
Distance: far	0.60 (0.22)	0.61 (0.22)

Experiment 2

Given the absence of general differences between the self- and not-self-related stimuli, we could investigate the influence of positive mood on attention for self-related information, being confident that the self- versus not-self-related words did not differentially influence attentional breadth in itself. In Experiment 2, we used the same task with the same central stimuli but now in relation to an experimental manipulation of mood.

Method

Participants. Fifty-five other undergraduate students (45 females) between 17 and 30 years of age (*M* = 18.76, *SD* = 2.40) volunteered to participate in this study in partial fulfilment of undergraduate course requirements. Participants were randomly assigned to either a positive or neutral mood induction condition (MIP). This experiment was approved by the local ethical committee of the Faculty of Psychology at Ghent University.

Materials.

Questionnaire measures. Mood state was measured using two visual analogue scales (VAS), with the anchor points "0%" and "100%" (0 to 10 cm, resulting in a 0-100 scale), measuring how happy and sad participants were feeling "*at this moment*" respectively. In the current study we decided to use VAS as these are most sensitive to fluctuations in affect due to their visual presentation (Rossi & Pourtois, 2012).

Mood induction procedure. The MIP consisted of an imagery procedure where participants were instructed to vividly imagine either a self-provided neutral- or happy-inducing autobiographical memory. Participants first practiced the use of mental

imagery by completing an imagery practice task of cutting a lemon (Holmes, Coughtrey, & Connor, 2008). Following this practice task, participants in the positive MIP condition were instructed to recall a memory of an event that happened on a specific day, more than one week ago, which made them feel very happy at that time, while participants in the neutral MIP condition were instructed to recall a memory of a specific event that did not elicit strong negative or positive emotions at that time. All participants were asked to shut their eyes and to describe what they remembered in detail. Participants were given instructions (Watkins & Moberly, 2009; based on Holmes et al., 2008) to promote concreteness (e.g. "focus on how the event happened and imagine in your mind as vividly and concretely as possible a 'movie' of how the event unfolded"), and to promote field perspective imagery (e.g. "see it through your own eyes, from your own perspective"). Participants imagined the event for 30 seconds after which they were asked a series of questions (based on Watkins & Moberly, 2009), asking them to focus on what they could see, hear, and feel (e.g. "What can you see?", "What physical or bodily sensations do you feel?"). Following these questions, participants were instructed to continue imagining the event for another 30 seconds without describing it. In order to strengthen the induction of the desired mood, music was played during imagining the autobiographical memory and continued playing throughout the task. To induce positive mood we used Mike Oldfield's "Music of the spheres" (track 2, 3, 5, and 6). To induce neutral mood we used Chopin's "Waltzes Nos. 11 and 12", which have been successfully used to induce neutral mood in previous studies (Startup & Davey, 2001; Heene, De Raedt, Buysse, & Van Oost, 2007).

Experimental task. To measure attention for self-related information the same task was used as in Experiment 1.

Experimental design and procedure. Participants were randomized to receive either the positive or the neutral MIP. After informed consent, baseline levels of mood were measured with the VAS. Following this, participants completed the MIP and mood was measured again immediately afterwards. After the MIP, participants performed the experimental task. All participants were seated at a distance of 27 cm from a 19" CRT-computer screen, using a chin rest to ensure correct positioning. Participants received eight practice trials with a presentation time of 250 msec to allow participants to get acquainted with the task, followed by eight practice trials with a presentation time of

68 msec. The test phase consisted of 96 trials which were randomly presented in two blocks consisting of 48 trials each (the task was shortened as compared to Experiment 1 to maximize the chance that the mood induction effects would remain present during the whole task).

Results and Discussion

As we are interested in the direct effect of positive mood on attentional breadth for self-related information, taking into account interindividual differences in the effectiveness of the MIP that are neglected when analyzing the data on a group level, the change in positive mood was used as a continuous predictor to enhance power. Early research on the affective contrast theory (Bacon, Rood, & Washburn, 1914; Manstead, Wagner, & MacDonald, 1983) has shown that the impact of mood states depends on a contrast with the prior perceived state, therefore it was decided to look at the effects of the change in positive mood across the mood induction. Importantly, notwithstanding that the data are derived from two MIP groups (positive and neutral), based on graphical exploration and nonsignificant normality tests (both Kolmogorov-Smirnov and Shapiro-Wilk yielded $p > .05$) the change in positive mood was normally distributed. For the analyses of attention for self-related information, all trials were deleted in which the central word was incorrectly identified, to ensure that participants were focusing on the center of the screen during the task. This resulted in deleting an average of 6.23% of the trials. No differences were found between groups in terms of the percentage of trials that was deleted ($t < 0.5$).

Table 2.

Experiment 2: Group Characteristics

	Neutral MIP *M* (*SD*)	Positive MIP *M* (*SD*)
Age	19.30 (3.24)	18.25 (0.89)
Gender	22 females	23 females
VAS happy pre-MIP	66.19 (13.81)	71.71 (14.21)
VAS sad pre-MIP	10.11 (13.08)	8.79 (8.40)

Group characteristics. Twenty-eight participants received the positive MIP and 27 participants received the neutral MIP. Table 2 shows the mean and standard deviation for each variable. There were no significant differences between the groups in terms of gender, χ^2 (1, N = 55) = 0.004, p = .949, age, and baseline mood measures, all ts < 1.70.

Mood manipulation check. To assess the effect of the MIP on mood, mixed ANOVAs with Group (Positive MIP versus Neutral MIP) as between subject factor and Time (before versus after the MIP) as within subject factor were performed, separately for the happy and sad VAS. For the happy VAS, this revealed a significant Group x Time interaction, F(1,53) = 8.67, p = .005, η_p^2 = .14, whereas no Group x Time interaction for the sad VAS was found, F(1,53) = 0.98, p = .327, η_p^2 = .02. The Group x Time interaction was driven by a significant increase in levels of happiness in participants in the positive MIP group, t(27) = 3.82, p = .001, whereas participants from the neutral MIP group did not show such an increase, t(26) = 0.27, p = .792. While the positive and neutral group did not differ in levels of happiness before the MIP (M = 71.71 and M = 66.19 respectively), F(1,53) = 2.14, p = .149, η_p^2 = .04, the positive MIP group reported significantly higher levels of happiness than the neutral group afterwards (M = 80.71 and M = 66.63 respectively) when controlling for mood at baseline, F(1,52) = 9.73, p = .003, η_p^2 = .16.[4]

Mood and attention for self-related information. We performed a 2 Word (ME versus LR) x 2 Distance (far versus close) ANOVA with the change in positive mood across the mood induction (ΔVAShappy, M = 4.80, SD = 11.51) as a continuous predictor and the proportions of correctly localized target stimuli as dependent variable. Table 3 shows the means and standard deviations for the proportions of correctly localized target stimuli for each type of trial across all participants (i.e. regardless of the change in positive mood). This yielded a significant main effect of distance, F(1,53) = 345.94, p < .001, η_p^2 = .87, a significant main effect of ΔVAShappy, F(1,53) = 6.72, p = .012, η_p^2 = .11, and a Word x Distance x ΔVAShappy interaction, F(1,53) = 5.55, p = .022, η_p^2 = .10.

To explore the direction and magnitude of this significant interaction, an index of Attentional Narrowing (ANI = accuracy stimulus close to word - accuracy stimulus far

[4] Results of the analysis without correcting for baseline mood yielded similar results, F(1,52) = 10.28, p = .002, η_p^2 = .16

from word) was calculated for both self trials and not-self trials, and subsequently an ANI difference score (ΔANI = ANIself - ANInotself) was calculated (based on Bosmans et al., 2009). Higher ΔANI scores reflect stronger attentional narrowing when the central word was self-related contrasted to attentional narrowing when the central word was not-self-related. To investigate whether attentional breadth for self-related relative to not-self-related information is modulated by changes in positive mood we examined correlations between changes in positive mood and ΔANI scores. ΔVAShappy was negatively correlated with ΔANI, r = -.31, p = .022.[5] In line with our hypothesis, these results indicate that a bigger increase in positive mood was associated with a relative broadening of attention for self-related information.

Table 3.

Experiment 2: Proportion of correctly localized target stimuli for each type of trial across all participants (i.e. regardless of change in positive mood)

M (*SD)*	Word: "ME"	Word: "LR"
Distance: close	0.76 (0.19)	0.75 (0.19)
Distance: far	0.26 (0.13)	0.25 (0.13)

Additional analyses. Experiment 1 showed there were no significant attentional effects of the self and not-self related stimuli independent of mood manipulation effects. Experiment 2 showed that attentional broadening for self-related information contrasted to not-self-related information was influenced according to the change in positive mood. Additional analyses were performed to test whether the effects on attentional broadening without mood manipulation are statistically significant different from the effects found according to an increase in positive mood. As experiment 1 did not involve a mood measure whereas experiment 2 tested the influence of the change

[5] The change in positive mood was also correlated with the single accuracy scores on the peripheral task in both Word conditions (i.e. ME-close, ME-far, LR-close, LR-far trials). Results showed that an increase in positive mood was significantly associated with an increase in accuracy for localizing the target stimulus when it appeared far from the central stimulus in both the self condition, r = .36, p = .008, and in the not-self condition, r = .30, p = .024. An increase in positive mood was also correlated with an increase in accuracy for localizing the target stimulus when it appeared close to the central stimulus in the not-self condition, r = .30, p = .024.

in positive mood, we divided the participants from experiment 2 according to whether they showed an increase in positive mood above the overall average change (*M* = 4.80) or not. That is, a division was made between participants who increased in positive mood with more than 4.80 points (n = 23) on the VAS scale and participants who showed an increase of less than 4.80 points or even showed a decrease (n = 32). These two groups were compared to the participants from experiment 1 who received no mood manipulation (n = 35). As the assumption of homogeneity of variance was violated, we performed a nonparametric Kruskal-Wallis test to check for group differences on the calculated ΔANI score (ANI = accuracy stimulus close to word - accuracy stimulus far from word, ΔANI = ANIself – ANInot-self) representing attentional narrowing for self-related information contrasted to not-self-related information. This analysis showed a significant group difference, $H(2) = 6.68$, $p = .035$. Follow-up Mann-Whitney tests showed no differences in ΔANI between the participants who received no mood manipulation and participants who showed a change in positive mood of less than 4.80 points, $U = 521$, $p = .624$, $r = -.06$. Mann-Whitney tests between the participants without mood manipulation or participants with a change in positive mood of less than 4.80 points, and participants with an increase in positive mood above average showed significant differences, $U = 265$, $p = .029$, $r = -.29$ and $U = 230$, $p = .019$, $r = -.32$ respectively. These additional analyses showed that the participants without mood manipulation did not significantly differ on ΔANI (*M* = .03) from participants with a change in positive mood of less than 4.80 points on the VAS scale (*M* = .05). However, participants with an increase in positive mood above the average change (i.e. with more than 4.80 points on the VAS scale), as compared to the other two groups, showed a significant smaller attentional narrowing index for self-related information contrasted to not-self-related information (*M* = -.05).

General Discussion

The objective of this study was to investigate the relationship between positive mood and attention for self-related information. We hypothesized that positive mood would be related to a relative broadening of attention for self-related information, which was confirmed by our results. Our study is the first to show a broadening of visuospatial attentional breadth in relation to self-related information relative to not-self-related information using a performance-based measure.

The broaden-and-build theory, which makes a qualitative distinction between positive and negative emotions in their effect on cognition (Fredrickson, 1998; 2001), proposes a broadening function for positive emotions. Previous research has supported this theory by relating positive emotions to broadened visual attention, exploratory activity, and openness to others (for review see Garland et al., 2010). However, other research (e.g. Förster & Dannenberg, 2010; Gable & Harmon-Jones, 2008) suggests that besides emotional states also other factors may underlie the broadening effects of emotion. In the present study we only manipulated explicit mood using the recall of positive events, which is likely to induce low-approach positive mood (Gable & Harmon-Jones, 2008). We focused on manipulating the meaning of the target of attention itself, which remained under investigated to date, and investigated how this is interacting with the effects of positive mood on attentional broadening. The results from our study complement previous findings by showing the interaction of positive mood with trial-by-trial fluctuations in attentional broadening based on the value or meaning of the target of attention.

Previous research on the attentional broadening effects of positive emotions (e.g. Fredrickson & Branigan, 2005; Rowe, Hirsh, & Anderson, 2007) mostly investigated this relation with tasks using neutral (not-self-related) stimuli and looking at the effects of positive mood on 'tonic' attentional breadth. The task used in the current study allowed us to investigate effects of positive mood in relation to trial-by-trial fluctuations in attentional breadth (or 'phasic' attentional breadth) for self-related information relative to not-self information. Clearly, the current findings suggest that the breadth of attention - in interaction with mood – can efficiently be adjusted in a phasic manner based on the nature of encountered visual stimuli.

Investigating the effect of positive emotions on attentional processes in the presence of self-related information may especially be pertinent in the context of stress resilience as negative emotions have been associated with an increased self-focus (Mor & Winquist, 2002) and moreover, it is likely that people in those situations are confronted with information that is not neutral but related to the self. The effect of positive mood on broadened visuospatial attention (or a loosening of attentional focus) for self-related information may also further facilitate engagement in exploratory behavior, openness to new information, and social openness. By these broadening

effects, positive emotions may play a role in building resources and developing or strengthening both physiological and psychological resilience over time (Fredrickson 1998; 2001; Tugade & Fredrickson, 2004), though such a mediation model has yet to be tested experimentally.

A possible limitation to the present research is that, by design, the self-category and not-self-category are a word and non-word respectively. Therefore, in the first experiment we checked whether these stimuli would evoke a different attention effect in general, and we did not find a Word x Distance interaction. Based on previous criticism about using self versus other categories in implicit measures (e.g. Karpinski & Steinman, 2006), the use of a self versus non-defined but specific not-self category seemed most appropriate.

In summary, the current results indicate that an increase in positive mood is associated with a broadening of attention for self-related information when contrasted to not-self-related information, on a trial-by-trial basis. Our performance-based measure of attention for self-related information, based on an existing attentional breadth task (Bosmans, et al., 2009), provides an interesting task to use in further exploration on how mood changes interact with fluctuations in attentional breadth on a trial-by-trial basis. Furthermore, the results of the present study suggest that the meaning or value of the target of attention provides an interesting factor for further investigation into the relation between positive emotions and attentional broadening.

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CHAPTER 3

Effects of positive mood on attentional breadth for emotional stimuli[1]

Abstract

Although earlier studies have related positive emotions to attentional broadening, recent findings point out the complexity of this relation and show that these broadening effects interact with factors such as characteristics of the information that is presented. Besides stimuli characteristics, individual characteristics such as the presence of depressive symptoms could also influence the broadening effects as depressive symptoms have been related to a more narrow attentional scope. Therefore, the aim of this study was to further investigate attentional broadening effects of positive emotions, testing whether this is influenced by emotional valence of the information presented, and how the presence of depressive symptoms might interact with this relationship. We used a performance-based measure to assess attentional broadening for positive, neutral, and negative stimuli. We assessed the presence and severity of depressive symptoms in an unselected study sample and tested whether these symptoms moderate the relationship between induced positive mood and attentional breadth for emotional information. Results showed no direct relation between positive mood and attentional breadth, regardless of the emotional valence of the stimuli. However, the presence of depressive symptoms moderated this relationship in such a way that among low levels of depressive symptoms, positive mood was related to attentional broadening specifically when positive information was presented, while at high levels of depressive symptoms this relation was reversed. The current findings suggest that both stimuli characteristics, individual characteristics and their interplay should be taken into account when investigating the broadening effects of positive emotions.

[1] Based on Grol, M., & De Raedt, R. (2014). Effects of positive mood on attentional breadth for emotional stimuli. Manuscript submitted for publication.

Introduction

The broaden-and-build theory (Fredrickson, 1998; Fredrickson, 2001) states that negative and positive emotions have distinct cognitive and psychophysiological effects. Positive emotions would broaden one's thought-action repertoires which over time contributes to building personal resources. Interestingly, this broadening effect on cognition could play an important role in the relationship between positive emotions and resilience. Studies investigating these broadening effects of positive emotions have found some evidence showing that positive emotions increase creativity, social openness, and attentional breadth (Fredrickson & Branigan, 2005; Isen, Daubman, & Nowicki, 1987; Garland et al., 2010; Rowe, Hirsh, & Anderson, 2007). However, results on attentional broadening are not consistently found across the literature (Bruyneel et al., 2012) and may be conditional to other factors or processes. It has been suggested that the effects of emotion on attentional breadth depend on motivational factors related to mood or emotional information (Gable & Harmon-Jones, 2008; 2010). Positive mood and information low in approach motivation were shown to be related to attentional broadening, whereas positive mood and information (appetitive stimuli) high in approach motivation were related to a decrease in attentional broadening (Gable & Harmon-Jones, 2008). Furthermore, it has also been shown that the attentional broadening effects of positive mood interact with characteristics of the presented stimuli in the target of attention itself, such as the self-relevance of the stimulus (Grol, Koster, Bruyneel, & De Raedt, 2014) or the emotional valence (Wadlinger & Isaacowitz, 2006). Wadlinger and Isaacowitz (2006) applied eye-tracking while three similarly valenced images (either three positive, neutral, or negative images) were presented in varying central-peripheral arrays and found induced positive mood to be related to a broadening of visual attention, but only when positive stimuli were presented. In line with the proposed effect of positive emotions on attentional broadening (Fredrickson, 1998; 2001), it may be that emotional stimuli in the target of attention also influence attentional breadth itself, or that the emotional valence of the presented information interacts with the induced mood state. Measuring attentional narrowing/broadening when positive or negative information is in the target of attention could influence the effect of positive mood on attentional breadth.

The above described research findings considering factors of influence on attentional broadening by positive emotions, underscore the apparent complexity of the effects and point out the need for further research. Therefore, in this study we further investigated the relationship between positive mood and attentional broadening and how this interacts with the emotional valence of the presented information that is in the target of attention. Based on earlier findings (Wadlinger & Isaascowitz, 2006) we expected that positive mood would be related to attentional broadening for positive information but that the effect of positive mood on attentional broadening could be hampered when neutral or negative information is presented.

Besides studying how characteristics of the presented stimuli influence the attentional broadening effects of positive emotions, it is also relevant to investigate how personal characteristics may influence these broadening effects. The broaden-and-build theory proposes that the broadening effects play an underlying role in the relation between positive emotions and resilience (Fredrickson, 1998; 2001), which suggests that especially resilient people can benefit from positive emotions in the form of attentional broadening. In turn, this may also suggest that people who are vulnerable to develop mood disorders, for example reflected in the presence of depressive symptoms (Fergusson, Horwood, Ridder, & Beautrais, 2005), may be less able to benefit from positive emotions in the form of attentional broadening. That is, the presence of depressive symptoms could hamper the effects of positive emotions on attentional broadening, which is also suggested by previous research relating depressive symptoms to a local bias, which is related to a more narrowed attentional scope (Basso, Schefft, Ris, & Dember, 1996). Furthermore, it should be considered that in the context of mood disorders certain types of information are specifically relevant. In emotional disorders, attentional processes are often affected depending on the processing of specific types of information, such as self-relevant information or the emotional valence of the information (De Raedt & Koster, 2010). Although the processing of this kind of (meaningful) information could also affect attentional processes in healthy individuals, this may further interact with the presence of depressive symptoms. Therefore, we measured the presence of depressive symptoms and examined if this would moderate the relation between positive mood and attentional breadth for emotional material.

In this study we examined the effects of positive mood on attention for emotional information with a performance-based measure of visual attentional breadth. This measure has been successfully used before to measure fluctuations in attentional broadening/narrowing related to centrally presented, personally relevant information (Bosmans, Braet, Koster, & De Raedt, 2009) and self versus not-self-related information (Grol et al., 2014). The measure has a dual-task nature in the sense that participants both have to identify a central emotional stimulus and localize a peripheral target which are presented simultaneously. Central and peripheral stimuli are both task relevant, so one cannot ignore peripheral information to perform the task. To induce positive mood, we used a mood induction procedure based on imagining autobiographical memories of events, which is less likely to induce high approach motivated positive mood as compared to using appetitive stimuli or approach motivating cues (Gable & Harmon-Jones, 2008).

Method

Participants

Forty undergraduate students (36 females) aged between 18 and 26 years (M = 20.80, SD = 1.87) participated in this experiment in exchange for a financial reward (€8). This experiment was approved by the local ethical committee of the Faculty of Psychology at Ghent University. Participants provided written informed consent via a consent form which was approved by the ethical committee of the Faculty of Psychology at Ghent University.

Material

Questionnaire measures.[2] Mood before and after the mood induction was measured with the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) measuring how participants were feeling "*at this moment*". Participants were asked to give their ratings on a 5-point Likert scale ranging from 1 "very slightly" to 5 "very much".

The presence and severity of depressive symptoms was measured using the self-report Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996; Van der Does,

[2] We also administered the trait version of the State and Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagge, & Jacobs, 1983; Van der Ploeg, Defares, & Spielberger, 2000) and the Ruminative Response Scale (Nolen-Hoeksema & Morrow, 1991; Raes, Hermans, & Eelen, 2003), but these were not used to test the hypotheses of the current study.

2002). This self-report scale consists of statements (responses ranging from 0 to 3) and participants are asked to pick out the response that best fits the way the participant has been feeling during the past two weeks.

The tendency to use mental imagery in daily life was assessed using the 12 item Spontaneous Use of Imagery Scale (SUIS; Nelis, Holmes, Griffith, & Raes, 2014; Reisberg, Pearson, & Kosslyn, 2003). Participants rated the degree to which descriptions are appropriate for them on a 5-point scale ranging from 1 “never appropriate” to 5 “always completely appropriate”.

Mood induction procedure. The mood induction procedure (MIP) consisted of a procedure in which mental imagery is used. Participants were instructed to vividly imagine either a self-provided neutral- or happy-inducing autobiographical memory. All participants first practiced the use of mental imagery from a field perspective (i.e. first person perspective) by completing an imagery practice task of cutting a lemon (Holmes, Coughtrey, & Connor, 2008). Following the practice task, participants in the neutral condition were instructed to recall a memory of a specific event that did not elicit strong negative or positive emotions at that time, while participants in the positive condition were instructed to recall a memory of a specific event that happened more than one week ago which made them feel very happy at that time. Participants were asked to shut their eyes while describing what they remembered in detail. Participants received instructions (Watkins & Moberly, 2009; based on Holmes, et al., 2008) to promote concreteness and imagining the event from a field perspective. They imagined the event for 30 seconds after which they were asked a series of questions (based on Watkins & Moberly, 2009), asking them to focus on what they could see, hear, and physically feel. Following these questions, participants were instructed to continue imagining the event for another 30 seconds without describing aloud. During the mood induction, manipulation checks were administered to measure the use of field and observer perspective. Participants were asked to rate on a 5-point Likert scale the extent to which they adopted a field perspective, that is the extent to which they “saw the event through their own eyes and were actively involved?” and the extent to which they adopted an observer perspective, “to what extent did you experience the event looking at yourself from outside, as if you see yourself taking part in the situation?”. In order to make the induction of the desired mood more lasting throughout the

experimental task, music was played during imagining the autobiographical memory and continued playing throughout the task. In the positive condition we used Mike Oldfield's "Music of the spheres" (track 2, 3, 5, and 6). In the neutral condition we used Chopin's "Waltzes Nos. 11 and 12", which have been successfully used to induce neutral mood in previous studies (Startup & Davey, 2001; Heene, De Raedt, Buysse, & Van Oost, 2007).

Experimental task. Attentional breadth for emotionally valenced stimuli was measured using an adaptation of a task measuring attentional breadth in relation to centrally presented stimuli (Bosmans et al., 2009). Participants were seated at a distance of 27 cm from a 19" CRT-computer screen, using a chin rest to ensure correct positioning. In each trial, a picture of an emotional face without hairline (82 x 82 pixels) appeared in the center of the screen (see Figure 1). Faces were taken from the Karolinska Directed Emotional Faces database (Lundqvist, Flykt, & Ohman, 1998). For each condition (i.e. positive, neutral, negative) we selected 8 faces. The selection was based on a valence and arousal rating (low arousal = 1; high arousal = 9) obtained from prior validation (Goeleven, De Raedt, Leyman, & Verschuere, 2008) and an equal number of male and female faces was selected within each condition. The selected faces were positive (happy; mean arousal = 3.73, *SD* = .29), neutral (neutral; mean arousal = 2.37, *SD* = .15), and negative (sad; mean arousal = 3.51, *SD* = .33). The positive and negative faces did not differ in level of arousal ($t < 1.5$). Participants had to correctly identify the expressed emotion of the central face (i.e. happy, neutral, sad). Simultaneously with presentation of the central face, 16 gray dots with a diameter of 2 cm appeared around the word in two concentric circles (see Figure 1). One circle appeared at 4.5 cm from the central word at 10° of the visual angle, the other circle appeared at 11.2 cm from the central word at 25° of the visual angle. The gray dots were arranged in pairs of two, one close and one far, situated on one of eight imperceptible axes. Simultaneously with presentation of the face and gray dots, a smaller black circle with a diameter of 1.3 cm appeared in one of the gray dots, either close or far. Participants had to localize the black circle and the accuracy on localizing this peripheral target was used as the main dependent variable.

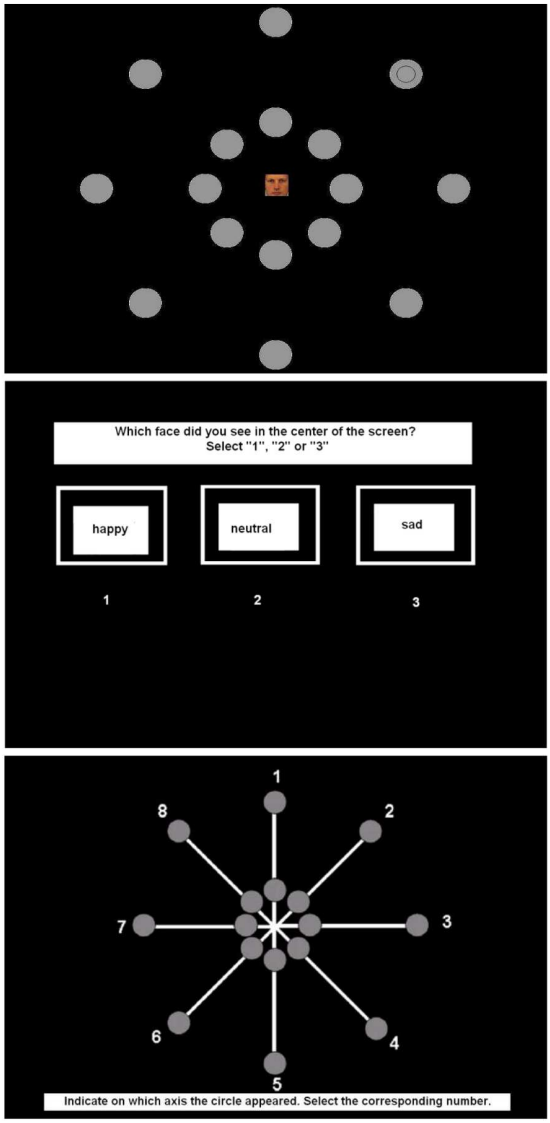

Figure 1. *Stimulus presentation of the Attentional Breadth Task. The gray dots are presented in pairs of two, simultaneously with the central word and the target stimulus. The first response screen asks participants which word they have seen. The second response screen asks participants on which of eight axes the target stimulus was presented.*

The proportion of correctly localized target stimuli was calculated based on trials in which participants also correctly identified the central stimulus to make sure participants maintained attention to the center of the screen during the task. This also allowed us to calculate indices of Attentional Narrowing (ANI = accuracy target stimulus close to face - accuracy target stimulus far from face) for both positive trials (ANIpositive), neutral trials (ANIneutral), and negative trials (ANInegative). All stimuli were presented for 68 msec in order to prevent confounds of saccadic eye movements in search of the peripheral target (Ball, Beard, Roenker, Miller, & Griggs, 1988).

The task consisted of eight practice trials with a presentation time of 250 msec, followed by eight practice trials with a presentation time of 68 msec similar to the test phase. The test phase consisted of 144 trials, with six types of trials: Positive close, Positive far, Neutral close, Neutral far, Negative close, and Negative far which were randomly presented in three blocks consisting of 48 trials each.

Procedure

Participants were randomized to receive either the positive or the neutral MIP. After written informed consent, baseline levels of mood were measured. Following this, participants completed the MIP procedure and mood was measured again immediately afterwards. After the MIP, participants performed the experimental task. Finally, participants were administered the additional questionnaires.

Results

Preliminary analyses

For the analyses of the attentional breadth task, all trials were deleted in which the central face was incorrectly identified. This resulted in deleting an average of 5.47% of the trials. Participants were excluded from further analysis if the number of deleted trials for any of the different trial types (Positive close, Positive far, Neutral close, Neutral far, Negative close, and Negative far) was more than 50%. This resulted in excluding two participants from further analysis, one participant from the positive MIP condition and one from the neutral MIP condition.

As data on the percentage of deleted trials was not normally distributed, we performed a nonparametric Mann-Whitney test to check for group differences in the number of deleted trials per trial type. This test showed no differences between groups in terms of the percentages of trials that were deleted for any of the trial types, all *p*s > .10. Across all participants there were differences in accuracy for identifying the central stimulus depending on the emotional valence of the presented stimulus, nonparametric Friedman's ANOVA yielded a significant effect, χ^2 (2, N = 38) = 22.61, $p < .001$. Follow-up Wilcoxon's signed-rank tests show that participants made less errors when identifying the positive faces compared to neutral faces, $T = 51.50$, $p < .001$, $r = -.40$, or negative faces, $T = 35$, $p < .001$, $r = -.49$. Participants also made less errors when identifying neutral faces compared to negative faces, $T = 131$, $p = .006$, $r = -.31$. However, nonparametric Spearman's rho correlations showed that the accuracy rates on

identifying the central stimuli were not related to attentional narrowing (ANI = accuracy target stimulus close to face - accuracy target stimulus far from face) for neither positive stimuli, neutral stimuli, nor negative stimuli, all *p*s > .20.

Group characteristics

Nineteen participants received the positive MIP and 19 participants received the neutral MIP. The means and standard deviations for the baseline variables can be seen in Table 1. Some variables (BDI) were not normally distributed and were therefore square root transformed before testing group differences with an independent t-test. As some variables remained not normally distributed after transformation (PANAS negative baseline, age) we performed nonparametric Mann-Whitney test for group differences on these variables. There were no significant differences between the groups in terms of gender, χ^2 (1, N = 38) = 0.36, p = .547, age, and baseline measures, all *ps* > .30.

Table 1.

Group Characteristics

	Neutral (*n* = 19) *M* (*SD*)	Positive (*n* = 19) *M* (*SD*)
Age	20.79 (2.15)	20.84 (1.50)
Gender	17 females	18 females
PANAS positive baseline	33.42 (6.67)	34.37 (4.78)
PANAS negative baseline	13.84 (4.48)	13.47 (4.65)
BDI	6.63 (5.75)	6.26 (6.85)
SUIS	41.11 (7.04)	40.79 (7.47)

Mood manipulation check

To assess the effect of the MIP on mood, a mixed ANOVA with Group (Positive MIP versus Neutral MIP) as between subject factor and Time (before versus after the MIP) as within subject factor was performed on the PANAS positive scale and negative scale separately. For the PANAS positive scale this revealed a significant main effect of Time, $F(1,36) = 11.16$, $p = .002$, $\eta^2 = .24$, and a Group x Time interaction, $F(1,36) = 5.11$,

p = .030, η^2 = .12. A nonparametric Mann-Whitney test was performed to test for group differences in the change scores on the PANAS negative scale across the induction (i.e. the difference scores). This test revealed no significant group difference, U = 164.50, p = .848, r = -.03[3].

The significant Group x Time interaction for the PANAS positive scale was driven by participants from the positive MIP group showing a significant increase in levels of positive affect from pre-MIP (M = 34.37) to post-MIP (M = 37.37), t(18) = 3.69, p = .002, while participants from the neutral MIP group did not show such an increase from pre-MIP (M = 33.42) to post-MIP (M = 34.00), t(18) = 0.83, p = .418. The positive MIP group tended to report significantly higher levels of positive affect afterwards, F(1,36) = 3.39, p = .074, η^2 = .09, which was significant when taking baseline mood levels into account, F(1,35) = 6.39, p = .016, η^2 = .15.

Mood and attention for emotional information

To look at the effect of the positive mood manipulation on attentional breadth for valenced stimuli we performed a 3 Valence (Positive vs Neutral vs Negative) x 2 Distance (far vs close) x Group (pos vs neu MIP) mixed ANOVA with the proportion of correctly localized peripheral targets as the dependent variable. This analysis yielded only a significant main effect of Distance, F(1,36) = 214.30, p < .001, η^2 = .86; that is, across all participants the proportion of correctly localized targets was higher when the target appeared at close distance (M = .89, SD = .14) than when the target appeared at further distance (M = .45, SD = .20). All other Fs, < 1.50.

As our research question is about the effects of positive mood, we also investigated the direct effect of positive mood on attentional breadth by including the change in positive mood across the induction (i.e. the difference score) as a predictor into the analysis, which enhances power considerably. This way, we take into account inter-individual differences in the effectiveness of the MIP to directly test the influence of positive mood changes. We performed a 3 Valence (Positive vs Neutral vs Negative) x 2 Distance (far vs close) mixed ANOVA on the proportion of correctly localized peripheral targets, with the change in positive mood across the mood induction

[3] A parametric mixed ANOVA with Time (pre- and post-MIP) as within-subject factor and Group as between-subject factor on the PANAS negative scale did not yield a significant Time x Group interaction either.

(ΔPANASpositive) as a continuous independent variable (i.e. covariate). Adding ΔPANASpositive as a covariate yielded also only a significant main effect of Distance, $F(1,36) = 157.56$, $p < .001$, $\eta^2 = .81$.

Moderation of the relation between mood and attention for emotional information

We further explored the data by investigating possible moderation of depressive symptoms (as measured by the BDI) on the relation between positive mood and attentional breadth to test whether the presence of depressive symptoms influences the effects of positive mood on attentional broadening.

Moderation effect of depressive symptoms. To investigate whether a potential moderation effect of BDI scores on the relation between positive mood and attentional breadth was different depending on the Valence of the central stimuli, we performed a mixed ANOVA on the proportion of correctly localized peripheral targets with Valence (Positive vs Neutral vs Negative) and Distance (far vs close) as within-subject factors. Group (positive vs neutral MIP) as between subjects variable and BDI scores as continuous independent variable (covariate) were entered. A custom model was specified in order to be able to investigate Group x BDI x within-subject factor interactions. Results revealed a near significant Distance x Group x BDI interaction, $F(1,34) = 3.88$, $p = .057$, $\eta^2 = .10$. This indicates that the BDI tends to moderate the relation between Group and Attentional narrowing/broadening but regardless of the Valence of the central stimulus. There was no significant correlation between the BDI and Group itself, $p > .10$.

To better understand the direction of the moderation effect of BDI on the relation between Group and overall Attentional narrowing/broadening, we did a simple slope analysis for the overall Attentional Narrowing Index (i.e. regardless of whether the central stimulus was positive, neutral, or negative). For the simple slope analyses we estimated different conditional effects of the focal predictor (i.e. Group) on the outcome variable at low (one *SD* below the mean), moderate (sample mean = 6.45), and high (one *SD* above the mean) values of the moderator (i.e. BDI scores), using Hayes and Matthes' SPSS macro (Hayes & Matthes, 2009). Results from the simple slope analyses showed a positive relation between Group and the overall Attentional Narrowing Index only among high levels (above 1 *SD*) of BDI scores, $t = 2.27$, $p = .030$, $b = .19$. Such relation was absent (i.e. nonsignificant) for moderate levels (mean) of BDI

scores, t = 1.22, p = .229, b = .07 and for low levels (below 1 *SD*) of BDI scores, t = -0.56, p = .580, b = -.05. The moderation analysis revealed no relation between positive mood and overall attentional narrowing/broadening at low and moderate levels of BDI scores. However, among high levels of BDI scores we found a relation between group and overall attentional breadth showing that participants in the positive MIP group showed more overall attentional narrowing compared to the neutral MIP group.

To take into account inter-individual differences in the effectiveness of the MIP and to test the effects of positive mood directly, we also investigated whether the BDI scores would moderate the relation between the change in positive mood across the mood induction (ΔPANASpositive) and attentional breadth for valenced stimuli. We performed a mixed ANOVA on the proportion of correctly localized peripheral targets with Valence (Positive vs Neutral vs Negative) and Distance (far vs close) as within-subject factors. ΔPANASpositive and BDI scores were entered as continuous independent variables (i.e. covariates). A custom model was specified in order to be able to investigate ΔPANASpositive x BDI x within-subject factor interactions. Results from this moderation model revealed a significant Distance x ΔPANASpositive x BDI interaction, $F(1,34) = 8.98$, p = .005, η^2 = .21, but also a significant Valence x Distance x ΔPANASpositive x BDI interaction, $F(2,33) = 4.65$, p = .017, η^2 = .22. This indicates that the moderation effect of the BDI on the relation between ΔPANASpositive and Attentional narrowing/broadening is different depending on the Valence of the central stimulus. There was no significant correlation between the BDI and ΔPANASpositive itself, $p > .10$.

To better understand the direction of this moderation effect and its interaction with Valence of the central stimulus, we performed simple slope analyses for the Attentional Narrowing Indices for positive, neutral, and negative central stimuli separately. For the simple slope analyses we estimated different conditional effects of the focal predictor (ΔPANASpositive) on the outcome variable at low (one *SD* below the mean), moderate (sample mean = 6.45), and high (one *SD* above the mean) values of the moderator (BDI scores), using Hayes and Matthes' SPSS macro (Hayes & Matthes, 2009).

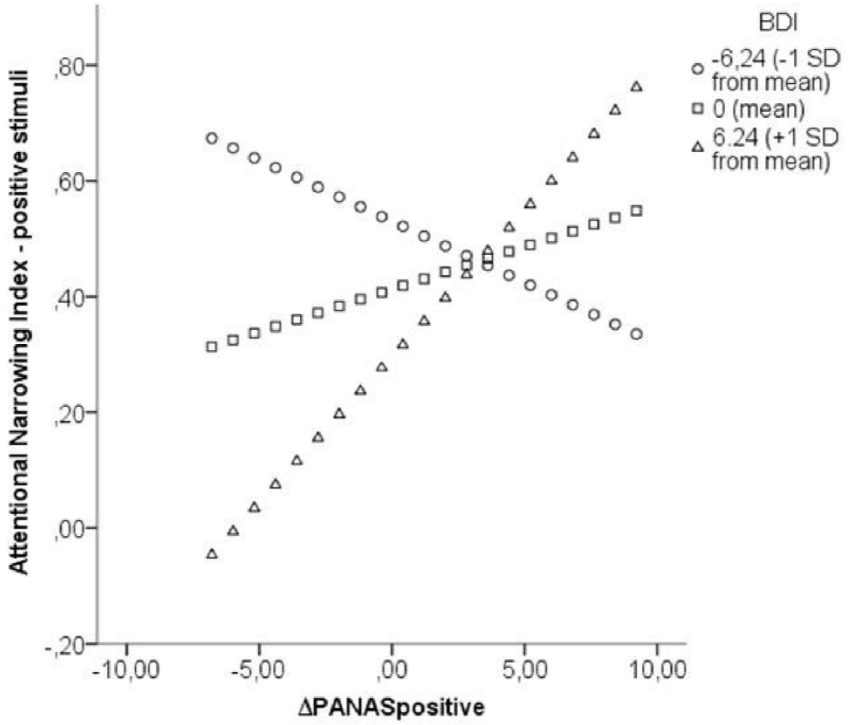

Figure 2. *Moderation effect of BDI on relation positive mood and attentional breadth for positive stimuli. Simple slope analysis on the moderation effect of BDI on the relation between ΔPANASpositive and the Attentional Narrowing Index for positive central stimuli. Regression lines were plotted by substituting low, moderate, and high values of BDI scores using Hayes and Matthes' SPSS macro (Hayes & Matthes, 2009).*

Results of the moderation analysis on ANIpositive shows a significant moderation effect, the interaction term (ΔPANASpositive x BDI) was a significant predictor, $t = 4.37$, $p < .001$, and added an explained variance to the model of $\Delta R^2 = .34$. Results from the simple slope analyses (see Figure 2) showed a positive relation between the increase in positive mood and attentional narrowing for positive stimuli among high levels (above 1 *SD*) of BDI scores, $t = 4.04$, $p < .001$, $b = .05$, while this relation was only near significant, $t = 1.83$, $p = .077$, $b = .02$, among moderate levels (mean) of BDI scores. Among low levels (below 1 *SD*) of BDI scores a negative relation between the increase in positive mood and attentional narrowing for positive stimuli was shown, $t = -2.04$, $p = .050$, $b = -.02$. Results from the moderation analysis indicated that among high levels of depressive symptoms a bigger increase in positive mood was actually related to more attentional narrowing for positive stimuli, while among moderate levels of depressive symptoms only a near significant relation between positive mood and attentional breadth for positive stimuli was found. However, for low levels of depressive symptoms we found a relation between a bigger increase in

positive mood and less attentional narrowing/more attentional broadening for positive stimuli.

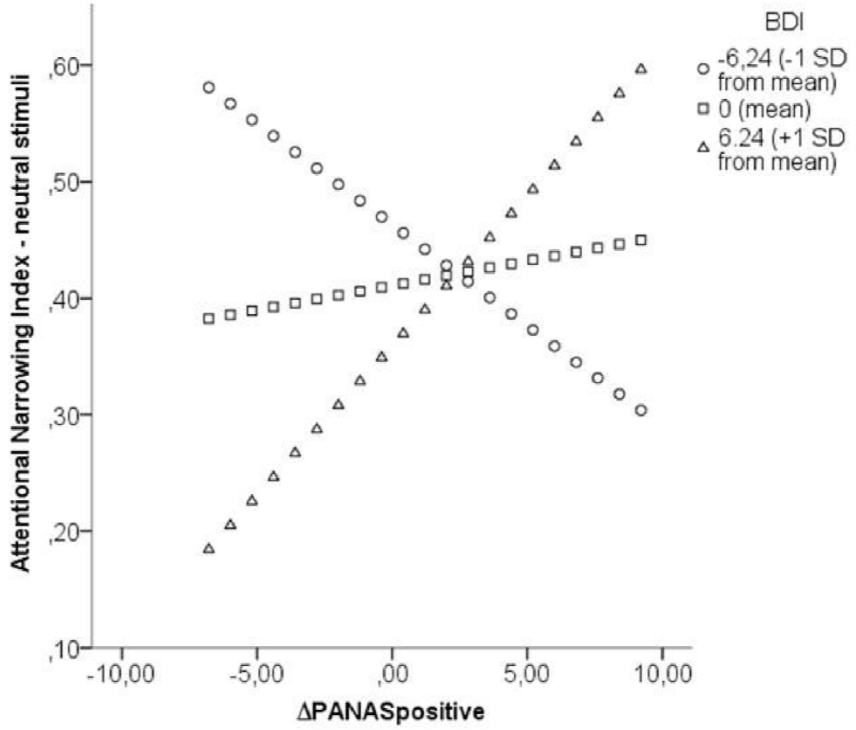

Figure 3. *Moderation effect of BDI on relation positive mood and attentional breadth for neutral stimuli. Simple slope analysis on the moderation effect of BDI on the relation between ΔPANASpositive and the Attentional Narrowing Index for neutral central stimuli. Regression lines were plotted by substituting low, moderate, and high values of BDI scores using Hayes and Matthes' SPSS macro (Hayes & Matthes, 2009).*

Results of the moderation analysis on ANIneutral shows a significant moderation effect, the interaction term was a significant predictor, t = 2.32, p = .027, and added an explained variance to the model of ΔR^2 = .14. Results from the simple slope analyses (see Figure 3) showed only a near significant positive relation between the change in positive mood and attentional narrowing for neutral stimuli among high levels (above 1 *SD*) of BDI scores, t = 1.82, p = .078, b = .03. This relation was absent (i.e. not significant) among moderate levels (mean) of BDI scores, t = 0.46, p = .647, b = .004, and among low levels (below 1 *SD*) of BDI scores, t = -1.47, p = .151, b = -.02. These results indicate that although the severity of depressive symptoms has a significant influence on the relation between positive mood and attentional narrowing for neutral stimuli, there is no significant relation between the change in positive mood and attentional breadth for neutral stimuli among moderate and low levels of BDI scores.

Only among high levels of depressive symptoms results show a tendency for an increase in positive mood to be related to attentional narrowing for neutral stimuli.

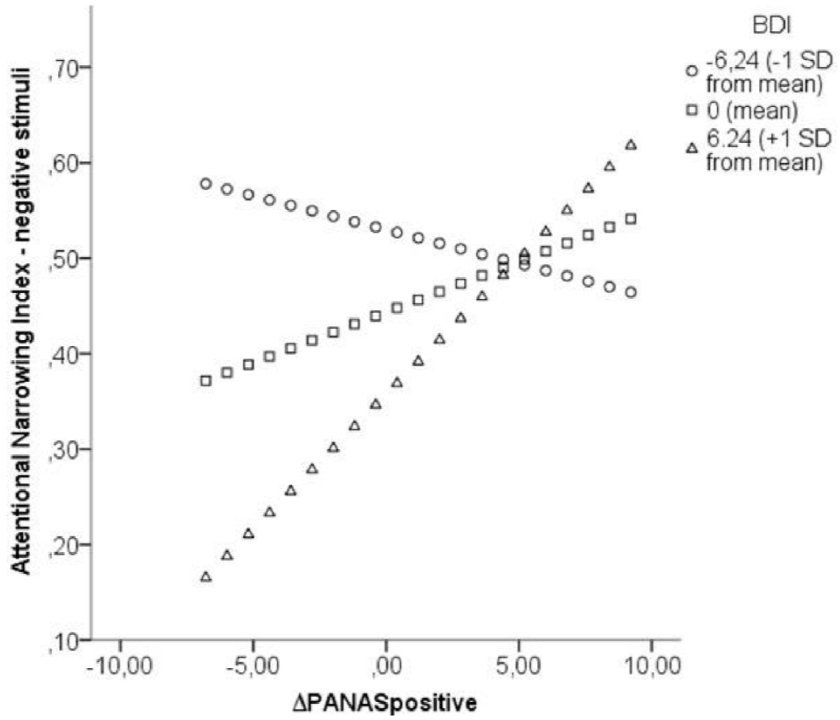

Figure 4. *Moderation effect of BDI on relation positive mood and attentional breadth for negative stimuli. Simple slope analysis on the moderation effect of BDI on the relation between ΔPANASpositive and the Attentional Narrowing Index for negative central stimuli. Regression lines were plotted by substituting low, moderate, and high values of BDI scores using Hayes and Matthes' SPSS macro (Hayes & Matthes, 2009).*

Results of the moderation analysis on ANInegative showed only a trend for a moderation effect, t = 1.77, p = .086, with an added explained variance to the model of ΔR^2 = .08. Simple slope analyses (see Figure 4) revealed only a near significant positive relation between the change in positive mood and attentional narrowing for negative stimuli among high levels (above 1 *SD*) of BDI scores, t = 1.86, p = .072, b = .03. Such a relation was absent (i.e. nonsignificant) among moderate levels (mean) of BDI scores, t = 1.08, p = .287, b = .01, and among low levels (below 1 *SD*) of BDI scores, t = -0.56, p = .578, b = -.01. These results indicate that the level of depressive symptoms only tends to influence the relation between change in positive mood and attentional narrowing for negative stimuli. Only among high levels of BDI scores we found a trend for a bigger increase in positive mood to be related to more attentional narrowing for negative stimuli.

Discussion

The aim of the current study was to investigate the relationship between positive mood and attentional breadth and to investigate whether this would interact with the emotional valence of the stimuli in the target of attention. Based on previous results from Wadlinger and Isaacowitz (2006) we expected that positive mood would be related to attentional broadening but specifically when the information in the target of attention is positive. However, our results did not confirm previous research as no direct relation was found between positive mood and attentional breadth, neither did this depend on the emotional valence of the presented information. These results are not in line with earlier findings (e.g. Fredrickson & Branigan, 2005) which confirmed the proposed broadening effect of the broaden-and-build theory (Fredrickson, 1998; 2001). Neither are our results fully consistent with earlier findings suggesting that the broadening effects of positive emotions are dependent on the emotional valence of the presented information (Wadlinger & Isaacowitz, 2006).

We further investigated whether the presence and severity of depressive symptoms could have an influence on the strength of the relationship between positive mood and attentional broadening. The broaden-and-build theory (Fredrickson, 1998; 2001) postulates that positive emotions are related to broadened cognition and it has been suggested that this broadening function plays an important role in explaining the relation between positive emotions and resilience against stress and possibly mood disorders. This would suggest that resilient people can benefit more from positive emotions at the cognitive level or more specifically, show the proposed broadening effects. On the other hand, vulnerability for mood disorders such as the presence of depressive symptoms (Fergusson et al., 2005), could have opposite moderating effects. It could be that the presence and severity of depressive symptoms influence the relation between positive mood and attentional breadth by hampering the cognitive effects of positive mood. The results from the moderation analyses with the BDI as a self-report measure of the presence and severity of depressive symptoms (in the last two weeks), showed that the BDI indeed moderated the relation between positive mood and attentional breadth. Results showed that the severity of depressive symptoms reversed the proposed direction of the relation. Among high levels of BDI scores - one standard deviation above the mean which was around the cut-off score for

mild depressive symptoms (i.e. ≥ 14; Beck et al., 1996) - an increase in positive mood was related to more attentional narrowing. When analyzing the results of positive mood on a group level, that is, comparing participants from the positive and neutral MIP condition, we did not find evidence for the proposed relation between positive mood and attentional broadening among low and moderate levels of BDI scores.

However, when investigating the effects of positive mood in a more direct manner, that is, investigating the effects of the change in positive mood across the induction in the entire sample (an interindividual differences approach), we found that the BDI moderates the relationship between positive mood and attentional breadth, depending on the emotional valence of the presented stimuli. Among high levels of the BDI we found that an increase in positive mood was related to attentional narrowing when positive stimuli were presented, whereas this relation was only near significant when neutral and negative information were presented. Among moderate levels of the BDI we did not find a relation between positive mood and attentional broadening/narrowing, regardless of the emotional valence of the presented stimuli. Interestingly however, when positive stimuli were presented we found that among low levels of the BDI, reflecting minimal depressive symptoms (i.e. ≤ 13; Beck et al., 1996), a bigger increase in positive mood was related to more attentional broadening. This is in line with previous research showing the broadening effect of positive emotions solely when positive information was presented (Wadlinger & Isaacowitz; 2006), except that results from our study indicate that individual characteristics, such as depressive symptoms, should be considered as well.

The current results on the moderating effect of depressive symptoms showed that among high levels of the BDI, around the cut-off for mild depressive symptoms (Beck et al., 1996), an increase in positive mood was related to attentional narrowing when positive stimuli were presented (although near significant for neutral and negative stimuli). This contrasts the broadening hypothesis, but could be seen in light of recent studies suggesting a flexible link between affect and attentional scope (Huntsinger, 2012; 2013; Huntsinger, Clore, & Bar-Anan, 2010). This theoretical view proposes that affect, instead of having fixed effects on cognition, provides information about the attentional orientation that is most accessible or dominant at that moment (Clore & Huntsinger, 2007; 2009; Huntsinger, 2013). That is, positive affect is believed

to act as a "go signal" for the use of the currently available or dominant mode of processing, while negative affect acts as a "stop signal" inhibiting this process (Huntsinger, 2012; 2013). Evidence for this view was found in two recent studies showing that positive mood encouraged either a global or local attentional focus, depending on which focus was made momentarily dominant by a priming procedure (Huntsinger, 2012; Huntsinger, Clore, & Bar-Anan, 2010). As depressive symptoms have previously been related to a local bias, which is related to a narrow attentional scope, and inversely related to a global bias, which is related to a broadened attentional scope (Basso, Schefft, Ris, & Dember, 1996), it is possible that the positive mood induction in the current study encouraged the more dominant narrow attentional focus among higher BDI scores. However, this is just a tentative explanation and further research would be necessary to investigate the interactive relations between individual characteristics, momentary mood and cognition.

In the current study we investigated how the presence of depressive symptoms would influence the cognitive effects of positive emotions, but a possible limitation of this study is the fact that we tested an unselected student sample which limited the number of participants with higher BDI scores. However, in the simple slope analyses, results are calculated at a high level of BDI scores – one standard deviation above the sample mean – which in the current sample was around the cut-off score for mild depressive symptoms (Beck et al., 1996) from where individuals are usually considered to be dysphoric. Moreover, previous studies (e.g. Fergusson et al., 2005) have shown that subthreshold levels of depression are a risk factor for the development of later depression. Thus, given that our results show a moderation effect of the BDI on the relation between positive mood and attentional breadth, it seems that interindividual variability in mostly nonclinical BDI scores already influences the strength and direction of the relation between positive emotions and cognition.

In summary, we did not find evidence that positive mood was directly related to attentional broadening, neither that this was influenced by the emotional valence of the information presented. However, moderation analyses revealed a moderation effect by the presence of depressive symptoms. Among low levels of BDI scores, reflecting minimal depressive symptoms, we did observe a relation between an increase in positive mood and attentional broadening specifically when positive stimuli

were presented in the target of attention. Among moderate levels of BDI scores such a relation was absent regardless of the valence of the presented stimuli, while among high levels of BDI scores, around the cut-off for mild depressive symptoms, a reversed relation was observed with an increase in positive mood being related to attentional narrowing. This shows that individual characteristics such as the presence and severity of depressive symptoms, which indicate a vulnerability for mood disorders, influence the strength and even direction of the relation between positive mood and attentional breadth. Current results suggest that the cognitive broadening effects of positive emotions are not so straightforward and could be influenced by several factors like characteristics of the information presented, but also by individual characteristics such as the presence of depressive symptoms which have a hampering effect.

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CHAPTER 4

The influence of psychological resilience on the relation between automatic stimulus evaluation and attentional breadth for surprised faces[1]

Abstract

The broaden-and-build theory relates positive emotions to resilience and cognitive broadening. The theory proposes that broadening effects underly the relation between positive emotions and resilience, suggesting that resilient people can benefit more from positive emotions at the level of cognitive functioning. Research has investigated the influence of positive emotions on attentional broadening, but the stimulus in the target of attention may also influence attentional breadth, depending on affective stimulus evaluation. Surprised faces are particularly interesting as they are valence ambiguous, therefore, we investigated the relation between affective evaluation –using an affective priming task- and attentional breadth for surprised faces, and how this relation is influenced by resilience. Results show that more positive evaluations are related to more attentional broadening at high levels of resilience, while this relation is reversed at low levels. This indicates that resilient individuals can benefit more from attending to positively evaluated stimuli at the level of attentional broadening.

[1] Based on Grol, M., & De Raedt, R. (2014). The influence of psychological resilience on the relation between automatic stimulus evaluation and attentional breadth for surprised faces. *Cognition & Emotion.* doi: 10.1080/02699931.2014.895299

Introduction

A central theory on positive emotions, the broaden-and-build-theory (Fredrickson, 1998), proposes positive emotions to be related to resilience and to broadening of people's thought-action repertoires. The idea that positive emotions are related to resilience has been supported by research showing that the experience of positive emotions, especially among high-resilient people, facilitates stress recovery after a negative emotion induction (Tugade & Fredrickson, 2004) and in response to naturally occuring stressors (Ong, Bergeman, Bisconti, & Wallace, 2006). The broadening function of postive emotions has also received support from research associating positive emotions to increased creativity, social openness, and visuospatial attentional breadth (for review, see Garland et al., 2010). The effects on attentional broadening are not always consistent though (Bruyneel et al., 2012), and indicate that more research is necessary into possible conditional factors.

Importantly, the broaden-and-build theory states that the cognitive broadening effects of positive emotions underlie the relation between positive emotions and resilience (Fredrickson, 1998). This suggests that especially resilient people can benefit from positive emotions at the level of cognitive functioning. That is, if the cognitive broadening effects of positive emotions underlie (the development of) resilience, then especially those individuals who have actually developed more resilience would show stronger cognitive responses to positive emotions. Furthermore, research on mood disorders has in recent years shifted its focus to investigating not only negative emotion regulation but also positive emotion regulation. Even more studies are showing that mood disorders are related to a disrupted regulation of positive emotions with, for example, depression being associated with avoidance and down regulation of positive emotions (for review see Carl, Soskin, Kerns, & Barlow, 2013). It is possible that this disrupted regulation of positive emotions depending on levels of depressive symptoms, reflecting lower levels of psychological resilience, extends to a dysregulation of effects of positive emotions on an information-processing level. Previous studies investigating the broadening effects of positive emotions have, however, not taken into account interindividual variability in (trait) characteristics and how this could influence the relationship between positive emotions and cognition, specifically attentional breadth. The broaden-and-build theory (Fredrickson, 1998) was developed from a resilience

perspective and proposes attentional broadening effects of positive emotions to underlie resilience, suggesting that especially highly resilient people show attentional broadening in response to positive emotions. Therefore we aimed at testing the moderating influence of psychological (trait) resilience on the relation between positive emotion and attentional breadth, as it is possible that the strength of this relationship differs depending on levels of psychological resilience. To our knowledge, it has not previously been investigated whether interindividual variability in levels of psychological resilience influences the relationship between positive emotions and attentional breadth. That is, whether the effects of positive emotions on an attentional processing level are different (or disrupted) depending on levels of psychological resilience.

When investigating conditional factors affecting the attentional broadening effects of positive emotions, it does not only seem relevant to take into account interindividual variability of (trait) characteristics like psychological resilience, but also to investigate the influence of the presented, processed stimulus when measuring attentional breadth. While in most studies investigating the attentional broadening effects of positive emotions, mood was manipulated and then a non-emotional attentional breadth task was administrated, a previous study found that positive mood interacted with the valence of the presented stimulus by showing that positive mood broadened attention only for positive stimuli (Wadlinger & Isaacowitz, 2006). This suggests that the presented stimulus in itself – without additional manipulation of mood - may also influence attentional breadth depending on its emotional valence. Following from the effect of positive emotions on attentional broadening, it may be that the processing of positively evaluated stimuli is related to attentional broadening when those stimuli are the target of attention. However, this direct effect of the presented stimuli on attentional breadth for those stimuli has not yet been tested.

The aim of the current study was to investigate how the processing of stimuli influences attentional breadth for these stimuli, depending on their affective valence and how this effect is influenced by resilience. Emotional stimuli that are particularly useful in investigating this effect are surprised faces, not because of the discrete emotion of surprise itself, but whereas most emotional expressions reveal information regarding the valence of their eliciting context, this remains ambiguous for surprised

expressions. In other words, one can be either pleasantly or unpleasantly surprised, but a surprised expression itself does not immediately predict the valence of the eliciting event or outcome (Kim, Somerville, Johnstone, Alexander, & Whalen, 2003; Tomkins & McCarter, 1964). This implies that people can vary in how they perceive surprised faces, as having more negative or more positive valence. Research from a related domain (affective neuroscience) has shown that the neural activation pattern in response to viewing surprised faces, contrasted to neutral faces, was dependent on the emotional rating of these faces (Kim et al., 2003). Kim and colleagues (2003) found that more negatively rated surprised faces were related to greater right ventral amygdala activity, a subcortical region implied in the processing of negative emotions, whereas more positively evaluated faces were related to greater activity in the ventral medial prefrontal cortex, a region that has a regulatory input to the amygdala. These results indicate that variation in the affective evaluation of surprised faces as more positive or negative can influence the effects elicited by viewing them. This characteristic of surprised facial stimuli, their valence ambiguity, makes this stimulus category very useful when investigating whether the processing of stimuli can directly influence attentional breadth, depending on their affective evaluation. Using variability in affective evaluation of one type of stimuli has a methodological advantage over, for example, comparing the attentional broadening effects of happy versus sad facial stimuli, because differences in basic visual characteristics of these two types of stimuli may also influence attention. Regarding the question of whether stimuli can directly influence attentional breadth depending on their valence, we hypothesized that evaluating surprise faces as more positive will evoke more attentional broadening when surprised facial expressions are presented, in line with the proposed broadening effects of positive emotions.

We examined the effects of the affective evaluation of (surprised) stimuli on attentional breadth using an affective priming paradigm, measuring affective evaluation in a more implicit manner. Attentional breadth was measured using a performance-based measure which has been used before to measure fluctuations in attentional breadth related to centrally presented stimuli (Bosmans, Braet, Koster, & De Raedt, 2009). We included a contrast category of neutral faces for methodological reasons as participants have to correctly identify the centrally presented stimulus (surprise versus

neutral) in this task. Moreover, including neutral faces as an additional category in both tasks allowed us to investigate the specificity of the effect.

We hypothesized that the processing of surprised stimuli when evaluated as more positive, indicated by the affective priming paradigm, would be related to more attentional broadening when these faces are presented. Furthermore, we hypothesized that this relationship would be influenced by resilience, with high resilience scores being associated with a stronger relation between affective evaluation of stimuli and attentional narrowing/broadening when these stimuli are presented.

Method

Participants

Fifty-one undergraduates (45 females) aged between 18 and 34 years (*M* = 22.37, *SD* = 3.42) participated in this study and were paid for their participation. Participants were recruited through an experiment website where students can voluntarily sign up for participation in psychology experiments. The sample size was based on previous experience with the attentional breadth task and all data exclusions are reported. All measures used in the study are described, except for the BIS/BAS scales (Carver & White, 1994) which were used for explorative reasons not related to the hypotheses of this study. This experiment was approved by the local ethical committee of the Faculty of Psychology at Ghent University.

Materials

Questionnaire measures. Both trait and state affect were measured with the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Participants were asked to rate the degree to which they felt the emotions "*at this moment*" for the state version and "*in general*" for the trait version on a scale ranging from 1 "very slightly" to 5 "very much".

To assess the presence of depressive symptoms, we used the self-report Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996; Van der Does, 2002).

Trait anxiety was measured with the State and Trait Anxiety Inventory (STAI-trait; Spielberger, Gorsuch, Lushene, Vagge, & Jacobs, 1983; Van der Ploeg, Defares, & Spielberger, 2000). Participants are asked to rate how they feel "*in general*" on a 4-point scale ranging from "almost never" to "almost always".

Trait resilience was measured using the Dutch Resilience Scale (RS-nl; Portzky, 2008). This scale consists of 25 items asking participants to rate to what degree they agree or disagree with statements on a 4-point scale ranging from “totally disagree” to “totally agree”. Two subscales can be calculated, Personal Competence and Acceptance of Self and Life. The subscale Personal Competence consists of 17 items and represents self-confidence, independence, determination, resourcefulness, and self-reliance. The subscale Acceptance of Self and Life consists of 8 items and represents equanimity, adaptability, acceptance of life as it comes, and a balanced perspective of life (Portzky, 2008). The RS-nl has shown to have good internal consistency with a Cronbach’s alpha of α = 0.85, the subscale Personal Competence also showed good internal consistency, α = 0.81, and the subscale Acceptance of Self and Life revealed acceptable internal consistency, α = 0.68 (Portzky, Wagnild, De Bacquer, & Audenaert, 2010). Cronbach’s alpha levels from the current study sample were comparable. The RS-nl showed good internal consistency, α = 0.85, as did the subscale Personal Competence, α = 0.81. The subscale Acceptance of Self and Life revealed acceptable internal consistency, α = 0.70.

Attentional breadth task. Attentional breadth for surprised and neutral faces was measured using a paradigm based on a task developed by Bosmans et al. (2009). This task was adjusted to measure attentional narrowing/broadening in relation to surprised and neutral facial stimuli. In each trial, a picture of a face without hairline appeared in the center of the screen, see Figure 1. Sixteen surprised and 16 neutral faces were selected from the Karolinska Directed Emotional Faces database (Lundqvist, Flykt, Ohman, 1998), based on a valence and arousal rating obtained from prior validation (Goeleven, De Raedt, Leyman, Verschuere, 2008). An equal number of male and female faces was selected within each condition. Surprised and neutral faces were randomly presented, intermixed throughout the task. Simultaneously with presentation of the central picture, 16 gray dots with a 2 cm diameter appeared around the picture in two concentric circles (eight per circle). The closest circle appeared at 4.5 cm from the central face at 10° of the visual angle, the furthest circle appeared at 11.2 cm from the central face at 25° of the visual angle. The gray dots were arranged in pairs of two, one close and one far, situated on one of eight imperceptible axes. Simultaneously with presentation of the picture and gray dots, a smaller, black circle with a diameter of 1.3 cm appeared in one of the gray dots, either close or far. This smaller circle was the

target stimulus participants had to identify. After presentation of the stimuli, participants were first asked to identify the central stimulus (i.e. neutral or surprised) and second to identify the axis on which the target stimulus (i.e. the smaller black circle) had appeared. Participants used the mouse to click on the corresponding buttons on the screen.

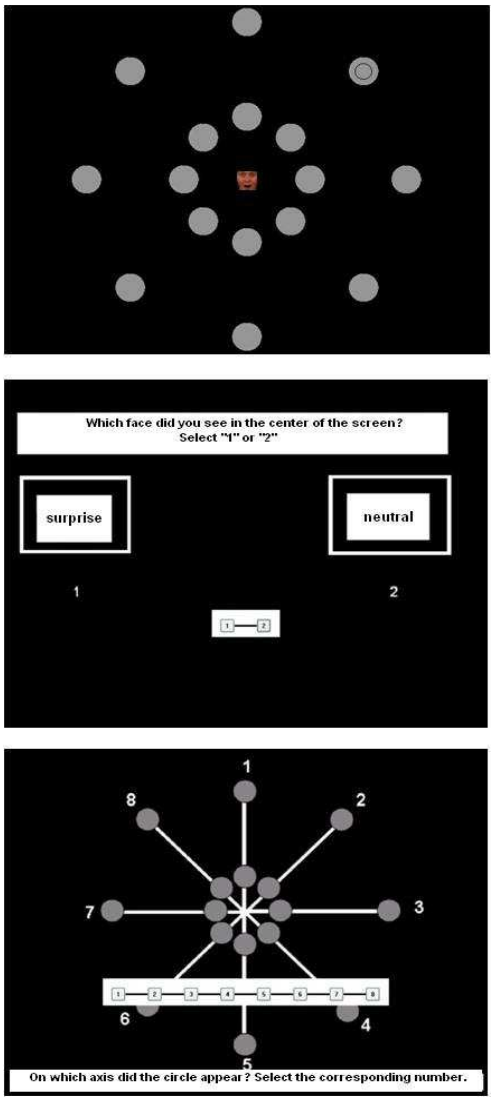

Figure 1. *Stimulus presentation of the Attentional Breadth Task. The gray dots are presented in pairs of two, simultaneously with the central face and the peripheral target stimulus. The first response screen asks participants which face they have seen. The second response screen asks participants on which of eight axes the target stimulus was presented.*

The main dependent variable was the proportion of correctly localized target stimuli, on trials in which participants also correctly identified the central stimulus. This

was to make sure participants maintained attention to the center of the screen during the task. From this we calculated an index of Attentional Narrowing (ANI = accuracy target stimulus close to face - accuracy target stimulus far from face) for both surprise trials (ANIsurprise) and neutral trials (ANIneutral). The more positive this score, the more attentional narrowing for the centrally presented stimuli. Because of our mere interest in early, automatic attentional processes, all stimuli were presented simultaneously for 68 msec in order to avoid confounds of saccadic eye movements in search of the peripheral target (Ball, Beard, Roenker, Miller, & Griggs, 1988). That is, the central and peripheral stimulus are shown at the same time for a short presentation time, to avoid individuals to perform a (serial) visual search for the peripheral target.

Affective priming. An affective priming paradigm was used to infer participants' affective evaluations of surprised and neutral stimuli categories, as this paradigm has been widely studied and used in assessing people's (implicit) attitudes to and evaluations of certain categories of stimuli (for a review, see De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009). Affective priming is based on the idea that people are faster at evaluating a target stimulus if that target is preceded by a prime stimulus of similar valence, compared to when a target is preceded by a prime with a different valence.

Each trial in the task consisted of presentation of a fixation cross for 500msec, followed by a blank screen for 500msec. Subsequently, the prime was presented for 200msec, followed by a blank screen for 50msec before the target was presented until a response was given, or the target disappeared automatically after 2sec if no response was given. The time between trials varied randomly between 500, 1000, or 1500msec. All stimuli were presented in the center of the screen. Primes consisted of the 16 surprised and 16 neutral faces which were shown in the attentional breadth task (384 x 384 pixels), or 8 different filler-images of geometrical shapes on a light blue background (512 x 384 pixels). Targets were five positive (baby, teddy bear, dolphin, kitten, bride) and five negative (explosion, skulls, gun, worms, corpse) colour pictures (512 x 384 pixels) based on targets used by Spruyt, Hermans, De Houwer, and Eelen (2002, experiment 3).

Participants were instructed that positive or negative pictures would be presented which are preceded by pictures of either surprised or neutral faces which

they had seen before, or images of geometrical shapes. Participants were told that they should focus their attention on the second image as the task consisted of identifying the second image as positive or negative as fast as possible. People are expected to be faster in evaluating the target when it has been preceded by prime of similar valence. We calculated an affective prime score for the surprise (APTsurprise) and neutral (APTneutral) condition separately, for example: (surprise-negative – surprise-positive) - (filler-negative – filler-positive). This score reflects the difference in reaction time for identifying the target as negative compared to identifying the target as positive when these targets were preceded by a surprise face (the prime), corrected for the main effect of target valence (fillers). A more positive score indicates that the participant was faster at correctly identifying a target as positive than correctly identifying a target as negative when the targets were preceded by a surprised face, suggesting that the participant evaluated the prime stimuli (i.e. the surprise stimuli) as more positive based on the idea of affective priming. That is, based on the idea that people are faster at evaluating a target stimulus if that target is preceded by a prime stimulus of similar valence.

Procedure

After informed consent, all participants filled out the PANAS state questionnaire, followed by the attentional breadth task. Participants were seated at a distance of 27 cm from a 19" CRT-computer screen, using a chin rest to ensure correct positioning. The task consisted of eight practice trials with a presentation time of 250 msec to allow participants to get acquainted with the task, followed by eight practice trials with a presentation time of 68 msec. The test phase consisted of 128 trials, with four types of trials: surprise-close, surprise-far, neutral-close and neutral-far which were randomly presented in two blocks consisting of 64 trials each. Following this, participants performed the affective priming task. The task consisted of 10 practice trials in which participants only had to identify the target pictures as positive or negative. Five positive and five negative pictures were randomly presented with the restriction that the same picture was never presented consecutively. This was followed by 12 practice trials in which the target was preceded by the prime, similar as in the test phase. The test phase consisted of 144 trials, with six types of trials: surprise-positive, surprise-negative, neutral-positive, neutral-negative, filler-positive and filler-negative which were

randomly presented in two blocks of 72 trials each. Within each type of trial, the prime was randomly selected from the list of surprise, neutral, or filler images with the restriction that each image from the list was presented at least once and that the same picture was never presented consecutively. After the test phase participants were also asked to rate three neutral and three surprised faces randomly drawn from the list. Ratings were made on a 9-point Likert scale ranging from 1 "negative" to 5 "neutral" to 9 "positive". Finally, participants were asked to fill out the other questionnaires.

Results

Participant Characteristics

Means and standard deviations for all variables are presented in table 1.

Table 1.

Participant characteristics

	M (SD)
Age	22.37 (3.42)
PANAS state Positive	32.18 (5)
PANAS state Negative	12.76 (3.94)
PANAS trait Positive	35.25 (4.88)
PANAS trait Negative	16.76 (4.98)
BDI-II	6.55 (6.35)
RS total	78.88 (8.23)
RS personal competence	54.96 (5.78)
RS acceptance	23.92 (3.43)
STAI-trait	37.75 (9.30)

Stimulus Evaluation And Attentional Breadth

Preliminary analyses. To ensure that participants focused on the center of the screen during the attentional breadth task we deleted all trials in which the central face was incorrectly identified. This resulted in deleting an average of 4.09% of the trials. When calculating the reaction times in the affective priming paradigm, only correct trials were taken into account, and for each type of trial separately (i.e. surprise-pos, surprise-neg, neutral-pos, neutral-neg, filler-pos, filler-neg) reaction times that fell

2.5*SD*s below or above a persons' mean reaction time were discarded. The percentage of deleted trials for all different trial types ranged between 5.72-6.86% and no differences in accuracy were found between conditions, nonparametric Wilcoxon Signed Ranks tests all *p*s > .10.

We explored whether state and trait affectivity, depressive symptoms, trait anxiety, and trait resilience had an influence on emotional evaluation and attentional breadth. Although the literature is mixed, negative affect and depressive symptoms have been related to a more local attentional scope (Basso, Schefft, Ris, & Dember, 1996). If these variables would have an influence on attentional breadth, this should be taken into account as this could obscure the relation between attentional breadth and the emotional evaluation of the facial stimuli. However, a priori exploration of the data revealed no significant correlations between the questionnaire measures and the ANI, all *p*s > .05[2]. For the APT scores, only PANAS negative trait affectivity and STAI trait anxiety were negatively related to the affective priming score for neutral faces, $r = -.28$, $p = .045$ and $r = -.32$, $p = .024$ respectively. RS-nl total trait resilience was positively related to the affective priming score for neutral faces, $r = .29$, $p = .036$. This indicates that people who report to generally experience more negative affect and anxiety automatically evaluate neutral faces as more negative, while more resilient people evaluate neutral faces as more positive.

Affective priming scores for surprised and neutral faces were significantly correlated, $r = .51$, $p < .001$, indicating that people who perceive surprised faces as more positive also show this for neutral faces. Furthermore, there was also a significant correlation between the attentional narrowing index for surprised and neutral faces, $r = .70$, $p < .001$, indicating that relative attentional narrowing/broadening shows a similar pattern for surprise and neutral faces. A paired t-test showed that there is no significant difference between affective priming scores for surprised faces ($M = -1.07$, $SD = 31.69$) and neutral faces ($M = 3.05$, $SD = 27.46$), $t(50) = 0.99$, $p = .325$. The ANI index of attentional narrowing for surprised faces ($M = 0.47$, $SD = 0.14$) and neutral faces ($M = 0.48$, $SD = 0.15$) did not significantly differ either, $t(50) = 0.32$, $p = .753$. The APT scores

[2] BDI and STAI-trait scores were square root transformed. For the RS-nl acceptance subscale, PANASstate positive and negative, and PANAStrait positive and negative, nonparametric Spearman correlations were calculated.

for surprised faces ranged from -75.48msec to 95.83msec, and for neutral faces from -56.56msec to 63.75msec. The average APT score for surprised faces did not differ from zero, $t(50) = 0.24$, $p = .811$, nor for neutral faces, $t(50) = 0.79$, $p = .431$. This indicates that both categories of faces were averagely evaluated as neutral, but the range of scores and standard deviations indicate there was variance between participants in whether they rated surprised and neutral faces as more negative or more positive.

Stimulus evaluation and attentional breadth. Relations between automatic stimulus evaluation and attentional narrowing indices were investigated for surprised and neutral stimuli separately. There was no significant correlation between the affective priming score and the attentional narrowing index for Surprise trials, $r = -.11$, $p = .440$, nor for Neutral trials, $r = .10$, $p = .490$. We also investigated the relation between the explicit ratings and the attentional narrowing index, but no significant correlation was found for Surprise trials, $r = -.004$, $p = .977$, nor for Neutral trials, $r = -.01$, $p = .954$.

Moderation effects of trait resilience. We further investigated moderation effects of trait resilience on the relation between stimulus evaluation and attentional breadth. A hierarchical multiple regression analysis was performed to test moderation effects, following the approach of Aiken and West (1991). The APT scores and RS-nl scores were centered and the interaction was calculated by multiplying the centered APT and RS-nl scores. In the regression analysis on the ANI score, the centered variables were entered as predictors in a first step and the interaction term in the second step of the analysis. Results from this analysis revealed that the RS-nl did not significantly moderate the relation between the APT score and ANI score for neutral faces. The RS-nl total score near significantly moderated the relation between the APT score and the ANI score for surprised faces, $t = -1.84$, $p = .071$, observed power .44; however, the specific subscale Personal Competence significantly moderated this relation, $t = -3.22$, $p = .002$, observed power .88, and added an explained variance to the model of $\Delta R^2 = .18$[3].

[3] Results are reported for the moderation analysis after exclusion of 2 cases that strongly influence the model as indicated by scores above 1 on the DfFIT fitting index. As both APT and ANI scores for surprised and neutral stimuli were correlated, we performed additional analyses to investigate the specificity of the moderation effect. However, resilience did not moderate the relation between APTsurprise and ANI for neutral faces, nor vice versa, all interaction terms *p*s > .10.

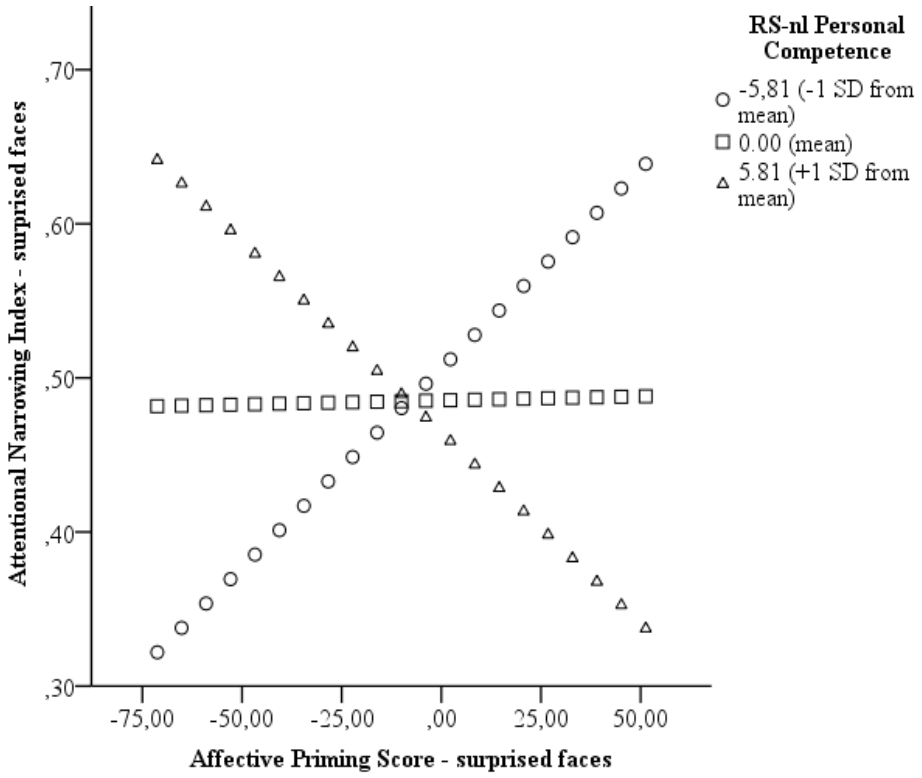

Figure 2. *The regression lines derived from estimating the different conditional effects of the APT score (i.e. stimulus evaluation) for surprised faces on the ANI index (i.e. attentional narrowing index) for surprised faces at low, average, and high values of Personal Competence. This plot was derived using Hayes and Matthes' SPSS macro (2009).*

To better understand this moderation effect, we estimated and plotted different conditional effects of the focal predictor on the outcome variable at low (one SD below the mean), moderate (sample mean), and high (one SD above the mean) values of the moderator, using Hayes and Matthes' SPSS macro (2009), see Figure 2. Results show a positive relation between the APT score and ANI score for surprised faces at low levels (below 1 SD) of personal competence, t = 2.26, p = .029, b = .003, while a negative relation was found at high levels (above 1 SD) of personal competence, t = -2.63, p = .012, b = -.003. Such relation was nonsignificant at a moderate level (mean) of personal competence, t = -0.08, p = .940, b < .001. This indicates that more positive automatic evaluation of surprised faces was related to more attentional broadening for surprised faces among high levels of personal competence, in line with the broaden-and-build theory. However, among low levels of personal competence this relation was reversed with more positive evaluation of surprised faces being related to more attentional narrowing for surprised faces. Trait resilience did not moderate the relation between

the explicit rating of surprised faces and attentional breadth for surprised faces. Resilience moderated the relation between the explicit rating and attentional breadth for neutral faces, t = 2.06, p = .045. However, simple slope analyses revealed no significant relation between the explicit ratings and attentional breadth at any level of the moderator.

Discussion

This study aimed at investigating the effect of the emotional evaluation of surprised faces on attentional breadth for this category of stimuli and whether this effect is influenced by psychological resilience. We hypothesized that a more positive evaluation of surprised faces would be related to attentional broadening when surprised faces are the target of attention, but that this relation would be especially apparent among highly resilient people.

First, there was no correlation between attentional breadth or affective stimulus evaluation for surprised faces and resilience as such. Moreover, based on the first analyses in this study, no direct relation was found between the automatic affective evaluation and attentional breadth for surprised faces. However, this relation was moderated by resilience, specifically feelings of personal competence. As predicted, we found that a more positive evaluation of surprised faces was related to more attentional broadening when surprise stimuli were presented, among high levels of personal competence. However, this relation was absent with average levels of personal competence and even reversed among low levels, with a positive evaluation being related to attentional narrowing. These results show it is not the processing of surprise stimuli itself that is related to attentional broadening per se, but the effect of surprise stimuli on attentional breadth, relative narrowing or broadening, was depending on the interaction between levels of resilience and how the valence of surprise stimuli was perceived. The results among high levels of personal competence are in line with the broaden-and-build theory (Fredrickson, 1998) and show that not only being in a positive mood can influence attentional breadth, but that the processing of positively evaluated emotional stimuli itself is also related to more attentional broadening. However, this relation was reversed among low levels of personal competence. Although we did not necessarily expect a reversed relation, this result could be viewed in light of recent research proposing a more complex link between

affect and attentional breadth (Huntsinger, 2013). Affect is proposed to provide information on the attentional orientation that is most dominant at that moment, suggesting that negative affect acts as a "stop signal" while positive affect acts as a "go signal" for use of the momentarily dominant mode of processing (Huntsinger, 2013). Although there is no immediate evidence suggesting that for highly resilient people attentional broadening is the more dominant attentional orientation, this would be in line with the broaden-and-build theory (Fredrickson, 1998) proposing that attentional broadening by positive emotions underlies the building of personal resources and resilience. On the other hand, vulnerability factors like depressive symptoms or trait rumination, which reflect lower levels of resilience, have been linked to a more local or narrow attentional orientation (Basso et al., 1996; Whitmer & Gotlib, 2013). Therefore, a tentative explanation for the reversed relation at high and low levels of resilience might be that processing of more positively evaluated emotional stimuli encouraged the continuation of the more dominant attentional orientation mode (and more negatively evaluated stimuli being more related to the lesser dominant attentional orientation mode given the nature of the linear relation). However, more research would be necessary to test this.

Although there was a correlation for both attentional breadth and affective priming between neutral and surprise faces, we found the moderated relation between stimulus evaluation and attentional breadth specifically for surprised stimuli but not for neutral stimuli. This may be due to the specific characteristic of surprised expressions, which is an emotional expression but as there is uncertainty about the valence of the elicited context or outcome it can be perceived as having positive or negative valence. Among high resilience levels, more attentional broadening in response to surprised faces was shown when these were evaluated more positively, in line with the idea of the broaden-and-build theory that positive emotions broaden attention. This attentional broadening may reflect some kind of exploratory behavior in case the stimuli are seen as more positive or 'safe', while more negative evaluations were related to more attentional narrowing. The broaden-and-build theory (Fredrickson, 1998) ascribes an important role to the broadening effects of positive emotions in the relation between positive emotions and resilience. It proposes that resilient people can use positive emotions to undo the effects of stress responses and over time build

personal resources by experiencing positive emotions, through the broadening effects of positive emotions. Interestingly, this suggests that it is resilient people that can benefit from the experience of positive emotions at a cognitive level. Indeed, we found the relation between evaluation of surprised faces and attentional breadth in the presence of surprised faces, specifically amongst high levels of personal competence. The subscale Personal Competence represents characteristics as self-confidence, independence, determination, resourcefulness, and self-reliance. These are individuals who believe in their own strengths and competences to cope with difficult situations, which may guide future behavior in dealing with issues, that seem to 'cognitively respond' by attentional narrowing/broadening to the emotional information presented at hand, depending on how this information is evaluated. The Acceptance of Self and Life subscale was not related to attentional broadening, although this may be caused by the lower reliability of this subscale.

A possible limitation to this study is the fact that we measured psychological resilience with a self-report questionnaire assessing how people generally behave or think, instead of assessing resilience following a stressor. However, self-reported resilience, has shown to account for variation in the emotional response to daily stressors (Ong et al., 2006). For future studies it may be interesting to measure stress reactivity and see how this influences the relation between positive emotions or evaluation of stimuli and attentional breadth.

Secondly, the effect we found could be explained by the fact that viewing surprised faces (even though interleaved with neutral faces) influences general mood when evaluated as more positive or negative, which then would cause the effect on attentional breadth. However, this seems unlikely as we would then expect a more general effect on attentional breadth for both surprised and neutral stimuli, which was not the case. We specifically found a moderated relation between the evaluation of surprised faces and attentional breadth when surprised faces were presented, suggesting that fluctuations in attentional breadth were related to the value of the target of attention.

In summary, we found that the affective evaluation of stimuli can influence attentional breadth when presented with those stimuli. Specifically among high levels of personal competence, there is a relation between more positively evaluating

surprised faces and more attentional broadening when surprised faces are presented, while this relation was reversed among low levels of personal competence. This suggests that specifically highly resilient people seem to be able to benefit – in the form of attentional broadening - from attending to information that they automatically evaluate as more positive.

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CHAPTER 5

The effects of rumination induction on attentional breadth for self-related information[1]

Abstract

The recently developed attentional scope model of rumination describes the links between rumination (repetitive negative thought) and attentional breadth. The model postulates that a more narrow attentional scope, caused by negative mood, increases the likelihood that thoughts become repetitive on the same topic, which in turn could exacerbate negative mood and lead to more attentional narrowing, turning it into a vicious cycle. We aimed to experimentally test this model by examining the attentional effects of rumination using a newly developed rumination- versus problem-solving induction. In the first experiment an effect was found on attentional breadth for self-related contrasted to other-related information, but this effect was qualified by trait rumination. Only at high levels of trait rumination, induction of rumination compared to a problem-solving approach was associated with more attentional narrowing for self-related information. A second experiment on the relationship between trait rumination and attentional breadth in the absence of induced rumination, revealed that especially trait brooding was related to more narrowed attention for self-related information. Results provide partial confirmation of the attentional scope model of rumination.

[1] Based on Grol, M., Hertel, P., Koster, E.H.W., & De Raedt, R. (2014). The effects of rumination induction on attentional breadth for self-related information. Manuscript submitted for publication.

Introduction

Rumination can be defined as repetitive, intrusive, negative thoughts, and as a mode of responding to distress. Rumination has been related to depression and even predicts (new episodes of) depression (Nolen-Hoeksema, 2000). Chronic negative affect is related to heightened self-focus and especially a ruminative self-focus, suggesting a reciprocal relation (Mor & Winquist, 2002). Indeed, it has been shown that self-focused rumination induction leads to more negative thinking and impairs interpersonal problem-solving in dysphoric people (Lyumbomirsky & Nolen-Hoeksema, 1995). Many studies have also investigated the maladaptive consequences of rumination at the level of cognitive functioning. A recent review gives an overview of these research findings with regard to control-related processes and proposes an *attentional scope model* of rumination (Whitmer & Gotlib 2013).

The attentional scope model of rumination postulates that a narrow attentional scope, caused by negative mood or low positive mood, will limit the activated thought-action repertoires. This increases the likelihood that thoughts become repetitive, for example biasing thoughts and attention to self-related information, and rumination is defined as repetitive thinking about one's feelings and problems (Nolen-Hoeksema, Wisco, & Lyubomirski, 2008). In turn this ruminative focus could exacerbate negative mood leading to attentional narrowing and more repetitive thoughts, turning it into a vicious cycle (Whitmer & Gotlib, 2013). This is in line with a more recent theory on the cognitive mechanisms of the relation between emotions and resilience, the broaden-and-build theory (Fredrickson, 1998; 2001), which proposes that positive emotions are related to a broadening of the attentional scope, whereas negative emotions are related to attentional narrowing (e.g. Derryberry & Tucker, 1994; Fredrickson & Branigan, 2005). Furthermore, trait rumination has been related to spontaneous use of perspectives low in self-distance (Ayduk & Kross, 2010). Whitmer and Gotlib (2013) therefore suggest that trait ruminators might have a more narrow attentional scope compared to non-ruminators.

The attentional scope model by Whitmer and Gotlib (2013) was based on a large number of studies which provided, however, mostly indirect evidence for attentional narrowing, because they mainly investigated working memory processes. Therefore, we aimed to further improve our understanding of the relation between rumination and

attentional breadth by directly testing whether experimentally induced rumination causes a narrowing of visuospatial attentional breadth, especially when the target of attention is self-related. We developed a new rumination induction and contrasted it to a problem-solving induction. The same negative, self-related scenario was presented to both induction conditions, with the only difference being whether people think about the situation in a ruminative or problem-solving manner. In this way we sought to reduce the likelihood of influences on attentional breadth for self-related information by factors other than the style of thinking about a self-relevant stressful situation.

In the present experiment we first investigated the effectiveness of our new developed rumination versus problem-solving induction on a measure of state rumination. We also assessed the effect of the induction on heart rate variability because previous research has shown that decreased heart rate variability is associated with the experience of stressful events and worry (Pieper, Brosschot, Van der Leeden, & Thayer, 2007). Our main research question concerned the relation between the style of thinking in response to a stressful self-related event and visuospatial attentional breadth for self-related information, compared to information that is not related to the self (other). We also examined whether trait rumination, the presence of depressive symptoms, or trait resilience qualified the effect of induced rumination on attentional breadth in our paradigm. It could be that high levels of trait rumination and depressive symptoms are associated with stronger effects of induced rumination on attentional narrowing for self-related information, in keeping with the habitual mode of processing experienced by people who ruminate when they are sad. Trait resilience on the other hand, may be related to weaker effects of induced rumination on attentional narrowing for self-related information. Additionally we tested whether trait rumination would be related to more narrowed attention in general, that is, in the absence of induced rumination, in line with predictions from the attentional scope model of rumination (Whitmer & Gotlib, 2013).

To measure attentional breadth in response to self-versus-other information, we used a performance-based task which has been used before to measure fluctuations in attentional breadth related to centrally presented stimuli (Bosmans, Braet, Koster, & De Raedt, 2009). A previous study in which the original paradigm was adjusted for our current purposes showed that an increase in positive mood was associated with

attentional broadening for self-related information when contrasted to other-related information (Grol, Koster, Bruyneel, & De Raedt, 2014). In the present study we hypothesized that inducing a ruminative way of thinking, reflecting a repetitive focus on the same topic over time, leads to a more narrowed attentional focus especially for self-related information. To investigate whether an effect of the rumination induction on attentional narrowing would be explained by changes in negative mood as proposed by Whitmer and Gotlib (2013), we also took into account changes in negative mood due to the induction.

Experiment 1

Method

Participants and design. Thirty-seven healthy undergraduates (32 females) aged between 18 and 27 years (*M* = 21.27, *SD* = 2.01) participated in this experiment and were paid €12. They were randomly assigned to the rumination or problem-solving induction task. This experiment was approved by the local ethical committee of the Faculty of Psychology at Ghent University.

Materials and tasks.

Questionnaire measures. To check whether the rumination induction had worked, we administered the Momentary Ruminative Self-focus Inventory (MRSI; Mor, Marchetti, & Koster, 2013) before and after the rumination induction. The MRSI is a six-item questionnaire measuring to what extent people are ruminating *"at this moment."* An example item is: "Right now, I am thinking about the possible meaning of the way I feel." Participants rate this on a 7-point scale ranging from "totally not agree" to "totally agree."

Mood state was measured before and after the induction procedure with the Dutch version of the Profile of Mood States (POMS; McNair, Lorr, & Droppelman, 1971; Wald, 1984). The POMS consists of 32 descriptions of feelings and participants are asked to rate how the description fits their feeling "*at this moment*" on a scale ranging from 0 "absolutely not" to 4 "very much." From these 32 items, five subscales are calculated (Depression, Anger, Tension, Fatigue, and Vigor). The Depression subscale was of primary interest in this study.

Along with mood state, we also assessed trait affectivity with the 20-item trait version of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen,

1988). Participants were asked to rate the degree to which they felt the emotions "*in general*" giving their ratings on a 5-point Likert scale ranging from 1 "very slightly" to 5 "very much."

To measure the general tendency to ruminate, we administered the Ruminative Response Scale (RRS; Nolen-Hoeksema & Morrow, 1991; Raes, Hermans, & Eelen, 2003). Participants are instructed to indicate to what extent they think or do what is described in statements on a 4-point scale ranging from "almost never" to "almost always", when the participant is feeling "… *down, sad, or depressed.*" A total score and two subscales can be calculated, Reflection and Brooding, with the former representing a more adaptive form of rumination and the latter a more detrimental form (Treynor, Gonzalez, & Nolen-Hoeksema, 2003).

To assess the presence and severity of depressive symptoms, we used the 21-item Beck Depression Inventory (BDI-II-NL; Beck, Steer, & Brown, 1996; Van der Does, 2002). The questionnaire consists of 21 statements (responses ranging from 0 to 3) and participants are asked to select the response that best describes the way the participant has been feeling during the past two weeks.

Trait anxiety was measured using the trait version of the State Trait Anxiety Inventory (STAI-trait; Spielberger, Gorsuch, Lushene, Vagge, & Jacobs, 1983; Van der Ploeg, Defares, & Spielberger, 2000). Participants are asked to rate how they feel "*in general*" on a 4-point scale ranging from "almost never" to "almost always."

Trait resilience was measured using the Dutch version of the Resilience Scale (RS-nl; Portzky, 2008). This 25 item scale asks participants to rate their agreement with statements on a 4-point scale ranging from "totally disagree" to "totally agree." The RS-nl has shown to have good internal consistency with a Cronbach's alpha of α = 0.85 (Portzky, Wagnild, De Bacquer, & Audenaert, 2010).

Attentional breadth for self-related information. To measure attentional breadth for self-related information we used a variant of a previously developed attentional breadth task (Bosmans et al., 2009) that measures fluctations in attentional breadth related to centrally presented, personally relevant stimuli. We adjusted the task in such a way that attentional breadth is measured for centrally presented self-related contrasted to other-related information (Grol et al., 2014). The word "ME" (Dutch = IK) was used as self-related stimulus and "LR" was used as the other-related

stimulus. Because of previous criticism about the use of "self" versus general "other" categories in implicit measures (e.g. Karpinski & Steinman, 2006), we used a specific stimulus that does not refer to self.[2] "LR" was described as the initials of an unknown-other participant who had already taken part in this study. None of the participants' initials were "LR."

In each trial of the experimental task a word appeared in the center of the screen, "ME" (Dutch: "IK") or "LR." Simultaneously with presentation of the central word, 16 gray dots with a diameter of 2 cm appeared around the word in two concentric circles. One circle appeared at 4.5 cm from the central word at 10° of the visual angle, the other circle appeared at 11.2 cm from the central word at 25° of the visual angle. The gray dots were arranged in pairs of two, one close and one far, situated on one of eight implicit axes. Simultaneously with presentation of the central stimulus and gray dots, a smaller, black circle with a diameter of 1.3 cm appeared in one of the gray dots, either close or far. The small black circle was the target stimulus that participants were asked to identify. After the simultaneous presentation of the stimuli, participants were asked to identify the central stimulus and to identify the axis on which the target stimulus (i.e. the smaller black circle) had appeared. Figure 1 illustrates a trial in this task.

The main dependent variable was the accuracy rate on the peripheral task (i.e. the proportion of correctly localized target stimuli) on trials in which participants also correctly identified the central word (to make sure participants maintained attention to the center of the screen during the task). Subsequently we calculated indices of Attentional Narrowing (ANI = accuracy when the black circle was close to the word minus accuracy when it was far from the word) for both ME trials and LR trials. This allowed us to calculate the ANI difference score ($\Delta ANI = ANI_{ME} - ANI_{LR}$) representing each individual's attentional breadth in response to presentation of self-related information contrasted with other-related information. Higher ΔANI scores reflect stronger attentional narrowing when the central word was self-related in contrast to when the central word was other-related.

[2] Using self versus more general "other" stimuli (e.g. ME, THEM) is problematic in that it becomes more difficult to infer that effects are driven by self-related stimuli or by the fact that other people in general (as a category) evoke attentional processes due to certain attitudes towards that category of other people. This is less likely with a non-defined but specific stimulus.

The task consisted of eight practice trials with a presentation time of 250 ms to allow participants to get acquainted with the task, followed by eight practice trials with a presentation time of 68 ms. In the test phase itself, stimuli were simultaneously presented for 68 ms in order to prevent confounds of saccadic eye movements in search of the peripheral target (Ball, Beard, Roenker, Miller, & Griggs, 1988). The test phase consisted of 96 trials of four types: ME close, ME far, LR close, and LR far. They were randomly presented in two blocks of 48 trials.

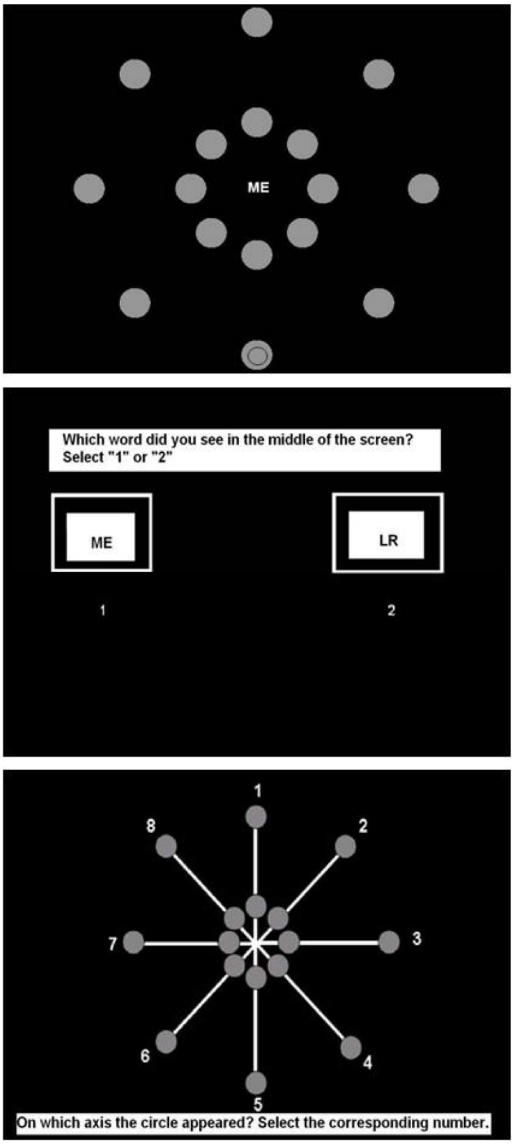

Figure 1. *Illustration of a trial in the Attentional Breadth Task. The gray dots are presented in pairs of two, simultaneously with the central word and the smaller black circle. The first response screen asks participants which word they have seen. The second response screen asks participants on which of eight axes the black circle was presented.*

Heart rate variability. Beat-to-beat heart rate was measured using a telemetric heartbeat monitor (Polar S810). Data were moderately filtered, a minimum zone of 6 beats a minute (Cottyn, De Clercq, Pannier, Crombez, & Lennoir, 2006) with the Polar Precision Performance Software for Windows and further analyzed with Kubios. This is a specialized program in analyzing heart rate and heart rate variability (Niskanen, Tarvainen, Ranta-Aho, & Karjalainen, 2004). We investigated heart rate variability (HRV) using the Root Mean Square of the Differences of Successive Intervals (RMSSD), based on the recommendations of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996). This index provides an indication of modulations in parasympathetic outflow (Kleiger, Stein, Bosner, & Rottman, 1992), and it is recommended for short-term HRV analysis (Task Force, 1996).

Thinking style induction. We provided the following self-related scenario to all participants: *The person is driving a car after a busy day. The person sits a little dazed behind the wheel and decides to put on some music. When he/she reaches for a CD from the glove box he/she suddenly hears and feels a load bang and the person is pressed hard back in the car seat. Startled and a little in shock the person gets out of the car and realizes that he/she hit a mother with two children on the bike. They are lying on the ground and it doesn't look good. Some of them seemed to have been seriously injured.*[3]

Participants were asked to first vividly imagine the scenario, experiencing the event through their own eyes, from a first person perspective, as if they are driving the car that causes the accident. Participants were then instructed to think about this situation and its consequences either in a ruminative manner, or in a problem-solving manner. Participants in both conditions received 6 different sentences of instructions, given at once on the screen. Instructions in the rumination condition were for example "think about how guilty you feel" or "think about what the consequences this has for how you see yourself." Instructions in the problem-solving condition were for example "think about which steps to take, a plan of action" or "think about which organizations could help you at this moment." Participants were asked to describe their thoughts and were instructed not to be concerned with the use of correct language or fluent sentences but to write their spontaneous thoughts as they occur. Instructions were

[3] A previous, unpublished experiment with a similar design used a scenario with less emotional impact. In that experiment, no effect of the thinking-style manipulation was found.

given via a Word document on the computer and participants typed their thoughts, starting below the instructions.

Procedure. At the beginning of the experiment participants were asked whether they had recently been involved in a traffic accident; no participant was excluded on this basis. After informed consent, participants completed the trait questionnaires. No participant was excluded on the basis of a BDI-II-NL score greater than 29. Next, we put on the telemetric heartbeat monitor and measured a 20-min heart rate baseline in which participants were asked to relax. After this baseline period we continued beat-to-beat heart rate registration throughout the rest of the experiment, but the critical time period was during the thinking-style induction. After the baseline heart beat registration, the POMS and MRSI were administered. Then participants received either the rumination or problem-solving induction. A total of 10 min were allocated to both imagining the scenario and describing their thoughts. After the induction, the MRSI and POMS were administered again, followed by the attentional breadth task. For the attentional breadth task, participants were seated at a distance of 27 cm from a 19-in CRT-computer screen, using a chin rest to ensure correct positioning. At the end of the experiment, participants in the rumination condition also received the problem-solving induction for ethical reasons. Finally, participants were fully debriefed about the experiment.

Results

Preliminary analyses. All trials on the attentional breadth task were deleted in which the central word was identified incorrectly, to ensure that participants were focusing on the center of the screen during the task; an average of 2.93% of the trials were deleted. Due to non-normality of the data, a Mann-Whitney nonparametric test was performed to test for differences between induction conditions. No induction-related differences were found in terms of the percentages of trials that were deleted, $U = 169$, $p = .964$.

For the heart rate baseline data, we analyzed the data from only the last 10 min of the 20-min baseline period. This way, arousal due to starting to measure heart rate was excluded in the baseline. The duration of the baseline heart rate registration was of similar length as the heart rate registration during the thinking-style induction.

Table 1.

Participant characteristics

	Rumination (*n* = 19)	Problem-solving (*n* = 18)	No induction (*n* = 26)
	M (*SD*)	*M* (*SD*)	*M* (*SD*)
Age	21.21 (1.96)	21.33 (2.11)	23.19 (5.41)
Gender	16 females	16 females	22 females
PANAS trait positive	34.37 (5.68)	32.78 (7.65)	34.38 (5.46)
PANAS trait negative	17.24 (4.61)	17.94 (7.33)	17.35 (5.61)
RRS total	43 (11.15)	45.22 (11.37)	45.08 (10.40)
RRS reflection	8.84 (2.34)	9.78 (3.86)	8.88 (2.90)
RRS brooding	10.53 (3.75)	11.00 (3.45)	10.85 (3.31)
MRSI baseline	19.11 (5.41)	21.88 (6.62)	24.27 (5.78)
BDI	4.26 (4.70)	8.11 (8.17)	7.58 (7.89)
POMS depression baseline	1.00 (2.73)	1.83 (3.60)	3.12 (6.47)
STAI-trait	36.95 (7.80)	43.78 (11.54)	40.88 (11.80)
HRV baseline	42.09 (25.35)	59.54 (35.63)	n.a.

Participant characteristics. Means and standard deviations for scores on the questionnaires and mood measures are shown in Table 1. To test for pre-existing differences between the two experimental conditions, independent *t*-tests were performed on age, MRSI state rumination at baseline, and POMS depressive mood at baseline. For HRV at baseline a non-parametric Mann-Whitney test was performed (non normality of the data). No significant differences were found between the conditions at baseline, all *p*s > .05, and gender was evenly distributed as well, χ^2 (1, *N* = 37) = 0.17, *p* = .677. To test for pre-existing differences on PANAS trait affectivity, RRS trait rumination, BDI depressive symptoms, STAI trait anxiety, and RS-nl trait resilience, we performed a multivariate ANOVA with Thinking Style as between-subjects variable given the interrelations between these questionnaire measures. Some variables were transformed with a logarithmic transformation before analysis (STAI-trait, RRS reflection, and PANAS negative trait affectivity). A marginally significant effect of Condition was found, *F*(8, 28) = 2.05, *p* = .076, η_p^2 = .37. Univariate ANOVAs showed a significant difference between conditions only on STAI trait anxiety[4], *F*(1, 35) = 4.29, *p* = .046, η_p^2 = .11.

Thinking-style manipulation check. The effect of the manipulation on state rumination was investigated in a mixed ANOVA, with Time (baseline, post-induction) as a within-subjects factor, Thinking Style (rumination vs. problem-solving) as the between-subjects factor, and the scores on the MRSI[5] as dependent variable. Results from the mixed ANOVA on state rumination showed a significant main effect of Time, *F*(1, 34) = 53.62, *p* < .001, η_p^2 = .61, and a significant Time x Thinking Style interaction, *F*(1, 34) = 8.39, *p* = .007, η_p^2 = .20. When investigating the effect on state rumination, we also controlled (as a covariate) for the change in negative mood across the induction, assessed with the POMS depression scale, but results remained similar.

Repeated measures ANOVAs with Time (baseline, post-induction) as within-subjects variable for each induction condition separately, revealed that the rumination condition showed a significant increase in state rumination from baseline (*M* = 19.11, *SD* = 5.40) to post-induction (*M* = 27.53, *SD* = 5.27), *F*(1,18) = 80.14, *p* < .001, η_p^2 = .82, also when taking into account the change in depressive mood across the induction,

[4] Including STAI trait anxiety as a covariate in following analyses had no influence on the results.
[5] Data for baseline MRSI was missing for one participant from the problem-solving condition.

$F(1,17) = 29.33$, $p < .001$, $\eta_p^2 = .63$. The problem-solving group showed a significant increase in state rumination from baseline ($M = 21.88$, $SD = 6.62$) to post-induction ($M = 25.53$, $SD = 7.98$) as well, $F(1,16) = 6.88$, $p = .018$, $\eta_p^2 = .30$, also when taking into account the change in depressive mood across the induction, $F(1,15) = 4.56$, $p = .050$, $\eta_p^2 = .23$.

We next conducted an ANOVA with Thinking Style as the between-subjects factor and the logarithmically transformed HRV index during the induction as the dependent variable. This analysis revealed a near significant effect of Thinking Style, $F(1,31) = 3.92$, $p = .057$, $\eta_p^2 = .11$[6]. The rumination condition tended to show lower scores on the RMSSD index of HRV (untransformed $M = 41.70$, $SD = 24.75$) than the problem-solving condition (untransformed $M = 60.72$, $SD = 35.75$).[7]

Rumination and attentional breadth for self-related information. We performed a mixed ANOVA with Word (ME vs. LR) and Distance (close vs. far) as within-subjects factors and Thinking Style (rumination vs. problem-solving) as between-subjects factor with accuracy rates on the peripheral task as dependent variable (i.e. the proportions of correctly localized target stimuli in the attentional breadth task). This analysis yielded only a significant main effect of Distance, $F(1,35) = 130.41$, $p < .001$, $\eta_p^2 = .79$, indicating that as expected in general participants were better in localizing close targets as compared to far targets (all other Fs < 2.5; ps > .10). Taking into account, as a covariate, the change in POMS depressive mood across the induction, did not change these results.

Moderation influences. We investigated whether trait rumination (the RRS), depressive symptoms (the BDI-II-NL), or trait resilience (the RS-nl) qualified the effect of induction condition on attentional breadth for self-related information contrasted to other-related information. First, hierarchical multiple regression analyses were performed to test for moderation effects, following the approach of Aiken and West (1991), with a separate analysis for each moderator. The scores of the RRS (subscales),

[6] Heart rate data was missing for 2 participants from the rumination condition and 1 participant from the problem-solving condition, due to error in measurement with the telemetric heart rate monitor. Result after removing a multivariate outlier as indicated by standardized residuals > 2.5SDs.

[7] Additionally we examined whether trait rumination, the presence of depressive symptoms, or trait resilience qualified sensitivity to the rumination or problem solving induction. However, neither trait rumination (i.e. the RRS), depressive symptoms (i.e. the BDI-II-NL), nor trait resilience (i.e. the RS-nl) moderated the effect of the thinking-style manipulation on state rumination or heart rate variability.

BDI-II-NL, and RS-nl were centered and subsequently the interactions were calculated with the variable Thinking Style. In the regression analysis, Thinking Style (0 = problem-solving, 1 = rumination) and the moderator variable were entered as predictors in a first step and the interaction term was entered as a predictor in the second step of the analysis (separately for each moderator variable). The calculated ΔANI score, which represents attentional narrowing for self-related information contrasted to other-related information, was entered as the dependent variable. Results from the moderation models revealed neither the presence of depressive symptoms, nor trait resilience moderated the effect of induction condition on attentional breadth, all *p*s > .05. However, importantly, the RRS total score moderated the relation, the interaction term was significant, $t = 2.62$, $p = .013$, $\Delta R^2 = .18$[8]. Moreover, when the change in POMS depressive mood across the induction was also entered in the first step of the hierarchical regression analysis to take into the change in depressive mood across the induction, results remained similar.

To better understand this moderation effect, we estimated different conditional effects of Thinking Style on ΔANI at low (one SD below the mean), moderate (sample mean), and high (one SD above the mean) values of the moderator (i.e. the RRS score), using Hayes and Matthes' SPSS macro (Hayes & Matthes, 2009). Results showed a positive relation between Thinking Style and the ΔANI score at high levels of trait rumination, $t = 2.10$, $p = .044$, $b = 0.13$, whereas such a relation was nonsignificant at moderate levels, $t = 0.32$, $p = .752$, $b = 0.01$, and at low levels of trait rumination, $t = -1.64$, $p = .111$, $b = -0.10$. This outcome indicates that at high levels of trait rumination induced rumination, compared to the problem-solving condition, showed more attentional narrowing for self- compared with other-related information.

Relation between questionnaire measures and attentional breadth for self-related information. We further examined the relations between (trait) characteristics assessed with the questionnaires and attentional breadth for self-related information (i.e. ΔANI). Across all participants ΔANI was related to the RS-nl total score, $r = .34$, $p = .039$, and results were similar after controlling (with partial correlations) for the change

[8] Results are reported after removal of an influential case, indicated by DfFit value > 1. Analysis including this influential case yielded a marginal significant interaction term, $t = -1.86$, $p = .072$.

in MRSI state rumination or POMS depressive mood across the thinking-style manipulation.

Discussion

The aim of this experiment was to investigate the relation between the style of thinking in response to a stressful self-related event and visuospatial attentional breadth for self-related information, compared to information that is not related to the self. We first investigated the effectiveness of our new developed rumination versus problem-solving induction on a measure of state rumination and heart rate variability. Results from the manipulation check revealed that the adjusted induction scenario (after the pilot study, see footnote 3) increased the effectiveness. This was shown by a significant difference between induction conditions in the increase in state rumination, as well as a marginally significant difference between conditions in heart rate variability during the thinking-style manipulation. The rumination condition, compared to the problem-solving condition, showed lower heart rate variability, which has previously been associated with the experience of stress and worry (Pieper et al., 2007).

The main aim was to test the prediction that thinking style influences attentional breadth for self-related contrasted to not-self-related information. Results from this experiment failed to show evidence for a direct relation between thinking style and attentional breadth. However, moderation analyses revealed that trait rumination qualified this relation. Only at high levels of trait rumination a significant effect was found of thinking style on attentional breadth for self-related information. The rumination condition, as compared to the problem-solving condition showed more attentional narrowing for self-related information when contrasted to other-related information. This finding shows that individuals who already have the tendency to ruminate in daily life are the ones who show fluctuations in attentional narrowing for self-related information when rumination is induced.

Importantly, the effects of the thinking-style manipulation on attentional breadth at high levels of trait rumination remained significant when taking into account induction-related changes in depressive mood. Whitmer and Gotlib (2013) proposed negative mood to narrow attention, increasing the likelihood of rumination which in turn exacerbates negative mood leading to more attentional narrowing and more repetitive thoughts. However, our results indicate that a more ruminative way of

thinking by itself can already be associated with more attentional narrowing for self-related information at high trait rumination levels and that these attentional effects are not fully explained by the relation of rumination with negative mood.

Examination of the relationships between (trait) characteristics and attentional breadth revealed that only trait resilience was related to more attentional narrowing for self-related information. Even though we had no strong hypothesis on the direct relationship between trait resilience and attentional breadth for self-related information, the direction of the relationship is surprising as chronic negative affect, which could reflect lower levels of resilience, has previously been related to increased self-focused attention (Mor & Winquist, 2002). However, examining the relation between trait characteristics and attentional breadth may be difficult following a thinking-style manipulation that could obscure the relation between trait characteristics and attentional breadth. Furthermore, the attentional scope model (Whitmer & Gotlib, 2013) proposed that trait ruminators in general show a more narrowed attentional scope. Therefore, in a second experiment we further investigated the direct relation between trait characteristics and attentional breadth for self-related information in the absence of a thinking-style manipulation.

Experiment 2

Method

Twenty-seven undergraduates (22 females) aged between 17 and 45 years (M = 23.15, SD = 5.31) participated in this experiment and were paid €5. This experiment was approved by the local ethical committee of the Faculty of Psychology at Ghent University.

Materials and procedure. The questionnaires and attentional-breadth task from the previous experiment were used in this one. After informed consent, participants filled out the trait questionnaires, the POMS, and MRSI, and then they performed the attentional breadth task.

Results

Preliminary analyses. The data from one participant were deleted because in more than 50% of self-trials the central stimulus was incorrectly identified. In the remaining sample an average of 2.92% of the trials was deleted because of incorrectly identifying the central stimulus. Due to non-normality of the data a nonparametric

Kruskal-Wallis test was performed to test for differences among the three groups (i.e. rumination condition – experiment 1, problem-solving condition – experiment 1, current sample). No group related differences were found in terms of the percentages of trials that were deleted, $H(2) = 0.31$, $p = .857$.

Participant characteristics. Means and standard deviations for scores on the questionnaires and baseline mood measures in the current sample are shown in Table 1. To investigate whether this sample was comparable to the sample from the first experiment we tested for pre-existing differences among the three groups. We performed ANOVAs with Group (rumination condition from experiment 1, problem-solving condition from experiment 1, current sample) as a between-subjects factor and age and MRSI state rumination at baseline as separate dependent measures. A non-parametric Kruskal-Wallis test was performed on POMS depressive mood at baseline (due to non-normality of the data). No group differences were found on age and POMS depressive mood, all *p*s > .05. However, a significant effect of Group was found for MRSI state rumination, $F(2,59) = 4.19$, $p = .020$, $\eta_p^2 = .12$; Gabriel post-hoc tests revealed that the current sample reported significantly higher MRSI state rumination scores than the rumination condition from experiment 1, $p = .015$. Gender was evenly distributed, χ^2 (2, $N = 63$) = 0.53, $p = .769$. To test for pre-existing differences on PANAS trait affectivity, RRS trait rumination, BDI depressive symptoms, STAI trait anxiety, and RS-nl trait resilience, we performed a multivariate ANOVA with Group as a between-subjects factor, given the interrelations between these questionnaire measures. No significant effect of Group was found, Pillai's Trace $F(16, 108) = 0.99$, $p = .472$, $\eta_p^2 = .13$.

Relation between questionnaire measures and attentional breadth. We investigated the relations between trait characteristics as measured with the questionnaires and attentional breadth for self-related information contrasted to other-related information (i.e. ΔANI). Results from the analyses showed that ΔANI only tended to be related to the RRS total score, $r = .35$, $p = .083$, but this seemed driven by the RRS brooding subscale which was significantly related to ΔANI, $r = .41$, $p = .038$. The MRSI state rumination score at baseline was also significantly related to ΔANI, $r = .41$, $p = .038$, this result is reported after removing a multivariate outlier as indicated by standardized residuals > 2.5*SD*s, Trait resilience on the other hand was not significantly

related to ΔANI, r_{sp} = -.34, p = .097, this result is reported after removing an influential case as indicated by a score > 1 on fitting indices DfBeta and DfFit.

Discussion

The aim of the second experiment was to investigate the relations between (trait) characteristics and attentional breadth when no thinking style induction was performed. Results from this experiment revealed that higher levels of trait brooding are associated with increased attentional narrowing for self- compared with other-related information. These findings are in line with predictions from the attentional scope model of rumination (Whitmer & Gotlib, 2013).

General Discussion

The main aim of this series of experiments was to investigate the relationship between thinking style and visuospatial attentional breadth for self-related information, based on the proposed association of (trait) rumination and a more narrow attentional scope (Whitmer & Gotlib, 2013). Based on the attentional scope model, we hypothesized that the induced ruminative way of thinking, compared to a problem-solving approach, would narrow attentional scope for self-related information.

In the first experiment we investigated the effects of a rumination induction, as compared to a problem-solving induction, on attentional narrowing for self- compared with other-related information and whether this effect would be qualified by trait rumination, the presence of depressive symptoms, or trait resilience. The thinking-style manipulation check indicated that the rumination condition reported a significant greater increase in state rumination than the problem-solving condition, and the rumination condition tended to show lower heart rate variability than the problem-solving condition. We observed an effect of thinking style on attentional breadth for self-related contrasted to other-related information, but this effect was only significant at high levels of trait rumination. Interestingly, this effect of thinking style on attentional breadth, qualified by trait rumination, could not be explained by individual differences in the change in depressive mood across the induction. While the attentional scope model of rumination (Whitmer & Gotlib, 2013) proposes that increases in negative mood lead to attentional narrowing which then increases the likelihood of thoughts becoming repetitive, our results suggest that differences in

thinking style itself are connected to differences in attentional narrowing for self-related information, compared to other-related information.

In the second experiment we examined the relation between trait characteristics and attentional breadth for self-related information, without a thinking-style manipulation that could influence this relation. Based on the attentional scope model (Whitmer & Gotlib, 2013), we hypothesized that higher trait rumination scores would be related to more attentional narrowing for self- compared with other-related information. Indeed we observed that higher trait rumination scores, specifically trait brooding (considered to be the more maladaptive form of rumination), were associated with more attentional narrowing for self- compared with other-related information.

The presented experiments are the first to directly test the influence of induced rumination and trait rumination on visuo-spatial attentional breadth for self-related information. The predictions of the attentional scope model (Whitmer & Gotlib, 2013) about the relation between trait rumination and a more narrowed attentional scope were mostly based on evidence for attentional narrowing at the level of working memory processes. Our results, however, indicate that rumination interacts with lower-level cognition, as shown by an influence on fluctuations in the visuo-spatial scope of attention. The results indicate that trait ruminators generally show more narrowed attention for self-related information. Although this finding provides no information about the causal direction of this relation, it could explain why some individuals—high trait ruminators—are more vulnerable to rumination in response to distress. Moreover, the finding that especially at high levels of trait rumination more attentional narrowing for self-related information was shown in response to induced rumination, could explain the self-perpetuating nature of this mode of processing, by reducing the likelihood that thoughts shift away from one's feelings and problems, once activated in mind. This pattern could also characterize the cognitive contribution of rumination to a worsening or maintaining of depressive mood.

Several limitations deserve mentioning. The current study examined visuo-spatial attention whereas several authors have argued that rumination is largely verbal in nature and could be more directly related to conceptual breadth of attention. By design, we only tested the effect of a thinking-style manipulation on attentional breadth for self-related information, whereas a more narrowed attentional scope might

also increase the occurrence of rumination, consistent with the attentional scope model of rumination (Whitmer & Gotlib, 2013). Clearly, this was a first effort in testing direction of causality, and future research should also explore how manipulating the attentional scope affects the probability of state rumination. Second, a newly developed rumination induction was contrasted to an active problem-solving approach. Although the manipulation successfully differentiated state-rumination scores according to the two induction conditions, state rumination increased in the problem-solving condition, possible due to the very negative nature of the scenario. The ideal choice for a scenario would be one that is negative enough to invite rumination in an unselected sample following ruminative instructions but ambiguous enough to sidestep rumination following problem-solving instructions.

In summary, we found a rumination induction, compared to a problem-solving induction, to be associated with more attentional narrowing for self- contrasted to other-related information. Importantly, this effect was only observed at high levels of trait rumination. Additionally, we also observed a relationship between brooding and more attentional narrowing for self-related information without a rumination induction at the outset. These results suggest that as high trait ruminators, especially brooders, already show more attentional narrowing for self-related contrasted to other-related information in general, this makes them more likely to start ruminating in response to potential stressors in life. Furthermore, especially at high levels of trait rumination more attentional narrowing for self-related information was shown, in response to the ruminative induction, and this pattern could contribute to 'getting stuck' in this mode of processing. Future research should therefore continue to further clarify these cognitive processes. They may be crucial in understanding how rumination at a cognitive level contributes to recurrent patterns of depression (Nolen-Hoeksema, 2000).

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CHAPTER 6

The effect of positive mood on flexible processing of affective information and the relationship with stress reactivity[1]

Abstract

The broaden-and-build theory proposes that the effect of positive emotions on broader and more flexible cognitive processing is the underlying mechanism in the relation between positive emotions and resilience. Cognitive flexibility, including attentional flexibility for affective information (affective flexibility), is important for emotion regulation, and could thus be important for stress resilience. Therefore, we investigated, in an unselected sample, how positive mood influences affective flexibility, and how these cognitive effects of positive mood underlie stress reactivity. Results showed that positive mood induction is associated with decreased flexible processing of negative information. Furthermore, the positive mood induction had an adaptive effect on stress reactivity, reflected in a diminished response of arousal and tenseness to a stressor. Crucially, the positive mood induction was associated with smaller increases in arousal during a stressor, via decreased flexibility when shifting attention towards affective aspects of negative information. Moreover, less flexibility when shifting attention towards non-affective aspects of negative information mediated the relationship between positive mood and negative effects on positive and sad mood during a stressor. These findings are discussed in relation to the predictions of the broaden-and-build theory of positive emotions and resilience.

[1] Based on Grol, M., & De Raedt, R. (2014). The effect of positive mood on flexible processing of affective information and the relationship with stress reactivity. Manuscript in preparation.

Introduction

Over the last decades research on the development, maintenance and recurrence of mood disorders has mostly focused on understanding cognitive "vulnerability". However, in recent years research has also started to focus on understanding mechanisms of "resilience" and cognitive factors that are associated with adequate and adaptive responding to stress. There is a large body of research relating optimism and positive emotionality to increased psychological well-being (e.g. Affleck & Tennen, 1996). More recent studies have shown that especially among high-resilient people, positive emotions facilitate physiological stress recovery after a negative mood induction (Tugade & Fredrickson, 2004) and emotional stress recovery in response to naturally occuring stressors (Ong, Bergeman, Bisconti, & Wallace, 2006).

The broaden-and-build theory of positive emotions (Fredrickson 1998; 2001) relates positive emotions to (the development of) resilience, and importantly, proposes that the effect of positive emotions on a broader and more flexible cognitive processing style would be an underlying mechanism in this relationship. Although the literature is mixed with regard to the broadening effects of positive emotions as this may be found only under specific conditions (e.g. Bruyneel, Van Steenbergen, Hommel, Band, De Raedt, & Koster, 2012; Gable & Harmon-Jones, 2008), there is evidence that links positive emotions to increased creativity, social openness, and visual attentional breadth (e.g. Fredrickson & Branigan, 2005; Garland et al., 2010; Grol, Koster, Bruyneel, & De Raedt, 2014; Isen, Daubman, & Nowicki, 1987).

A crucial component of mental health is emotion regulation (Gross, 1998) and problems with emotion regulation are underlying different forms of psychopathology. Emotion regulation entails a set of processes in order to redirect the spontaneous flow of emotions (Koole, 2009), so normal emotion regulation should allow adaptive coping with situations by down-regulating negative or up-regulating positive emotions. It has been proposed that cognitive flexibility is important for emotion regulation (Ochsner & Gross, 2007), including the ability to flexibly process affective material (Genet & Siemer, 2011). This is in line with the proposition that a broader and more flexible cognitive processing style underlies the relation between positive emotions and resilience (Fredrickson, 1998; 2001). Biases in the processing of emotional information and impairments in cognitive control associated with depression (for review, see De Raedt &

Koster, 2010; Gotlib & Joormann, 2010) are likely affecting one's ability to regulate emotions. In this perspective, the ability to flexibly attend to and disengage from affective aspects of emotional material seems important for emotion regulation and thereby resilience. Recent studies found evidence in support of this idea by showing that flexible processing of emotional material is related to individual differences in trait resilience (Genet & Siemer, 2011). Greater flexibility specifically when switching attention from affective aspects to non-affective aspects of negative material and greater flexibility when switching attention from non-affective aspects to affective aspects for positive material were associated with more successful reappraisal after a sad mood induction (Malooly, Genet, & Siemer, 2013). On the other hand, less flexibility specifically when switching away from attending to affective aspects of negative material has been related to increased rumination in daily life (Genet, Malooly, & Siemer, 2013). However, less flexibility specifically when switching away from attending to affective aspects of positive material was related to decreased rumination, suggesting inflexibility is not always maladaptive per se (Genet et al., 2013).

Previous research has shown that greater flexibility in the processing of affective material is related to reappraisal ability and trait resilience. Up to now, it is however unclear how mood state is related to affective flexibility. Following from the broaden-and-build theory (Fredrickson 1998; 2001) we would expect that a positive mood is related to more flexible processing of affective material. In addition to our interest in the effects of positive mood on affective flexibility, we also aimed to directly test whether the effects of positive mood on flexible processing of affective material underlie the relation between positive mood and stress reactivity in response to a stressful situation. To measure physiological stress reactivity, we used heart rate variability (HRV). We investigated HRV, using the index Root Mean Square of the Differences of Successive Intervals (RMSSD), based on recommendations of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996). The index is recommended for short-term HRV analysis (Task Force, 1996) and provides an indication of modulations in parasympathetic outflow (Kleiger, Stein, Bosner, & Rottman, 1992). Previous research has shown that HRV provides an index of reactivity to stressful events, with decreases as a maladaptive reaction related to worry (Pieper, Brosschot, Van der Leeden, & Thayer, 2007) and

increases as an adaptive self-regulatory physiological reaction to stressors (Park, Vasey, Van Bavel, & Thayer, 2014).

In the current experiment we first tested the effects of induced positive mood on affective flexibility. Crucially, we then further investigated whether effects of induced positive mood on affective flexibility were underlying the relation between positive mood and (emotional and physical) stress reactivity in response to a stressful task. We used a previously developed paradigm measuring switching between attending to affective and non-affective aspects of emotional picture material (Genet et al., 2013; Malooly et al., 2013). This will be the first study to investigate whether affective flexibility is subject to influences of (positive) mood state. Although based on the broaden hypothesis we might expect a general increase in affective flexibility, we anticipated that positive mood would be related to greater affective flexibility when switching attention towards affective aspects of positive information and away from affective aspects of negative information. Moreover, based on the idea that the cognitive effects of positive emotions underlie resilience, we hypothesized that there would be an indirect effect of positive mood on stress reactivity via affective flexibility. Thus, we hypothesized that positive mood would be related to more adaptive responding to stress (i.e. smaller decreases in positive mood and heart rate variability, and smaller increases in sadness, arousal, anger, and tenseness) via increased affective flexibility.

Method

Participants

Forty undergraduate students (33 females) aged between 18 and 29 years (M = 21.79, SD = 2.45) volunteered to participate in this experiment and were paid for their participation. This experiment was approved by the local ethical committee of the Faculty of Psychology at Ghent University.

Material And Mood Induction Procedure

Questionnaire measures. We measured mood state throughout the experiment with visual analogue scales (VAS) measuring how happy, sad, aroused, angry, and tense participants were feeling “at this moment”. VAS scales (0 to 10 cm, resulting in a 0-100 scale) were used because of their visual presentation which makes these sensitive to fluctuations in affect (Rossi & Pourtois, 2012a). We measured how happy and sad

participants were feeling on a scale with the anchor points “neutral” and “as happy/sad as I can imagine”, and we measured arousal on a scale with the anchor points “calm” and “aroused”. Additionally, we measured anger and tenseness on a scale with the anchor points “not at all” and “as angry/tense as I can imagine”.

We also measured trait affectivity with the 20 item Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Participants were asked to rate the degree to which they felt the emotions “*in general*”. Participants gave their ratings on a 5-point Likert scale ranging from 1 “very slightly” to 5 “very much”.

The presence and severity of depressive symptoms was measured using the 21-item Beck Depression Inventory (BDI-II-NL; Beck, Steer, & Brown, 1996; Van der Does, 2002). This questionnaire consists of statements (responses ranging from 0 to 3) and participants are asked to pick out the response that best fits the way the participant has been feeling during the past two weeks.

The tendency to ruminate was assessed with the Ruminative Response Scale (RRS; Nolen-Hoeksema & Morrow, 1991; Raes, Hermans, & Eelen, 2003), a 22-item scale measuring what participants tend to think or do when feeling *down, sad, or depressed,* rated on a 4 point scale ranging from “almost never” to “almost always”.

Trait anxiety was assessed using the State Trait Anxiety Inventory trait version (STAI-trait; Spielberger, Gorsuch, Lushene, Vagge, & Jacobs, 1983; Van der Ploeg, Defares, & Spielberger, 2000), in which participants were asked to rate how they feel “*in general*” on a 4-point scale ranging from “almost never” to “almost always.”

Trait resilience was measured using the Dutch version of the Resilience Scale (RS-nl; Portzky, 2008). Participants were asked to rate their agreement with statements on a 4-point scale ranging from “totally disagree” to “totally agree”. The RS-nl has shown to have good internal consistency with a Cronbach’s alpha of $\alpha = 0.85$ (Portzky, Wagnild, De Bacquer, & Audenaert, 2010).

The Spontaneous Use of Imagery Scale (SUIS; Nelis, Holmes, Griffith, & Raes, 2014; Reisberg, Pearson, & Kosslyn, 2003) was used to measure the use of mental imagery in daily life. Participants rated the appropriateness of descriptions applying to themselves on a 5-point scale ranging from 1 “never appropriate” to 5 “always completely appropriate”.

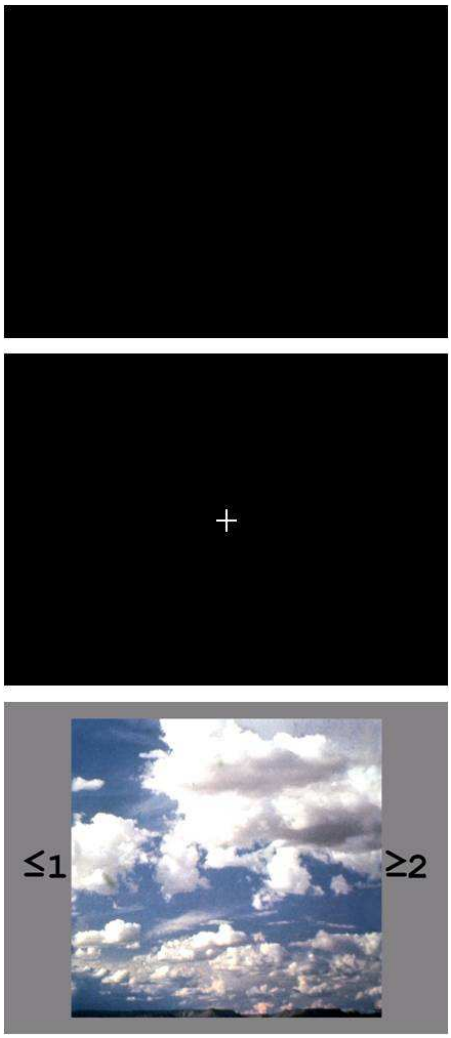

Figure 1. *Example of a trial in the affective switching task. Each trial starts with a blank screen for 250msec, followed by a fixation cross presented for 250msec. The picture and trial cues are presented until a response is given.*

Affective switching task. Affective flexibility was measured using a previously developed design (Genet et al., 2013; Malooley et al., 2013) for which only the instructions were translated to Dutch. During the task participants had to sort emotional pictures (positive and negative) according to two different rules; either according to an affective rule (indicating the picture as positive or negative) or according to a non-affective rule (identifying the number of humans depicted on the picture). Pictures were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Forty pictures were selected for each of the following four picture types: negative pictures with one or fewer human beings, negative pictures with two or more human beings, positive pictures with one or fewer human beings, and positive pictures with two or more human beings, resulting in a final set of 160 IAPS

pictures. In each trial (see Figure 1) one picture is presented in the middle of the screen with the trial cues presented left and right of the picture, indicating which rule applies to this trial. For the affective rule, "+" and "-" represent positive and negative respectively. For the non-affective rule, "≤1" and "≥2" represent one or fewer human beings and two or more human beings respectively. The background of the screen was either gray or white which could also be used as an indicator of the sorting rule. There were eight different versions of the task, counterbalancing for the combination of background color and sorting rule, and combination of sorting response and response key (e.g. left key for both "positive" and "two or more humans", and right key for "negative" and "one or fewer humans"). Participants had to categorize the pictures according to the sorting rule as fast and accurately as possible by pressing one of two keys on the keyboard to indicate their response. The combination of picture type (i.e. positive or negative) and sorting rule (i.e. affective or non-affective) followed a pseudorandom sequence (Genet et al., 2013; Malooley et al., 2013). The task consisted of two 10-trial practice blocks in which both sorting rules where practiced separately. This was followed by two 160-trial test blocks, during which the picture type and sorting cue followed the pseudorandom sequence.

Stress induction task. To induce stress we used a visual oddball task in which participants received manipulated negative feedback on their task performance. This task has been developed to measure effects of stress on attention (Rossi & Pourtois, 2012b) and has been validated as a stress induction task (Baeken, Vanderhasselt, Remue, Rossi, Schiettecatte, Anckaert, & De Raedt, 2014; Rossi & Pourtois, 2013). The task was introduced as measuring people's ability to detect differences in line orientation. Participants were told that people can detect very small differences and that they can improve with practice. To maximize the stress response, participants were told that their performance on this task would partly be the result of this learning effect and is partly related to general intelligence. Therefore participants are told that at the end of the experiment they will receive an IQ-test, which was actually not administered.

During the task, participants were asked to maintain attention to a fixation cross at the center of the screen as they are presented with a stream of white tilted lines on a black background. The lines were presented for 250msec, with an inter-stimulus-interval randomized between 900 and 1250msec. Participants are instructed to detect

and mentally count the number of presented lines that deviate in orientation from the standard tilted line (always 35°). Additionally, in half of the trials the presentation of the tilted line was followed by presentation of horizontal line elements at the top of the screen which were presented for 250msec during the inter-stimulus-interval. However, these peripheral stimuli were unrelated to the task and were presented as distracters (Rossi & Pourtois, 2012b; Rossi & Pourtois, 2013).

During an initial practice session (20 stimuli) participants were presented with only the standard line and were instructed to try to learn the standard line orientation. This was followed by three test blocks (each block 100 stimuli, 80 standard lines, 20 deviating lines), in which participants were instructed to count the number of deviating line orientations that were randomly intermixed with the standard lines. Participants were prompted to enter this number at the end of each test block. Across the three test blocks the angular difference between the standard and deviating line was manipulated to vary task difficulty in order to maintain motivation in participants. Although unknown to the participants, the first block was always most difficult (standard-deviant angular difference = 3°), the second block was intermediate (standard-deviant angular difference = 5°), and the last block the easiest (standard-deviant angular difference = 10°). After each block participants received bogus feedback on their performance during the block. The feedback screen was presented for 20sec and consisted of a neutral face with a text balloon containing statements such as “You performed badly! Your response accuracy is lower than average in comparison to previous participants.” Additionally a fake scatter plot was presented showing the participants’ performance against the scores of previous (alleged) participants.

Physiological stress reactivity. To measure the physiological stress response we assessed heart rate during a baseline period, the stress induction task and during a 15 minute recovery period afterwards. Beat-to-beat heart rate was measured using a telemetric heartbeat monitor (Polar S810). Data were moderately filtered with a minimum zone of 6 beats a minute (Cottyn, De Clercq, Pannier, Crombez, & Lennoir, 2006) with the Polar Precision Performance Software for Windows and further analyzed with Kubios (Niskanen, Tarvainen, Ranta-Aho, & Karjalainen, 2004).

Mood induction procedure. The procedure to induce mood (MIP) consisted of a procedure using mental imagery. Participants were instructed to vividly imagine a self-

provided autobiographical memory to induce either a happy or neutral mood. Participants had to recall a memory of a specific event, that is, an event that took place on a specific day, more than one week ago. All participants first practiced mental imagery from a field perspective (i.e. first person perspective) with a practice task (Holmes, Coughtrey, & Connor, 2008). After this practice task, participants in the neutral condition were asked to recall a memory of an event that did not elicit strong negative or positive emotions at that time, while participants in the positive condition were instructed to recall a memory of an event which made them feel very happy at that time. Participants were asked to shut their eyes while describing what they remembered in detail. Instructions (based on Holmes, et al., 2008; Watkins & Moberly, 2009) were given to all participants to promote concreteness and imagery from a field perspective (as if they see the situation through their own eyes). Participants imagined the event for 30 seconds after which they were asked a series of questions (based on Watkins & Moberly, 2009), letting them focus on what they could see, hear, and physically feel. Following these questions, participants continued imagining the event for another 30 seconds without describing aloud. Halfway the mood induction and at the end, imagery perspective checks were administered to measure to what extent participants adopted a field and observer perspective. Participants were asked to rate on a 5-point Likert scale the extent to which they "saw the event through their own eyes and were actively involved?" (i.e. field perspective) and "to what extent did you experience the event looking at yourself from outside, as if you see yourself taking part in the situation?" (i.e. observer perspective).

Procedure

Participants were randomized to receive either the positive or the neutral MIP. After signing the informed consent form, participants filled out the questionnaires. Next, we put on the telemetric heartbeat monitor and measured a baseline level of heart rate during a 15 minute period in which participants were asked to relax. After the baseline period we continued beat-to-beat heart rate registration throughout the rest of the experiment, but the critical time period was during the stress induction task. Following this, baseline levels of mood were measured and participants completed the MIP procedure, followed by another mood assessment immediately afterwards. After the MIP, participants performed the affective switching task. Following the affective

switching task, mood was measured again and participants performed a quick repetition of the MIP procedure to prolong the effects (the procedure was similar, but participants did not repeat the imagery practice task). Subsequently, mood levels were measured before the stressful task. Participants then performed the stressful task in which they received manipulated negative feedback. Following the task, mood levels were measured again and participants were asked to do nothing during a following 15-minute recovery period in which also heart rate registration was continued. For ethical reasons, after this recovery period, mood levels were measured a last time in order to verify that the effects of the stressor were diminished.[2] Finally, participants were hooked-of the HRV equipment, and were debriefed about the experiment in general and specifically about the stressful task and the manipulated feedback.

Results

Preliminary Analyses

For the heart rate baseline data, we only analyzed the data from the last 10 minutes of the 15-minute baseline period. This way, possible arousal when starting to measure heart rate is excluded in the baseline. For heart rate data registered during the stress induction task, we only analyzed the data starting from the first time participants received negative feedback until the end of the task, which was for a period of about 7 minutes.

In the affective flexibility task, reaction times (RT) from incorrect trials were excluded from further analysis which resulted in deleting an average of 7.67% of the trials. A nonparametric Mann-Whitney test (due to non-normality of the data) revealed no induction condition related differences in the percentage of deleted trials, U = 183.50, p = .664. The influence of outlying reaction times was reduced by using a window of 2.5*SD*s from the mean (within that trial type). If a RT was outside this window, it was replaced with the value corresponding to 2.5*SD*s below or above the mean, in a similar way to former research using the same task (Genet et al., 2013; Malooy et al., 2013). General switch costs were calculated first, regardless of switch type. Paired-samples t-test confirmed that RTs on switch trials (M = 1407msec, SD = 262) were significantly higher than RTs on repetition trials (M = 1270msec, SD = 268),

[2] Analyses indicated that participants reported a general increase in positive mood, a general decrease in sadness, arousal, anger, and tenseness, and no significant change in HRV across the recovery period.

$t(39) = 9.69$, $p < .001$, confirming the presence of switch costs. Following this, specific switch costs were calculated (based on Genet et al., 2013; Malooly et al, 2013). Switch costs were calculated when switching from the affective to the non-affective rule when the image remained negative (negative non-affective switch costs) or remained positive (positive non-affective switch costs), by subtracting RTs on trials in which the affective rule was repeated from RTs on trials in which the rule switched to the non-affective rule (for negative and positive pictures separately). Similarly, switch costs were calculated when switching from the non-affective to the affective rule when the image remained negative (negative affective switch costs) or remained positive (positive affective switch costs), by subtracting RTs on trials in which the non-affective rule was repeated from RTs on trials in which the rule switched to the affective rule.

Table 1.

Participant Characteristics

	Neutral MIP *M* (*SD*) *n* = 20	Positive MIP *M* (*SD*) *n* = 20
Age	21.63 (2.31)	21.95 (2.63)
Gender	16 females	17 females
PANAStrait positive	35.58 (6.12)	36.05 (5.42)
PANAStrait negative	18.90 (5.34)	15.25 (4.96)
BDI	8.30 (5.71)	6.80 (5.69)
RRS total	46.15 (10.62)	44.80 (7.22)
RS-nl total	76.60 (9.36)	80.26 (8.41)
STAItrait	42.20 (8.20)	36.00 (8.03)
SUIS	40.40 (7.76)	39.05 (7.13)
Baseline HRV (RMSSD)	42.99 (25.45)	56.70 (35.28)

Participant Characteristics

Twenty participants were randomized to receive the positive MIP and 20 participants received the neutral MIP. The means and standard deviations for the baseline variables can be seen in Table 1. To test for pre-existing differences between

the two experimental conditions, independent t-tests were performed on age, the SUIS and HRV at baseline (after logarithmic transformation because of not normality of the data), but no significant differences were found, all *p*s > .05. Gender was evenly distributed as well, χ^2 (1, *N* = 40) = 0.17, *p* = .677. To test for pre-existing differences on PANAS trait affectivity, RRS trait rumination, BDI depressive symptoms, RS-nl trait resilience, and STAI trait anxiety, we performed a multivariate ANOVA with Condition as between-subjects variable given the interrelations between these measures. No significant effect of Condition was found, *F*(6,31) = 1.59, *p* = .185, η_p^2 = .24.

Mood Manipulation Check

During the mood induction, participants rated to what extent they had imagined the situation from a field and observer perspective. Nonparametric Mann-Whitney tests (variables remained not normally distributed after transformation) revealed no differences between the positive (*M* = 4.18) and neutral (*M* = 4.38) conditions in the extent to which they had imagined the memory from a field perspective, *U* = 188.5, *p* = .762, *r* = -.05, or the extent to which the positive (*M* = 2.10) and neutral (*M* = 2.10) groups had imagined the memory from an observer perspective, *U* = 199.5, *p* = .994, *r* < -.01.

To investigate the differences between conditions in the effects of the MIP on VAS scales happy, sad, aroused, angry, and tense, we performed a multivariate mixed ANOVA with Time (pre- vs. post-induction) as within-subjects variable and Condition (neutral vs. positive) as between-subjects variable. A significant main effect of Time was found, *F*(5, 34) = 2.84, *p* = .030, η_p^2 = .30, and a Time x Condition interaction, *F*(5, 34) = 3.70, *p* = .009, η_p^2 = .35. Univariate tests showed a significant main effect of Time, *F*(1, 38) = 8.13, *p* = .007, η_p^2 = .18, and a Time x Condition interaction, *F*(1, 38) = 6.93, *p* = .012, η_p^2 = .15, for VAS happy. Similarly, for VAS arousal univariate tests showed a significant main effect of Time, *F*(1, 38) = 4.24, *p* = .046, η_p^2 = .10, and a Time x Condition interaction, *F*(1, 38) = 12.68, *p* = .001, η_p^2 = .25.

Paired t-tests on the VAS happy showed that the neutral MIP condition did not show a significant change from baseline (*M* = 54.90, *SD* = 29.63) to post-induction (*M* = 55.60, *SD* = 26.89), *t*(19) = 0.18, *p* = .858, whereas the positive MIP condition did show a significant increase from baseline (*M* = 42.85, *SD* = 32.99) to post-induction (*M* = 60.45, *SD* = 25.09), *t*(19) = 3.43, *p* = .003. Paired t-tests on VAS arousal showed that the neutral

MIP condition did not show a significant change from baseline (*M* = 37.55, *SD* = 31.89) to post-induction (*M* = 31.65, *SD* = 26.78), *t*(19) = 1.05, *p* = .308. The positive MIP condition did show a significant increase on the VAS arousal from baseline (*M* = 17.25, *SD* = 21.43) to post-induction (*M* = 39.35, *SD* = 27.35), *t*(19) = 4.02, *p* = .001.[3]

Positive Mood And Affective Switching Costs

To investigate the influence of mood on affective flexibility, we analyzed the influence of positive mood on each of the four different switch types using a Univariate ANOVA with Condition as a between-subjects factor for each of the four switch types separately (see also Malooy et al, 2013). These analyses revealed no significant effects of Condition for positive affective and positive non-affective switch costs, all *F*s < 1, *p*s > .05.

A marginally significant effect of Condition was found for negative affective switch costs *F*(1,38) = 3.21, *p* = .081, η_p^2 = .08, with the positive MIP condition tending to show higher negative affective switch costs (*M* = 2msec, *SD* = 164msec) compared to the neutral MIP condition (*M* = -107msec, *SD* = 216msec), which shows more difficulties to switch towards the negative affective rule of negative pictures in a positive mood.

A significant effect of Condition was found for negative non-affective switch costs *F*(1,38) = 5.81, *p* = .021, η_p^2 = .13. The positive MIP condition showed higher negative non-affective switch costs (*M* = 358msec, *SD* = 181msec) compared to the neutral MIP condition (*M* = 258msec, *SD* = 150msec), which shows more difficulties to switch to the non-affective rule of negative pictures in a positive mood.

Positive mood and stress reactivity

Emotional response during stressor. To investigate the effects of the stress induction on emotional stress reactivity, we performed a multivariate mixed ANOVA with Time (pre- vs. post-stress induction) as within-subjects variable and Condition as between-subjects variable on the VAS scales happy, sad, aroused, angry, and tense (all scales were square root transformed due to non-normality of the data). Results from the multivariate mixed ANOVA showed a significant main effect of Time, *F*(5, 34) = 5.05, *p* = .001, η_p^2 = .43, and a Time x Condition interaction, *F*(5, 34) = 2.89, *p* = .028, η_p^2 = .30.

[3] Assumptions for parametric tests were violated in the multivariate mixed ANOVA and paired *t*-tests, but non-parametric tests yielded similar results.

Univariate tests showed a significant main effect of Time for VAS happy, $F(1, 38) = 9.27$, $p = .004$, $\eta_p^2 = .20$, a significant effect of Time for VAS sad, $F(1, 38) = 7.06$, $p = .011$, $\eta_p^2 = .16$, a significant effect of Time for VAS anger, $F(1, 38) = 17.39$, $p < .001$, $\eta_p^2 = .31$, and a significant main effect of Time for VAS tenseness, $F(1, 38) = 18.88$, $p < .001$, $\eta_p^2 = .33$. This indicated that across the stress induction participants reported a general decrease in positive mood, but an increase in sadness, anger, and tenseness.

Univariate tests also revealed significant Time x Condition interactions for VAS arousal, $F(1, 38) = 8.68$, $p = .005$, $\eta_p^2 = .19$, and VAS tenseness, $F(1, 38) = 5.72$, $p = .022$, $\eta_p^2 = .13$. Paired t-tests on VAS arousal revealed that the neutral condition showed a significant increase from pre-stressor (untransformed $M = 22.25$, $SD = 20.23$) to post-stressor ($M = 34.45$, $SD = 23.92$), $t(19) = 3.62$, $p = .002$, whereas the positive condition did not show such a significant increase from pre-stressor ($M = 23.80$, $SD = 22.50$) to post-stressor ($M = 20.25$, $SD = 21.56$), $t(19) = 1.00$, $p = .330$. Similarly, the neutral MIP condition did show a significant increase in VAS tenseness from pre-stressor ($M = 13.60$, $SD = 15.31$) to post-stressor ($M = 31.95$, $SD = 21.62$), $t(19) = 4.94$, $p < .001$, whereas the positive MIP condition did not show a significant change on VAS tenseness from pre-stressor ($M = 14.90$, $SD = 18.20$) to post-stressor ($M = 23.00$, $SD = 25.38$), $t(19) = 1.34$, $p = .198$.[4]

Physiological response during stressor. A mixed ANOVA on the HRV data[5] (after logarithmic transformation because of non-normality of the data) with Time (baseline, stressor) as within-subjects factor and Condition as between-subjects factor, revealed only a significant main effect of Time, $F(1,34) = 9.18$, $p = .005$, $\eta_p^2 = .21$, reflecting a general increase in heart rate variability, but no effect of Condition.

Recent studies suggest that people characterized by higher tonic HRV, show an enhancement of phasic HRV in response to negative emotional stimuli, reflecting self-regulatory efforts, whereas people with lower tonic HRV show a more typical autonomic stress response (e.g. Aldao & Mennin, 2012; Gaebler, Daniels, Lamke, Fydrick, & Walter, 2013; Park et al., 2014). Therefore, we examined nonparametric Spearman correlations between HRV baseline level and the change score in HRV from

[4] Assumptions for parametric tests were violated in the multivariate mixed ANOVA, but non-parametric tests yielded similar results.

[5] Due to measurement error, HRV data was missing for 4 cases. Two cases in the neutral condition and two cases in the positive condition.

baseline to stress task (parametric assumptions were violated for the change score), r_{sp} = .35, p = .036. This indicates that higher baseline (tonic) HRV levels were related to a greater increase in HRV from baseline to the stress induction task, which is in line with previous research (Aldao & Mennin, 2012; Gaebler et al, 2013; Park et al., 2014).

Influence of affective flexibility on the relation between positive mood and stress reactivity. To investigate whether affective flexibility influences the relation between positive mood and stress reactivity, we tested the indirect effects of induction condition (predictor: Condition) on stress reactivity (outcome variable: the change in mood, arousal, tenseness, and HRV across the stressful task) through affective flexibility (mediator: negative non-affective switch costs, negative affective switch costs, positive non-affective switch costs, positive affective switch costs separately for each mediator).

To test for mediation effects we used Hayes' SPSS macro PROCESS (2012). In order to test the statistical significance of the indirect effect we adopted the bias corrected bootstrapping approach, following the recommendations of Preacher and Hayes (2008). We estimated 10000 bootstrap bias-correct 95% Confidence Intervals (CI) to test for the significance of the indirect effect, which was considered significant if the CI does not contain zero. Although for the mediation model neither path *a* – the relation between the focal predictor and mediator – nor path *b* – the relation between the mediator and outcome variable – needs to be significant (Hayes, 2009), we computed the regression weights to clarify the direction of the relation between the focal predictor and mediator (*a*) and the relation between the mediator and outcome variable (*b*). Table 2 provides the results for the models with a significant indirect effect including the bootstrap analysis, and regression coefficients for path *a,* path *b*, and path *c'* which is the direct effect of the focal predictor on the outcome variable taking into account the mediator.

VAS Positive. Results from the mediation analyses revealed an indirect effect of induction condition on the change in *positive mood* across the stressful task via contribution of negative non-affective switch costs[6] (see confidence interval in table 2). Induction condition was positively related to negative non-affective switch costs (path

[6] It is possible that competing indirect and direct effects (i.e. effect of focal predictor on outcome variable after controlling for the mediator variable) are present which alleviate the total relationship between the focal predictor and outcome variable when the mediating variable is not taken into account (Mathieu & Taylor, 2006). A total effect is not necessary for mediation (Hayes, 2009).

a), which in turn was negatively related to the change in positive mood across the stressful task (path *b*). The direct, positive relation between induction condition and the change in positive mood across the stressor when controlling for negative non-affective switch costs (path *c'*) was non-significant. Results from the mediation model indicate that participants in the positive MIP condition, as compared to participants in the neutral MIP condition, showed bigger decreases in positive mood across the stressor via contribution of less efficient shifting to non-affective aspects of negative material.

VAS Sad. A significant indirect effect was also found of induction condition on the change in *sad mood* across the stressful task via contribution of negative non-affective switch costs. Induction condition was positively related to negative non-affective switch costs (path *a)*, which was also positively related to the change in sad mood across the stressful task (path *b*). There was an insignificant direct, negative relation between induction condition and the change in sad mood across the stressor when controlling for negative non-affective switch costs (path *c'*). Results from the mediation model indicate that participants in the positive MIP condition, as compared to participants in the neutral MIP condition, showed bigger increases in sad mood across the stressor via contribution of less efficient shifting to non-affective aspects of negative material.

VAS Arousal. Results also showed an indirect effect of induction condition on the change in arousal across the stressful task via contribution of negative affective switch costs. Induction condition was positively related to negative affective switch costs (path *a)*, which in turn was negatively related to the change in arousal across the stressful task (path *b*). There was a direct, negative relation between induction condition and the change in arousal across the stressor when controlling for negative affective switch costs (path *c'*). The results from the mediation model show that participants in the positive MIP condition, as compared to participants in the neutral MIP condition, showed smaller increases in arousal across the stressor via contribution of less efficient shifting towards attending to affective aspects of negative material.

Table 2.

Indirect effects of induction condition on stress reactivity through affective flexibility

Mediator (switch type)	Outcome variable	Indirect effect	Boot *SE*	Boot 95% CI		*a* coeff	*b* coeff	*c'* coeff
				LL	UL			
Negative non-affective	ΔVAS happy during stressor	-7.60	3.69	-17.09	-2.14	158.51*	-0.05*	1.85
Negative non-affective	ΔVAS sad during stressor	4.30	2.30	1.09	10.39	158.51*	0.03*	-8.25
Negative affective	ΔVAS arousal during stressor	-4.40	3.08	-12.90	-0.16	108.59†	-0.04*	-11.35*

Note: *N* = 40. Boot = bootstrap analysis; LL = lower level; UL = upper level; *a* = relation focal predictor and mediator; *b* = relation mediator and outcome variable; *c'* = direct effect of focal predictor on outcome variable taking into account mediator; * < .05; † < .09.

Discussion

The aim of the experiment was to more directly test the proposition that effects of positive emotions on information processing are underlying the relation between positive emotions and resilience (Fredrickson, 1998; 2001). To our best knowledge, we are the first to examine this proposition by experimentally testing how the effects of positive mood on affective flexibility are underlying state resilience (i.e. stress reactivity). Evidence from previous studies have related increased affective flexibility to trait resilience (Genet & Siemer, 2011) and showed that greater flexibility when switching attention to non-affective aspects of negative material and to affective aspects of positive material was associated with more successful reappraisal after a negative mood induction (Malooly et al., 2013). Moreover, less flexibility when switching attention towards non-affective aspects of negative material has been related to increased rumination in daily life (Genet, et al., 2013). These results on affective flexibility support the idea that a more flexible cognitive processing style could work as a mechanism underlying effects of positive emotions on psychological resilience (Fredrickson, 1998; 2001).

First, we tested the effect of our mood induction on affective flexibility. Our mood manipulation check revealed that positive mood induction using imagery was successful. Contrary to expectations based on the broadening hypothesis, that positive mood would be related to more affective flexibility, results showed that the positive MIP condition, as compared to the neutral MIP condition, showed less affective flexibility for negative material. A possible explanation for the unexpected finding that the positive MIP condition was related to relatively less affective flexibility for negative material, may be that it is a mood-congruent effect. Being in a more positive mood may have caused less flexibility when processing negative material. However, this is only a tentative explanation as with a mood-congruent effect it would also be likely to observe opposite effects on affective flexibility for positive material (i.e. increased flexibility for positive material). Despite the unexpected finding of a relation between positive mood and decreased affective flexibility for negative material, it does seem that (positive) mood state influences the flexible processing of emotional material. Future research should therefore try to further examine in what way flexibility in attentional processing

of emotional material is influenced by mood state and to what extent it is more a stable disposition.

Secondly, we investigated stress reactivity in response to a stressful task. We examined the effects of the mood induction on the stress response and most crucial, we tested the indirect effects of positive mood on stress reactivity through affective flexibility. The stress induction task seemed to cause a general decrease in positive mood and increase in sadness, anger, and HRV, however, this was not different for the positive and neutral mood induction condition. Interestingly, an effect of MIP condition on the change in arousal and tenseness was found across the stressful task. Whereas the neutral condition was associated with a significant increase in arousal and tenseness during the stressor, the positive condition did not show such an increase. This is in line with the idea from the broaden-and-build theory and previous findings that the experience of positive emotions can have protecting effects during the experience of stress (Fredrickson, 1998; 2001; Ong et al., 2006; Tugade & Fredrickson, 2004).

When testing the indirect effects of the mood induction on the stress response via contribution of affective flexibility, differences between induction conditions were observed in the emotional stress response. As hypothesized based on a relation between positive mood and resilience, the positive mood induction condition, compared to the neutral condition, showed a smaller increase in arousal across the stressful task via contribution of less efficient switching of attention towards the affective aspects of negative material. This finding shows that the effects of positive mood on cognitive processing may indeed underlie the relation between positive mood and resilience. Although the broaden-and-build theory proposes positive emotions to be related to resilience through a more broadened and flexible cognitive processing style, our results indicate that less flexibility when shifting attention towards affective aspects of negative material can be adaptive. This finding would also fit previous evidence showing that difficulties disengaging attention away from negative material is related to depression (e.g. De Raedt & Koster, 2010; Gotlib & Joormann, 2010).

Contrary to what we anticipated based on the build hypothesis from the broaden-and-build theory, less flexibility when switching attention towards non-affective aspects of negative material mediated the relationship between positive mood

after the positive mood induction and a decrease in positive mood and increase in sad mood across the stressful task. These findings are surprising as we expected positive mood to be unequivocally related to increased stress resilience, also anticipated by - however absent - smaller decreases in positive mood and smaller increases in sad mood across the stressful task. Current findings that the positive condition, via less efficient switching of attention towards non-affective aspects of negative material, showed a greater stress response on positive and sad mood, could be seen in light of recent findings that increased flexibility on negative non-affective switch costs is related to increased reappraisal effectiveness (Malooly et al., 2013). Thus, decreased flexibility on negative non-affective switch costs seems to be more maladaptive for emotion regulation effectiveness and might explain the direction of the indirect relation between positive mood and increased stress reactivity on positive and sad mood. But, this also suggests that effects of positive mood on the stress response can be more or less adaptive depending on how and/or what cognitive processes are influenced by positive emotions. Thus, differential effects on stress reactivity are possibly depending on how induced positive mood influenced specific cognitive processes. This could suggest that as positive emotions can have complex effects on cognitive processes which might be influenced by, for example, individual characteristics, that this then also influences how positive emotions are indirectly related to stress resilience. This may hold implications for the proposition of the broaden-and-build theory (Fredrickson, 1998; 2001) that positive mood is related to undoing the effects of negative emotions and increased resilience, and that the effects of positive mood on cognitive processing are underlying this relation. Therefore, it would be interesting for future research to further investigate how positive mood influences different aspects of cognitive processing and whether, or in what way, that underlies resilience.

To summarize, results showed that a positive mood induction, as compared to a neutral mood induction, was associated with decreased affective flexibility for negative material, indicating that the flexible processing of emotional material is subject to influences of (positive) mood state. Furthermore, the mood induction was found to influence the emotional stress response, reflected in the positive condition showing a reduced effect on arousal and tenseness in response to a stressor, suggesting that the experience of positive emotions can have protecting effects during distress.

Importantly, the current study provides some first empirical evidence to suggest that the cognitive effects of positive mood could work as a mechanism in the relation between positive mood and stress reactivity. Results showed that the effect of a positive mood induction on decreased flexibility when shifting attention towards affective aspects of negative information is adaptive as indicated by smaller increases in arousal during a stressor. However, the positive mood induction was also indirectly related to greater increases in positive mood and decreases in sad mood across the stress induction, through decreased flexibility when shifting attention towards non-affective aspects of negative information. Although this is not surprising given previous findings on the relation between switching efficiency towards non-affective aspects of negative information and reappraisal ability after a negative mood induction (Malooly et al., 2013), this suggests that differential effects of positive mood on stress resilience could depend on how positive mood influenced specific cognitive processes. At this point more research is needed on how the effects of positive mood on information processing, such as affective flexibility for emotional material, underlie immediate stress reactivity or can contribute to developing resilience as a trait. Nonetheless, investigating the role of flexible attentional processing of emotional material as a cognitive mechanism underlying the relationship between positive mood and psychological resilience seems an interesting path for future research.

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CHAPTER 7

Positive mood and processing of ambiguous information in formerly depressed individuals: The influence of residual depressive symptoms and the relationship with stress reactivity[1]

Abstract

Depression is associated with high recurrence rates, stressing the importance of studying mechanisms of resilience against stress. The broaden-and-build theory describes the relation between positive emotions and resilience, proposing effects of positive emotions on cognitive processing to be a mechanism in this relation. As a postive processing bias is likely to influence the way we perceive our environment, we investigated in formerly depressed people how positive mood influenced one's tendency to interpret ambiguous information in positive or negative ways, using the Scrambled Sentence Test, and how these cognitive effects of positive mood influence stress reactivity. Additionally we investigated whether the presence of residual depressive symptoms qualified the effects of positive mood on cognition. Results showed that only at low levels of residual depressive symptoms, an increase in positive mood was related to a more positive processing bias. There was some indication that, at low levels of depressive symptoms, increased positive mood was related to a stronger stress response, reflected by a greater increase in arousal during the stress induction, via contribution of a more positive processing bias. Although caution should be remained in interpreting this effect, it could suggests the occurrence of a contrast effect. Findings are discussed in relation to predictions of the broaden-and-build theory of positive emotions and resilience.

[1] Based on Grol, M., Bruyneel, L., Koster, E.H.W., & De Raedt, R. (2014). Positive mood and processing of ambiguous information in formerly depressed individuals: The influence of residual depressive symptoms and the relationship with stress reactivity. Manuscript in preparation.

Introduction

Major depressive disorder is one of the most common mental disorders, with studies showing stunningly high prevalence rates. Epidemiological studies have shown life-time prevalence rates around 19% in the US (Kessler et al., 2009) which is similar to Europe (Wittchen et al., 2011).

Many studies have investigated vulnerability factors associated with depression, and much research has focused on the development of treatments resulting in a wide variety of available pharmacological and psychological interventions that are effective in the short term (e.g. Hollon & Ponniah, 2010); however, relapse rates remain high (Mueller et al., 1999). One of the best predictors of relapse or recurrence is a history of depressive episodes, with the risk of developing new episodes increasing with the number of pervious episodes (Keller, 2003). Moreover, successive depressive episodes are triggered by progressively milder stressors *(*Monroe & Harkness, 2005). Despite the wealth of research into risk factors related to depression, research on resilience factors protecting against depressive responding to stress is scarce, whilst understanding the mechanisms of resilience could be essential in understanding recurrent depression and its prevention (Waugh & Koster, 2014).

Studies on cognitive risk factors have shown a link between depression and biases in cognitive processes such as memory, attention, and interpretation. Depression has been associated with an increased accessibility of negative material and overgeneral memory recall (for review, see Williams et al., 2007), difficulties in disengaging from negative information in attention, and the tendency to negatively interpret ambiguous stimuli (for review, see De Raedt & Koster, 2010; Gotlib & Joormann, 2010). These biases in information processing are likely to affect the ability to regulate emotions and may thereby affect one's mental health given that emotion regulation is an essential component of mental health (Gross, 1998; Gross & Munoz, 1995).

Several studies have shown a link between depressive symptoms and the tendency to negatively intepret or process ambiguous information (e.g. Cowden Hindash & Amir 2012; Mogg, Bradbury, & Bradley, 2006), and such a negative processing bias has even shown to predict subsequent depressive symptoms (Rude, Wenzlaff, Gibbs, Vane, & Whitney, 2002). On the other hand, positive interpretation

bias training paradigms, training towards a more positive processing bias, have shown to improve positive mood (Holmes, Mathews, Dalgleish, & Mackintosh, 2006). Thus, it seems that negative biases in information processing are underlying prolonged negative mood or depression, but it seems plausible to hypothesize that resilience may also depend on such cognitive mechanisms (e.g. positive processing biases).

Processing of positive information might be crucial for resilience. A central theory on the relationship between positive emotions and resilience is the broaden-and-build theory (Fredrickson, 1998; 2001). The broaden-and-build theory describes the link between positive emotions and a *broadening* of one's though-action repertoires. Although evidence from several studies show an association between positive emotions and more flexible cognitive processing (Isen & Daubman, 1984), increased creativity (for review, see Baas, De Drue, & Nijstad, 2008), and increased attentional breadth (Derryberry & Tucker, 1994; Fredrickson & Branigan, 2005; Grol, Koster, Bruyneel, & De Raedt, 2014), results on visual attentional broadening are not always consistent (Bruyneel et al., 2012). The broaden-and-build theory also proposes that positive emotions are related to the *building* of psychological resilience and indeed studies show that the experience of positive emotions, especially among high-resilience individuals, facilitates their recovery from daily stressors (Ong, Bergeman, Bisconti, & Wallace, 2006). Importantly, the theory proposes the effects of positive emotions on cognitive processing to be an underlying mechanism in the relationship between positive emotions and resilience (Fredrickson, 1998; 2001).

One such mechanism in the relation between positive emotions and stress resilience may be the effect of positive emotions on one's mindset. That is, having a 'positive mindset' or postive processing bias will likely influence the way we perceive ourselves and the world around us, and may therefore also influence how individuals perceive stressfull situations and how they cope with this. Therefore, we hypothesized that the experience of positive emotions may increase the availability and accessibility of positive information in mind resulting in a more positive processing bias, which in turn could influence the respons to a stressful situation. In the current study we investigated this by examining the effects of positive mood on people's tendency to interpret ambiguous information as more positive or negative, using the Scrambled Sentence Task (SST; Wenzlaff, 1993). The study was performed in a sample of formerly

depressed individuals as they are especially at risk of developing new episodes, so studying mechanisms of stress resilience in this group is important in understandig and preventing recurrence of depression. However, as depressive symptoms have been related to negative intepretative biases (e.g. Cowden Hindash & Amir 2012; Mogg, Bradbury, & Bradley, 2006), it seems plausible that the presence of residual depressive symptoms may hamper the effect of positive mood on cognition. Therefore, we tested whether the presence of depressive symptoms would qualify the effect of positive mood on people's tendency to interpret ambiguous information in a positive or negative way. In addition to our interest in the effects of positive mood on the SST and the influence of residual depressive symptoms on this effect, we also examined whether the effects of positive mood on the interpretation of ambiguous material as positive or negative, is underlying the relation between positive mood and (emotional and physiological) stress reactivity in response to a stress induction. Physiological stress reactivity was assessed using heart rate variability (HRV). The index Root Mean Square of the Differences of Successive Intervals (RMSSD) was used as an index for HRV, based on recommendations of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (Taskforce, 1996). Previous research has shown that HRV can be used as an index of reactivity to stress. Decreases of HRV seem to indicate a maladaptive reaction related to worry (Pieper, Brosschot, Van der Leeden, & Thayer, 2007) and increases an adaptive self-regulatory physiological reaction to stressors (Park, Vasey, Van Bavel, & Thayer, 2014).

To induce positive mood we used a mood induction procedure involving the recall of positive autobiographical memories, compared to a control condition in which neutral autobiographical memories were recalled. Several studies in healthy samples have shown that using mental imagery from a field perspective (i.e. a first-person perspective) when processing positive descriptions is related to a more intense emotional response than verbal processing of positive descriptions (e.g. Holmes, Coughtrey, & Connor, 2008; Holmes et al., 2006). Next to our main research questions on the links between positive mood, information processing, and stress reactivity, we therefore also explored whether in a formerly depressed sample, imagining positive memories from a field perspective would result in a greater increase in positive mood than when verbally processing positive memories.

Method

Participants

Thirty-seven formerly depressed people (26 females), aged between 23 and 67 (*M* = 46.84, *SD* = 11.81), participated in this study and received a fixed allowance. This study was approved by the local ethical committee of the Faculty of Psychology at Ghent University as being part of a greater study concerning cognitive mechanisms of resilience in formerly depressed individuals.

Participants were recruited through advertisements in magazines and advertisements placed on internet forums. During a first telephone screening the main inclusion criteria were already checked such as the experience of at least one previous depressive episode, being in remission for at least six months, and no current/former diagnosis for bipolar disorder, psychosis, or neurological conditions. When people met these criteria, they were invited to come to Ghent University to complete the Dutch version of the Mini International Neuropsychiatric Interview (MINI; Sheehan et al., 1998), which is a structured interview assessing current and lifetime psychiatric disorders based on DSM-IV and ICD-10 criteria. When the inclusion criteria and an absence of other current axis-I disorders was met, participants were invited for a second visit to complete the experiment. Participants reported to have experienced on average 2.30 depressive episodes (*SD* = 1.54) and all participants had received treatment for at least one depressive episode (e.g. medication, psychotherapy). At the moment of testing 21 participants still received maintenance treatment (e.g. antidepressants, sleep medication, or psychotherapy).

Material[2]

Screening. To check the inclusion and exclusion criteria, participants were screened during a first telephone interview and afterwards more elaborately using the

[2] This study was part of a larger study in which three additional cognitive tasks were administered at the beginning of the experiment measuring attentional breadth with a global-local Navon letter task (Navon, 1977), affective flexibility with an affective switching task (Malooly, Genet, & Siemer, 2013), and attentional disengagement from non-emotional and emotional information measured with an emotional interference task (Fox, Russo, Bowles, & Dutton, 2001). Additional questionnaires that were administered were the Ruminative Response Scale (Nolen-Hoeksema & Morrow, 1991; Raes, Hermans, & Eelen, 2003), the trait version of the State Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagge, & Jacobs, 1983; Van der Ploeg, Defares, & Spielberger, 2000), and the Dutch version of the Resilience Scale (Portzky, 2008).

Dutch version of the MINI (Sheehan et al., 1998). This structured interview assesses current and lifetime psychiatric disorders based on DSM-IV and ICD-10 criteria.

Questionnaires. Throughout the experiment we measured mood state at various moments using visual analogue scales (VAS) measuring how happy, sad and aroused participants were feeling "at this moment". Before and after the stressor, and after the recovery period we additionally measured how angry and tense participants were feeling "at this moment". We used VAS scales (0 to 10 cm, resulting in a 0-100 scale) as these are very sensitive to fluctuations in affect because of their visual presentation (Rossi & Pourtois, 2012a). We measured how happy and sad participants were feeling on a scale with the anchor points from "neutral" to "as happy/sad as I can imagine", arousal was measured on a scale with anchor points from "calm" to "aroused", and we measured anger and tenseness on a scale with the anchor points "not at all" and "as angry/tense as I can imagine".

Trait affectivity was measured using the Positive and Negative Affect Schedule trait version (PANAS; Watson, Clark, & Tellegen, 1988), measuring to which degree participants felt the emotions "*in general*" on a scale ranging from 1 "very slightly" to 5 "very much".

The presence and severity of depressive symptoms in the former two weeks was assessed using the 21-item Beck Depression Inventory (BDI-II-NL; Beck, Steer, & Brown, 1996; Van der Does, 2002), a self-report scale with responses ranging from 0 to 3.

The Spontaneous Use of Imagery Scale (SUIS; Nelis, Holmes, Griffith, & Raes, 2014; Reisberg, Pearson, & Kosslyn, 2003) was administered to measure the use of mental imagery in daily life. Participants rated the degree to which descriptions applied to themselves on a 5-point scale ranging from 1 "never appropriate" to 5 "always completely appropriate".

Mood induction procedure. The mood induction procedure (MIP) consisted of a procedure in which mental imagery was used in two of the induction conditions and verbal processing in a third condition. Participants were instructed to vividly imagine either a self-provided neutral or positive autobiographical memory in the imagery conditions, while in the verbal condition participants verbally processed a positive autobiographical memory. Participants in the imagery conditions first practiced the use of mental imagery from a field perspective (i.e. first person perspective) by completing

an imagery practice task of cutting a lemon (Holmes et al., 2008). Participants in the verbal processing condition also completed a practice task with instructions to focus on the words and their meaning of descriptions (Holmes et al., 2008). All participants were then instructed to recall a memory of a specific event that happened more than one week ago, that either did not elicit strong negative or positive emotions at that time (i.e. a neutral memory), or a specific event which made them feel very happy at that time (i.e. a positive memory) depending on the induction condition they were in. Participants in the imagery conditions were asked to shut their eyes while describing what they remembered aloud, while no such instruction was given in the verbal condition. In the imagery conditions participants received instructions (Watkins & Moberly, 2009; based on Holmes, et al., 2008) to promote concreteness and imagining the event from a field perspective (as if they see the situation through their own eyes), while participants in the verbal condition were instructed to concentrate on the words and their meaning in the description of their memory. In the imagery conditions participants imagined the event for 30 seconds after which they were asked a series of questions (based on Watkins & Moberly, 2009), asking them to focus on what they could see, hear, and physically feel. Furthermore, during the mood induction, manipulation checks were administered to measure the use of field and observer perspective and verbal processing. Participants were asked to rate on a 5-point Likert scale the extent to which they adopted a field perspective, that is the extent to which they "saw the event through their own eyes and were actively involved?", the extent to which they adopted an observer perspective, "to what extent did you experience the event looking at yourself from outside, as if you see yourself taking part in the situation?", and to what extent they used verbal processing, "to what extent did you tell us about the situation, without seeing the situation in front of you, and were you more verbally analyzing the description of the situation?". Participants in the verbal condition also described the event for 30 seconds, after which they were only asked to give their ratings for the manipulation checks. Following these questions, participants in the imagery conditions were instructed to continue imagining the event for another 30 seconds without describing aloud. Participants in the verbal condition were asked to continue describing the event for another 30 seconds. At the end the manipulation checks were performed again by all participants.

Scrambled sentence task. To assess the availability of positive information in mind or a 'positive mindset', we used a computerized version of the Dutch translation of the Scrambled Sentence Task (SST; Van der Does, 2005; Wenzlaff, 1993). Scrambled sentences consisting of six words were presented on the screen and participants had to form correct sentences consisting of five words, leaving out one word. Participants used the numbers 1-6 to indicate the order of words from the scrambled sentence to form a correct sentence consisting of five words. Two correct sentences could be formed, a sentence with either a positive or a negative solution. Participants are instructed to form propositions and not interrogative sentences. Participants are told that each sentence can be reformed in several ways but they have to choose. They are instructed to work as quickly as possible to be able to reform as many sentences as possible because time was restricted to 6 minutes. Furthermore, participants were given a 6-digit number to remember while doing the task, based on a previously used procedure to increase the cognitive load during the task in order to undermine participants' tendency to suppress negative solutions in the task (Wenzlaff, 1993). In the current experiment we administered two lists of 20 scrambled sentences in counterbalanced order, one list before the mood induction and one list afterwards. We calculated a positive index which is the ratio of the number of correctly formed sentences with a positive solution on the total of correctly formed sentences.

Stress induction task. In order to induce stress we used a task in which participants received manipulated negative feedback on their task performance. This task has been previously used to study the effects of stress on attention (for a full description, see Rossi & Pourtois, 2012b, Rossi & Pourtois, 2013). During instructions, the task was told to be a task measuring people's ability to detect differences in line orientation. Participants were told that people can already detect very small differences and that they can improve with practice. During a practice session participants have to learn the standard line orientation which is presented in the center of the screen for several times. During three following test blocks, participants are instructed to count the number of deviating line orientations and give in this number at the end of each block in a response screen that appears on screen. Participants were instructed that after each block they would receive feedback on their performance during that block. The feedback screen was presented for 20sec and consisted of a neutral face with a text

balloon containing bogus, negative feedback (e.g. “You performed badly! Your response accuracy is lower than average in comparison to previous participants.”, “Try to do better!”). Additionally a fake scatter plot was presented comparing the participants’ performance against the performance of previous (alleged) participants.

Physiological stress reactivity. To measure the physiological stress reaction in response to the stressful task, we assessed heart rate first during baseline and then critically during the stress induction and during a 15 minute recovery period afterwards. Beat-to-beat heart rate was measured using a telemetric heartbeat monitor (Polar S810). Heart rate data was moderately filtered with a minimum zone of 6 beats a minute (Cottyn, De Clercq, Pannier, Crombez, & Lennoir, 2006) with the Polar Precision Performance Software for Windows. Data was then further analyzed with Kubios (Niskanen, Tarvainen, Ranta-Aho, & Karjalainen, 2004) in order to obtain the Root Mean Square of the Differences of Successive Intervals (RMSSD) index of HRV. The index is recommended for short-term HRV analysis (Task Force, 1996) and provides an indication of modulations in parasympathetic outflow (Kleiger, Stein, Bosner, & Rottman, 1992).

Procedure

Participants were recruited through advertisements in magazines and on internet forums. During a first telephone screening people were asked questions with regard to past and current depressive episodes and symptoms and with regard to a current/former diagnosis for bipolar disorder, addiction, psychosis, or neurological conditions. Participants were invited for a first appointment when they met the main inclusion criteria of being at least one time diagnosed as having a major depressive disorder but were no longer depressed for at least six months and never diagnosed with bipolar disorder, psychosis, or neurological conditions. During this first appointment participants were interviewed, after informed consent, with the Dutch version of the MINI to explore previous depressive episodes and other axis-I disorders. When the inclusion criteria and an absence of other current axis-I disorders was met, participants were invited for a second visit to complete the experiment.

Participants were randomized to receive either the neutral or positive mood induction using mental imagery, or the verbal positive mood induction. After informed consent participants first filled out the BDI-II-NL and PANAS. Scores on the BDI-II-NL

indicating moderate symptoms (i.e. < 29; Beck et al., 1996) reflecting some residual symptoms were still accepted given that according to the MINI participants were not clinically depressed, resulting in no exclusion of participants from further testing. Next, three additional cognitive tasks were administered but these analyses were not related to the hypotheses of the current study (see footnote 1). Following this, the additional questionnaires were administered. Next, we explained how the telemetric heartbeat monitor works and it was put on. A 20-minute heart rate baseline was then measured in which we ask participants to relax. After this baseline period we continued beat-to-beat heart rate registration throughout the rest of the experiment, but the time periods of interest were during the stressful task and recovery period. Following the heart rate baseline assessment, mood state was measured using the VAS and the first SST was performed. Afterwards, mood state was measured again followed by the mood induction procedure and a post-induction mood state assessment. The second SST was then administered. Following the second SST, mood state was measured and a quick repetition of the mood induction (without the practice task) was performed to lengthen the effects of the induction. Mood state was then measured right before participants performed the stressful task in which they received manipulated negative feedback. After the stressful task mood state was measured again and was followed by a 15-minute recovery period in which participants were instructed to do nothing. For ethical reasons, we measured mood levels again after this recovery period in order to verify that the effects of the stressor were diminished[3]. Finally, participants were fully debriefed, especially with regard to the manipulated feedback in the stressful task.

Results

Preliminary analyses

For the heart rate data during the baseline period, we only analyzed the data from the last 10 minutes of the 20-minute baseline period. Possible arousal when starting to measure heart rate is then excluded in the baseline. Registered heart rate data during the stress induction task was only used from the point when participants received negative feedback for the first time until the end of the task, which was for a

[3] Analyses indicated that participants reported a general increase in positive mood, a general decrease in sadness, arousal, anger, and tenseness, and a near significant decrease in HRV across the recovery period.

period of about 7 minutes. For the heart rate assessment during the 15-minute recovery period, we only analyzed the data starting two minutes after the end of the stress induction task and for a duration of ten minutes. This excludes the first two minutes after the ending of the stressful task in which participants are filling out the mood state scales. We only analyzed ten minutes of the registered heart rate data at baseline and recovery, in order to analyze time slots of heart rate data during baseline, stress task, and recovery that are of similar duration.

Table 1.

Participant Characteristics

	Neutral – imagery (*n* = 13)	Positive – imagery (*n* = 12)	Positive – verbal (*n* = 12)
Age	52.00 (10.04)	43.25 (12.17)	44.83 (12.17)
Gender	10 females	6 females	10 females
Education level	2.67 (0.65)	2.92 (0.90)	3.17 (0.72)
Nr. of depressive episodes	2.15 (1.07)	2.83 (2.21)	1.92 (1.08)
Hospitalization (past); %	46.2%	33.3%	33.3%
Current treatment; %	76.9%	58.3%	33.3%
PANAS trait positive	35.54 (6.31)	35.58 (6.26)	34.42 (5.98)
PANAS trait negative	17.77 (4.19)	14.67 (4.42)	21.50 (6.23)
BDI-II-NL	5.33 (4.44)	4.45 (6.17)	6.92 (7.13)
SUIS	33.54 (8.50)	37.08 (9.83)	36.75 (5.53)
HRV baseline	30.82 (18.55)	39.85 (21.90)	48.37 (45.78)

Note: Education level was coded as follows: 1 = did not graduate high school, 2 = graduated high school, 3 = higher education, 4 = University degree. Hospitalization (past) = participants who were in the past at least once hospitalized for depression. Current treatment = percentage of participants who still received maintenance treatment for past depressive episodes at time of testing (e.g. anti-depressants, sleep medication, or psychotherapy).

Participant characteristics

Baseline characteristics for participants in the three induction conditions are presented in Table 1. Participants in the three conditions did not differ in age,

distribution of gender or education level, all *p*s > .05. Conditions neither differed in the number of past depressive episodes participants experienced, past hospitalization, nor with regard to current maintenance treatment, *p*s > .05. To test for pre-existing differences between the experimental conditions, univariate ANOVAs were performed on the SUIS and HRV at baseline (after logarithmic transformation because of not normality of the data). There were no significant differences between conditions on these variables, all *p*s > .05. A multivariate ANOVA was performed on baseline VAS positive mood, sad mood (after logarithmic transformation due to non normality of the data), and arousal, with Condition as between-subjects variable[4]. However, no significant effect of Condition was found, Pillai's Trace $F(6,66) = 0.46$, $p = .837$, $\eta_p^2 = .04$. To test for pre-existing differences on PANAS trait affectivity and BDI depressive symptoms (PANAS negative affectivity and BDI were logarithmically transformed due to non normality of the data), we performed a multivariate ANOVA with Condition as between-subjects variable. A significant effect of Condition was found, Pillai's Trace $F(6,62) = 2.71$, $p = .021$, $\eta_p^2 = .21$. Univariate ANOVAs showed a difference between conditions on PANAS negative affectivity, $F(2,32) = 8.52$, $p = .001$, $\eta_p^2 = .35$, with Bonferroni corrected post hoc tests revealing that the positive imagery condition reported lower PANAS negative affectivity scores than the neutral imagery condition, $p = .044$, and the positive verbal condition, $p = .001$.

Mood manipulation check

During the mood induction procedure, participants were asked to rate the extent to which they had imagined the situation from a field or observer perspective and to which extent they had verbally processed the personal memory. A non-parametric Kruskal-Wallis test (due non-normality of the data) showed that the three induction conditions only significantly differed on the ratings considering verbal processing. Follow-up Mann-Whitney tests revealed that in the positive verbal condition ratings for verbal processing were higher ($M = 3.00$, $SD = 1.04$) than the neutral imagery condition ($M = 1.77$, $SD = 1.05$) and positive imagery condition ($M = 2.13$, $SD = 1.30$), $U = 27.50$, $p = .004$, $r = -.56$ and $U = 39.00$, $p = .054$, $r = -.39$ respectively.

[4] Standardized residuals for VAS positive mood were not-normally distributed, but results were similar with a non-parametric test.

A multivariate mixed ANOVA was performed on VAS positive mood, sad mood (after logarithmic transformation due to non-normality of the data), and arousal. Time (pre- vs. post-induction) was entered as a within-subjects variable and Condition (neutral imagery vs. positive imagery vs. positive verbal) as between-subjects variable[5]. A marginally significant main effect of Time was found, Pillai's Trace $F(3, 32) = 2.49$, $p = .078$, $\eta_p^2 = .19$, but no significant Time x Condition interaction was found, Pillai's Trace $F(6, 66) = 1.70$, $p = .136$, $\eta_p^2 = .13$. Univariate ANOVAs revealed only a significant main effect of Time on VAS positive mood, $F(1, 34) = 5.67$, $p = .023$, $\eta_p^2 = .14$, reflecting a general increase in positive mood, while this effect was not significant for VAS sad mood and arousal, all *p*s > .05.

Effect of mood induction on scrambled sentence task

Results from the mood manipulation check revealed that there was only an effect of time on our main variable of interest, positive mood. A general increase in positive mood was observed but the effect was not different between induction conditions. Therefore we more directly tested the effects of positive mood on the scrambled sentence test, taking into account interindividual differences in the effectiveness of the mood induction procedure, by including the change in positive mood across the induction (i.e. the difference score in positive mood from pre- to post-MIP) as a predictor.

We performed a linear regression analysis on the SST positive index at post-induction[6]. SST positive index scores at pre-induction were entered in a first step to control for pre-existing interindividual variance, and the change in positive mood across the mood induction (i.e. the difference score from pre- to post-induction) was entered as a predictor in the second step. The analysis did not show a significant effect of the change in positive mood on the SST positive index at post-induction when taking into account variability on the SST at pre-induction, $t = 0.29$, $p = .773$, $r_{partial} = .05$.

Moderation influences. We further explored moderation effects of depressive symptoms (i.e. the BDI-II-NL) on the effects of positive mood on the SST. Hierarchical multiple regression analyses were performed to test moderation effects of the BDI-II-

[5] Standardized residuals for VAS positive mood were not-normally distributed, but results were similar with a non-parametric test.

[6] SST data was missing for two participants because of measurement error.

NL, following the approach of Aiken and West (1991). Scores on the BDI-II-NL and the difference score of VAS happy from pre- to post-induction were centered. Subsequently, the interaction was calculated by multiplying the centered BDI-II-NL scores with the difference score of VAS happy from pre- to post-induction. In the regression analysis, the centered change score on the VAS happy scale, the centered BDI-II-NL, and the SST positive index at pre-induction were entered as predictors in a first step. The interaction term was entered as a predictor in the second step of the analysis. The SST positive index at post-induction was entered as the dependent variable. Results from the moderation analyses revealed that the presence of residual depressive symptoms (i.e. the BDI-II-NL) moderated the relation between the change in positive mood an de SST positive index at post-induction. The interaction term was near significant, t = -1.97, p = .059 and added an explained variance to the model of ΔR^2 = .08.

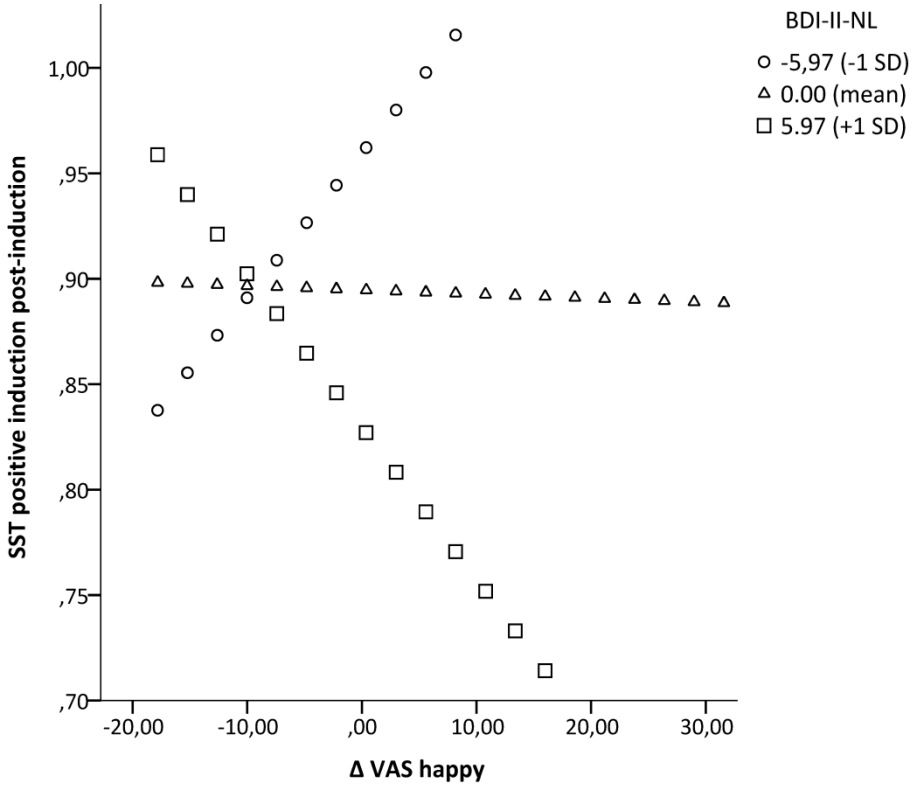

Figure 1. *The conditional effects of positive mood on the SST positive index at post-induction, taking into account the SST positive index at pre-induction, at low, moderate, and high values of the BDI-II-NL. This plot was derived using Hayes and Matthes' SPSS macro (2009).*

Results from the simple slope analyses (see Figure 1) using Hayes and Matthes' SPSS macro (Hayes & Matthes, 2009), show that only at low levels (below 1 SD) of depressive symptoms a near significant relation between the change in positive mood and the SST positive index at post-induction was found, t = 1.97, p = .058, b = 0.01, while such a relation was absent (i.e. not significant) at moderate (sample mean), t = -0.09, p = .928, b < -0.001, and high levels (above 1 SD) of depressive symptoms, t = -1.52, p = .141, b = -0.01. This indicates that only at low levels of depressive symptoms a trend was found for an increase in positive mood across the mood induction to be related to a higher SST positive index at post-induction, when taking into account pre-existing variability in the SST positive index.

Influence of the stress induction on the physiological and emotional stress response.

To examine how the stress induction task influenced the physiological state of the participants across the stress induction and recovery period, we performed paired t-tests across all participants HRV (after logarithmic transformation because of non-normality of the data). Results showed that across all participants there was an increase in HRV from baseline to the stress induction, $t(27) = 3.97$, $p < .001$.[7]

Previous studies suggest that tonic HRV levels can influence the change in phasic HRV, showing that people characterized by higher tonic HRV show an enhancement of phasic HRV in response to negative emotional stimuli, reflecting self-regulatory efforts, whereas people with lower tonic HRV show a more typical autonomic stress response (e.g. Park et al., 2014). Therefore, we examined the correlation between HRV baseline level and the change score in HRV from baseline to stress task (both baseline and difference scores were logarithmically transformed due to non normality of the data), r = .03, p = .881. This indicates that in this formerly depressed sample, there was no relation between baseline (tonic) HRV level and the change in HRV from baseline to the stress induction task.

To examine the emotional stress response across the stress induction task, a multivariate repeated measures ANOVA was performed on the VAS happy, arousal, sad, anger, and tense, with Time (pre- vs. post-stress induction) as a within-subjects

[7] HRV data was missing for some participants due to measurement error with the telemetric heartbeat monitor.

variable[8]. The repeated measures MANOVA revealed a significant effect of Time, $F(5, 32) = 6.17$, $p < .001$, $\eta_p^2 = .49$. Univariate tests showed a significant main effect of Time for VAS happy, $F(1, 36) = 8.04$, $p = .007$, $\eta_p^2 = .18$, for VAS anger, $F(1, 36) = 8.60$, $p = .006$, $\eta_p^2 = .19$, for VAS tense, $F(1, 36) = 7.51$, $p = .009$, $\eta_p^2 = .17$, and a near significant effect of Time for VAS sad, $F(1, 36) = 4.00$, $p = .053$, $\eta_p^2 = .10$. Results indicated that across the stress induction participants reported a general decrease in positive mood and an increase in anger, tenseness, and sadness.

Influence of the SST positive index on the relation between positive mood and stress reactivity.

We tested the effects of positive mood (predictor: difference score of VAS happy from pre- to post-MIP) on stress reactivity (outcome variable: the change in mood, arousal, tenseness, and HRV across the stressful task) through the SST positive index score (mediator: SST positive index at post-induction). The presence of depressive symptoms was entered as a moderator on the relation between positive mood and the SST positive index (moderator: BDI-II-NL).

We used Hayes' SPSS macro PROCESS (2012) to test the mediation models. The bias corrected bootstrapping approach was used to test for statistical significance of the indirect effect (Preacher & Hayes, 2008). We estimated 10000 bootstrap bias-correct 95% Confidence Intervals (CI) and the indirect effect was considered significant if the CI did not contain zero. For the mediation model neither the relation between the focal predictor and mediator (path *a*), nor the relation between the mediator and outcome variable (path *b*) needs to be significant (Hayes, 2009); however, we computed the regression weights to clarify the direction of these relations. The coefficient for the direct effect of the focal predictor on the outcome variable, independent of the moderated pathway through the mediator (path *c'*) was also computed.

A conditional mediation effect was found (see Figure 2) of positive mood on the change in arousal across the stressful task via contribution of the SST positive index at post-induction, at low levels (- 1SD from mean) of the BDI-II-NL, $b = .25$, Boot $SE = 0.16$, Boot 95% CI [0.01; 0.71]. The coefficient of the direct effect (path *c'*) was not significant, $b = .01$, $p = .976$, while the coefficient of path *b* was marginally significant, $b = 27.81$, $p =$

[8] Not all standardized residuals were normally distributed, but results were similar with non-parametric tests.

.091. Results from the above reported moderation analysis showed that an increase in positive mood was related to a higher SST positive index post-induction (path *a*) at low levels of the BDI-II-NL. The indirect effect indicates that at low levels of the BDI-II-NL, a greater increase in positive mood was related to a greater increase, or smaller decrease, in arousal during the stressful task via contribution of a higher positive index on the scrambled sentence task.

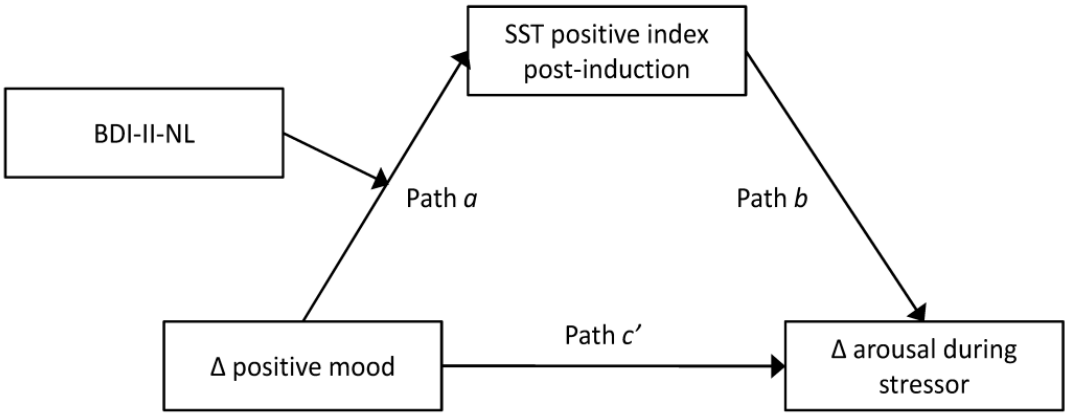

Figure 2. *Schematic overview of the conditional mediation effect of positive mood on the change in arousal across the stressful task via contribution of the SST positive index at post-induction, at low levels of the BDI-II-NL.*

Discussion

Major depressive disorder is one of the most common mental disorders. Both prevalence rates (Kessler et al., 2009; Wittchen et al., 2011) and relapse rates are high (Mueller et al., 1999), pointing out the need of research on mechanisms of psychological resilience. As a history of depressive episodes is a strong predictor of new depressive episodes (Keller, 2003), it is important to investigate mechanisms of resilience against a depressive responding to stress in formerly depressed individuals.

The broaden-and-build theory (Fredrickson, 1998; 2001) proposes positive emotions to undo the lingering effects of negative emotions and to contribute to developing resilience as a trait, with the effects of positive emotions on cognitive processing being a mechanism in this relation between positive emotions and resilience. Therefore, we investigated whether induced positive mood is related to a more positive processing bias, as measured with the SST, and whether this relation is qualified by the presence of residual depressive symptoms. We then further tested

whether the effect of positive mood on a positive processing bias influenced the relation between induced positive mood and stress reactivity. Additionally to our main research questions, we also explored whether in a formerly depressed sample, positive memory recall using field perspective imagery, as compared to verbal processing, resulted in a greater positive emotional response. This was based on research showing that field perspective imagery (i.e. first-person perspective), as compared to verbal processing, is related to a more intense emotional response (e.g. Holmes et al., 2006).

Our results of the mood induction showed that there was only a general increase in positive mood, but no differences across the three induction conditions in the positive emotional response. Although participants in the verbal processing condition reported to have verbally processed the memory to a greater extent than the other conditions, there were no differences between conditions in ratings of adopting a field and observer perspective. Previous research has shown that specific memories are much more associated with mental images than general memories (Mansell & Lam, 2004), so it is possible that the instructions to recall a specific memory increased the likelihood of mental images, intensifying the emotional response across all conditions. Furthermore, formerly depressed individuals may have experienced the task of imagining an autobiographical memory, even a neutral memory, as pleasant. However, at this point we can only speculate about the absence of differences in the emotional response between the induction conditions, and we cannot exclude that it is merely the small sample sizes in each condition that reduced statistical power to observe differences.

The first main aim of the study was to investigate the effect of induced positive mood on a positive processing bias, measured with the SST, and whether this effect was qualified by the presence of depressive symptoms. Based on first analyses, no direct relation was found between an increase in positive mood and a more positive processing bias; however, this relation tended to be moderated by the presence of depressive symptoms. As expected, we found that a greater increase in positive mood tended to be related to a higher SST positive index, reflecting a more positive processing bias, at low levels of depressive symptoms. Such relation was absent with average and high levels of depressive symptoms. This finding at low levels of depressive symptoms is in line with our expectation that being in a positive mood is associated

with having a more 'positive mindset' or positive processing bias, which may influence the way we perceive ourselves and the world around us. Combining this with previous studies showing that directly training towards a more positive interpretation or processing bias improves positive mood (Holmes et al., 2006), indicates that the relation between increased positive mood and a more positive processing bias is likely to be reciprocal. However, the presence of residual depressive symptoms hampered the effect of an increase in positive mood on a more positive processing bias, which could be explained by studies linking depressive symptoms to a more negative processing bias (e.g. Cowden et al., 2012; Mogg et al., 2006). This suggests that not everyone is able to benefit from the experience of positive emotions at the level of cognitive functioning, and in the current study especially formerly depressed individuals experiencing low levels of residual depressive symptoms showed a cognitive response to positive emotions.

In a second step of the analyses we directly tested the hypothesis derived from the broaden-and-build theory (Fredrickson, 1998; 2001) that positive emotions are related to stress resilience and that the effects of positive emotions on cognition can be a mechanism in this relation. Across all participants the stressful task caused a decrease in positive mood and an increase in anger, tenseness, sadness, and HRV, indicating that the stress induction involving negative feedback on task performance, had generally induced an emotional stress reaction. A moderated mediation model then revealed that only at low levels of depressive symptoms, a greater increase in positive mood was related to a greater increase, or smaller decrease, in arousal during the stress induction via contribution of a more positive processing bias. Though this may demonstrate that, as proposed by the broaden-and-build theory (Fredrickson, 1998; 2001), the effects of positive emotions on cognitive processing can underlie the relation between positive emotions and stress resilience, such an indirect effect was only found on one measure of the emotional stress response. Moreover, the current finding is difficult to interpret. Emotion research describes different dimensions of emotional experiences, such as valence and arousal, and shows that arousal can coincide with both positive and negative emotions (for a review, see Kuppens, Tuerlinckx, Russell, & Feldman Barret, 2013). Results revealed no general effect of the stress induction on arousal thus it is

difficult to interpret whether an increase (or smaller decrease) in arousal in the current study reflected an enhanced or diminished stress response.

In order to have an idea of whether a greater increase in arousal reflected an enhanced or diminished stress response, we examined the correlations between the change in arousal across the stressor and the change on the other measures of the emotional stress response. Non-parametric Spearman correlations (due to non-normality of some variables) revealed that the change in arousal across the stressor was positively related to the change in anger, r_{sp} = .36, p = .031, and tenseness, r_{sp} = .72, p < .001, suggesting that an increase in arousal reflected a greater stress response. This implies that at low levels of depressive symptoms, a greater increase in positive mood was related to a greater increase in arousal across the stress induction – reflecting a greater stress response - via contribution of a more positive processing bias. Although this seems to contradict predictions based on the broaden-and-build theory (Fredrickson, 1998; 2001) about the relation between positive emotions and stress resilience, our results are similar to previous findings in formerly and currently depressed individuals showing an inability to use positive memory recall to regulate emotions after a negative mood induction (Joormann, Siemer, & Gotlib, 2007). A possible explanation for this finding is the occurrence of a contrast effect (Joormann et al., 2007). That is, a greater increase in positive mood which led to a greater positive processing bias, may have adversely influenced participants' feelings of (negative) arousal during the stressful task because it suggested deterioration. Although this is only a tentative explanation, it would be interesting for future research to compare never-depressed and formerly-depressed individuals in how likely being in a more positive mindset leads to a focus on deterioration during distress, which increases the risk of a contrast effect when being in a positive mindset and encountering a stressful situation.

Taken together, findings reveal a qualified relation between an increase in positive mood and a more positive processing bias, suggesting that especially formerly depressed individuals experiencing low levels of residual depressive symptoms tend to benefit from positive emotions at the level of cognitive processing. This also indicates that the presence of residual depressive symptoms in formerly depressed individuals - a strong predictor of relapse (Keller, 2003) - hampered the effects of positive emotions

on cognitive processing which in turn could potentially hinder development of resilience (as a trait). There was some indication that at low levels of depressive symptoms, induced positive mood was related to a greater increase (or smaller decrease) in arousal during the stress induction via contribution of a more positive processing bias. However, we should remain cautious in concluding that a more positive processing bias could act as a mechanism in the relation between positive emotions and stress reactivity, as such an indirect effect was only observed on one aspect of the emotional stress response. Furthermore, we could only infer that the indirect effect of positive mood on arousal reflected an enhanced stress response by examining the correlations between the change in arousal across the stressor and the change on other measures.

This study was a first effort to experimentally investigate hypotheses derived from the broaden-and-build theory (Fredrickson, 1998; 2001) in a formerly depressed sample, by testing the effect of induced positive mood on cognitive processing and whether this underlies stress reactivity. Research should continue to investigate the cognitive mechanisms in the relation between positive emotions and psychological resilience, whether this is similar in never-depressed and formerly-depressed individuals, and how residual depressive symptoms or other vulnerability factors for recurrence influence the interplay between positive emotions, cognition, and stress reactivity. It is important to improve our understanding of the mechanisms of psychological resilience as this seems crucial in understanding recurrent depression and thereby its prevention (Waugh & Koster, 2014).

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CHAPTER 8

Mental imagery of positive and neutral autobiographical memories: A fMRI study comparing field perspective imagery to observer perspective imagery[1]

Abstract

Imagery perspective can influence what information is recalled, processing style, and emotionality; however, the understanding of possible mechanisms mediating these observed differences is still limited. We aimed to examine differences between memory recall from a field perspective and observer perspective at the neurobiological level, in order to improve our understanding of what is underlying the observed differences at the behavioral level. We conducted a fMRI study in healthy individuals, comparing imagery perspectives during recall of neutral and positive autobiographical memories. Behavioral results revealed field perspective imagery of positive memories, as compared to observer perspective, to be associated with more positive feelings afterwards. At the neurobiological level, observer perspective imagery was associated with greater activity in the right precuneus than during field perspective imagery. Provided that the precuneus has previously been linked to self-referential and evaluative processing, our results support the idea that observer perspective imagery is related to thinking about events in terms of their meaning in an individuals' life and in relation to the self-concept. This could imply that imagery perspective does not directly affect emotionality but that effects of observer perspective imagery on emotional intensity depend on how the past event is perceived in relation to the (current) self-concept.

[1] Based on Grol, M., Vingerhoets, G., & De Raedt, R. (2014). Mental imagery of positive and neutral memories: A fMRI study comparing field perspective imagery to observer perspective imagery. Manuscript submitted for publication.

Introduction

When people think back of past events and experiences, they often report to have mental images related to the event. Mental imagery of autobiographical memories can have powerful emotional effects (Holmes & Mathews, 2005; 2010) and influence thoughts and behavior like present situations. Due to the strong link with emotion, mental imagery is therefore also used in psychotherapy, for example, in the form of imagery rescripting (Holmes, Arntz, & Smucker, 2007). Furthermore, it has been demonstrated that the recall of positive autobiographical memories plays a role in the self-generation of positive emotions when faced with a stressful situation (Phillippe, Lecours, & Beaulieu-Pelletier, 2009). In healthy participants, positive memory recall has been shown to be a successful emotional regulation strategy to improve mood after a negative mood induction (Joormann & Siemer, 2004; Joormann, Siemer & Gotlib, 2007). This suggests that promoting imagery of positive emotional memories, possibly strengthening the emotional effects, may be interesting for applications of positive memory recall in emotion regulation.

A distinction is made between imagery from a field perspective and imagery from an observer perspective, with individuals being able to experience more than one perspective when recalling events (Rice & Rubin, 2009). Field perspective is about imagining a situation such that "people re-experience the event through their own eyes, as if they were looking outward, perceiving the situation now much as they did before." Observer perspective, on the other hand, is described as when people "take the perspective of an autonomous observer or spectator, so that they see themselves as actors in the remembered scene" (McIsaac & Eich, 2002, p. 146). Imagery perspective can influence the information that is recalled about events and the intensity of the emotional response. Previous research has indicated that individuals imagining memories from a field perspective gave more statements concerning affective reactions, physical sensations, and psychological states, whereas memories imagined from an observer perspective included more information concerning how the person looked, physical actions, or spatial relations (McIsaac & Eich, 2002). It has also been proposed that thinking about past events in terms of the experiences evoked by features of the event is related to a field perspective, as compared to thinking about the

event in terms of its broader context or meaning in an individuals' life which is related to an observer perspective (Libby & Eibach, 2011).

Imagery perspective is also believed to influence the emotional response. Field perspective imagery has been related to a greater emotional response than imagery from an observer perspective and/or verbal processing (Holmes, Coughtrey, & Connor, 2008; Holmes, Lang, & Shah, 2009; Holmes, Mathews, Dalgleish, & Machintosh, 2006) and individuals imagining memories from a field perspective perceive their memories as more emotional than individuals imagining memories from an observer perspective (McIsaac & Eich, 2002). Alternatively, it has been proposed that imagery perspective does not directly influences emotional impact, but that the differential effects of imagery perspective on emotional impact depend on whether considering the event in terms of its broader context or meaning in an individuals' life (during observer perspective) decreases or increases the emotional power (Libby & Eibach, 2011).

Research on mental imagery thus seems to indicate that imagery perspective can influence the type of information that is recalled and the intensity of the emotional response. Given that imagery of memories is often used in psychotherapy and has interesting possibilities for application in the self-generation of positive emotions and emotion regulation, it seems important to understand the underlying mechanisms of differences between imagery perspectives. However, our understanding of possible mechanisms mediating these observed differences between imagery perspectives is still limited. A possible explanation for the differences between imagery perspectives on emotional intensity has been proposed based on studies comparing self-distancing to self-immersion when reflecting on emotional experiences. Self-immersion has been described as focusing on concrete features of the experience leading to a reliving of the experience, which could be compared to taking a field perspective. Self-distancing on the other hand, might reflect more abstract processing and has been described as working through experiences from an ego-decentered perspective which is more in line with adopting an observer perspective (Korst, Ayduk, & Mischel, 2005). It has been argued that self-distancing can facilitate more adaptive forms of self-reflection (Kross & Ayduk, 2011). Taking a self-distanced perspective on negative or stressful events has shown to decrease emotional intensity (Kross et al., 2005; Kross et al., 2014), and shortens emotion duration for negative but also for positive emotional experiences

(Verduyn, Van Mechelen, Kross, Chezzi, & Van Bever, 2012). A different explanation has been suggested in studies on the role of imagery perspective in depression, proposing that adopting an observer perspective could promote evaluative thinking about the self, which could result in unfavorable self-comparisons (with an ideal self) reducing the positive affective response (Kuyken & Howell, 2006; Kuyken & Moulds, 2009). This seems also in line with the idea that an observer perspective is related to thinking about the recalled event in terms of its broader context or meaning in an individuals' life, with the meaning of such events in relation to the self-concept becoming more salient, which as a result can either decrease or increase the emotional power (Libby & Eibach, 2011).

Although behavioral research provides some suggestions on what might be underlying the observed differences depending on imagery perspectives, little is known about neurobiological differences between imagery perspectives in memory recall while this could complement knowledge from behavioral research. There are some functional Magnetic Resonance Imaging (fMRI) studies comparing visual perspectives, investigating whether a first-person perspective (i.e. field perspective) is related to a greater sense of 'reliving' a situation than a third-person perspective (i.e. observer perspective), but these studies mostly used externally generated images (e.g. Jackson, Meltzoff, & Decety, 2006). When participants were shown video clips of hand and foot actions, either from a first-person- or a third-person perspective, more activity was shown in the left sensory-motor cortex when viewing the video clips from a first-person perspective compared to a third-person perspective, which is in line with the idea of a greater sense of 'reliving' in field perspective imagery (Jackson et al., 2006).

To our knowledge there is only one study so far that directly investigated the neural systems mediating field and observer perspective when imagining memories (Eich, Nelson, Leghari, & Handy, 2009). In this study participants performed four tasks, which during a second-session a week later were to be recalled in the scanner (Eich et al., 2009). Three regions were found to show greater activity during field perspective imagery when directly compared to observer perspective imagery. During field memories increased activity was observed in the right posterior amygdala, bilateral insula, and in left motor and somatosensory areas (Eich et al., 2009). These results, combined with behavioral results of this study showing that field memories were

related to greater subjective emotionality, are consistent with studies associating subjective emotionality of autobiographical memories to the amygdala (Cabeza & St. Jacques, 2007). Furthermore, both the insula and somatosensory areas have been previously linked to interoceptive awareness of one's feelings (e.g. Critchley, Wiens, Rothstein, Öhman, & Dolan, 2004; Pollatos, Gramann, & Schandry, 2006) corresponding to the idea that adopting a field perspective as compared to an observer perspective is related to increased affective monitoring (Eich et al. 2009).

In the current study we aimed to extend our knowledge on differences in neural areas mediating field and observer memories, using fMRI, in order to improve our understanding of what might explain the observed differences between imagery perspectives on subjective emotionality. Eich et al. (2009) used memory recall of tasks that were performed as part of the experiment and aimed to represent everyday life situations. However, our goal was to compare a field and observer perspective when imagining self-generated memories for both neutral and positive emotional events, reflecting better how mental imagery could be applied to memory recall in the context of self-generation of positive emotions and emotion regulation.

We first aimed to identify the brain areas showing increases in the blood-oxygenation level dependent (BOLD) signal during recall of both positive and neutral memories from a field and observer perspective relative to the same control task, a visual search task, as Eich et al. (2009). We hypothesized that for both perspectives in neutral and positive memories, we would observe activity in prefrontal and medial temporal cortices, temporal-parietal areas, and the precuneus, in line with Eich et al. (2009) and previous research on autobiographical memory recall (for reviews, see Cabeza & St. Jacques, 2007; Svoboda, McKinnon, & Levine, 2006). Secondly, we directly contrasted field perspective imagery to observer perspective imagery regardless of type of memory (i.e. neutral and positive collapsed). Based on results of Eich et al. (2009) we would expect greater activity in the amygdala, insula, and motor and somatosensory areas during field perspective imagery when directly contrasted to observer perspective imagery, which could reflect a greater sense of 'reliving'. Additionally we hypothesized that the posterior cingulate cortex/ precuneus would show greater activity during observer perspective imagery as compared to field perspective imagery. Previous studies have shown activity in these areas when taking a third-person perspective, as

compared to a first-person perspective, during imagery of actions with objects (Ruby & Decety, 2001) and when describing reactions to both neutral and social emotional situations (Ruby & Decety, 2004). The precuneus has also shown to be active when comparing being an observer of social interaction as contrasted to being personally involved in the social interaction (Schilbach et al., 2006). Interestingly, activity in the posterior cingulate cortex and precuneus has been implicated in the self-distancing from neutral and negative pictures of social situations (i.e. as they were viewing the scene objectively) to down-regulate emotions (Koenigsberg et al., 2010). This was explained by the posterior cingulate cortex and precuneus being implicated in processes important for assuming a distanced perspective, such as being unengaged in witnessed social interactions and assessing the self-relevance of stimuli (Koeningsberg et al., 2010). Indeed, studies have associated the posterior cingulate cortex and precuneus with self-referential/-evaluative processing (for review, see Northoff et al., 2006). However, a recent review proposes the posterior cingulate cortex and precuneus to be part of a network involved in evaluative processes enabling identification, attribution, and reflection upon a subject, but not specifically for self or others (Legrand & Ruby, 2009). It is proposed that the posterior cingulate cortex and precuneus are crucial areas in this evaluation network in providing information from memory for evaluative processes (Legrand & Ruby, 2009). These findings may be interesting in light of the idea that observer perspective imagery is related to thinking about the recalled event in terms of its broader meaning in an individuals' life, with the meaning of such events in relation to the self-concept becoming more salient (Libby & Eibach, 2011), or evaluative thinking about the self (Kuyken & Howell, 2006; Kuyken & Moulds, 2009).

Finally, we examined whether differences in neural activity between imagery perspectives was different for neutral and positive emotional memories, by investigating the interaction with adopted imagery perspective and memory valence.

Method

Participants

Nineteen healthy, right-handed females, aged between 19 and 26 (*M* = 21.95, *SD* = 2.15), participated in this study and received €40 for their participation. This study was approved by the medical ethical committee of the University Hospital at Ghent University.

Material

Screening. Current and lifetime history of psychiatric disorders based on DSM-IV and ICD-10 criteria was assessed using the Dutch version of the structured Mini International Neuropsychiatric Interview (MINI; Sheehan et al., 1998).

Safety criteria for participation in an experiment using an MR-scanner were checked through a pre-scanning safety checklist developed by the Ghent Institute for Functional and Metabolic Imaging. This checklist is based on guidelines from the Institute for Magnetic Resonance Safety, Education and Research and the International Commission on Non-Ionizing Radiation Protection.

Questionnaires. Throughout the fMRI paradigm in the scanner we measured mood state and adopted imagery perspective using 9-point Likert scales. We measured how happy and sad participants were feeling "*at the moment*" on a 9-point scale from 1 "neutral" to 5 "moderate" to "as happy/sad as I can imagine." Furthermore, participants were asked to rate to what extent they "…saw the event through your own eyes, like you were actively involved?" (i.e. field perspective) and "to what extent did you experience the event looking at yourself from outside, as if you see yourself taking part in the situation?" (i.e. observer perspective) on a 9-point scale ranging from 1 "not at all" to 5 "somewhat" to 9 "very much."

A post-scanning checklist was administered at the end of the scanning session assessing whether the participant had experienced any symptoms as a result of time-varying magnetic fields. This checklist is based on guidelines from the Institute for Magnetic Resonance Safety, Education and Research and the International Commission on Non-Ionizing Radiation Protection.

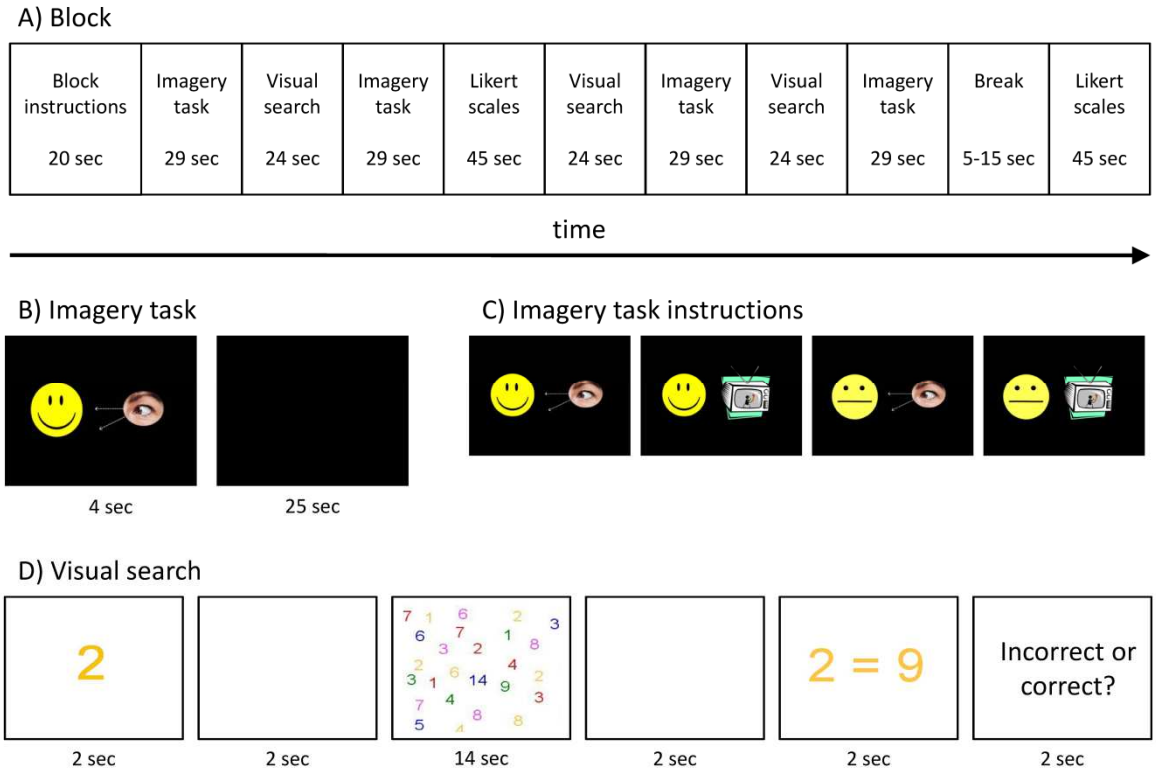

Figure 1. *Each block (A) consisted of an alternation of the mental imagery task (B) and visual search task (D). The imagery task started with instructions on memory type and imagery perspective, depicted by icons (C). All participants were familiarized with these icons and how they related to the different conditions prior to entering the scanner. The memory being recalled and the imagery perspective remained constant during the entire block.*

fMRI paradigm. The fMRI paradigm consisted of eight blocks (see Figure 1A) and was designed in such a way that hemodynamic activity during imagery of autobiographical memories was contrasted to hemodynamic activity during a control task, that is, a visual search task (based on Eich et al., 2009). Different experimental conditions in the paradigm were based on valence of memory (positive vs. neutral memory) and imagery perspective (field vs. observer perspective), resulting in four experimental conditions: positive-field, neutral-field, positive-observer, and neutral-observer. The memory being recalled and the imagery perspective remained constant during an entire block. Participants were asked to recall two different positive and neutral situations, which were each recalled from both a field- and observer perspective. Thus, each experimental condition/block occurred twice, resulting in eight blocks divided over two functional runs consisting of four blocks each. There were two

versions of the fMRI paradigm, counterbalancing the starting imagery perspective across participants, while each participant started with imagery of a positive memory which was then followed by a block imagining a neutral memory. That is, the order of blocks (i.e. experimental conditions) in one functional run was either: positive-field, neutral-field, positive-observer, and neutral-observer, or positive-observer, neutral-observer, positive-field, and neutral-field. Block order in the two functional runs was identical within one participant, but a different positive and neutral situation was recalled across the two functional runs.

Each block (see Figure 1A) consisted of an alternation of the mental imagery task and a visual search task. The visual search task was used as an active control task in order to avoid that increases in BOLD-signal during the mental imagery task could be attributed to a general increase in cognitive activity rather than memory retrieval itself (Eich et al., 2009). The block began with auditory instructions given by the experimenter on which specific memory was to be imagined and from which imagery perspective. Halfway and at the end of each block participants were asked to rate verbally, using the four Likert scales, how happy and sad they were feeling at the time and to what extent they had imagined the memory from a field perspective and observer perspective. Before the second administration of the Likert scales at the end of the block, there was a short break with a duration randomized between 5000 and 15000msec in steps of 500msec.

Imagery task. The imagery task (see Figure 1B) started with a screen presented for 4sec repeating the block instructions depicted by icons (see Figure 1C). These icons indicated whether a positive or neutral memory was to be recalled (the specific situation had been described in the auditory instructions at the beginning of the block) and from which imagery perspective. This screen was followed by a black screen presented for 25sec during which participants closed their eyes and silently imagined the recalled situation. At the end of the 25sec a beep sound was played to indicate the end of the imagery task and participants had to open their eyes.

Visual search task. The visual search task (see Figure 1D) was identical to that used by Eich and colleagues (2009). The task started with the 2-sec presentation of a single letter or number of a particular color, which was the target for the visual search (both letter and color need to match). This was followed by a 2-sec blank screen after

which the search display was presented for 14sec. After the search display again a 2-sec blank screen was presented followed by a suggestion of the number of displayed targets for 2sec. Participants then indicated whether this was the number of targets they had found in the search display by saying “correct” or “incorrect” for which they had 2sec. Across all visual search displays in the paradigm, the actual number of targets matched the suggested number of targets in only 50% of the time.

Procedure

Participants were recruited through an experiment website where people can voluntarily sign up for participation in psychology experiments. The first inclusion criteria such as gender and right-handedness were checked through questions on the website before people could actually register for the experiment. Information about the study on the website informed participants that only after additional screening, registration could be confirmed. After registration, participants were contacted by email and invited for a screening appointment. During this first screening appointment, inclusion criteria (no history of psychiatric disorders and meeting the safety criteria for participating in an MRI experiment) were further checked with the Dutch version of the MINI to explore a history of axis-I disorders and a pre-scanning safety checklist to make sure participants met the safety criteria for using the MRI system. When the inclusion criteria were met, participation in the fMRI experiment was confirmed. Further detailed information on the study was provided on paper. Participants were asked to read the information and were given the opportunity to ask further questions to the experimenter before signing the informed consent form.

During the actual testing appointment participants were first asked to provide four memories of specific events that happened more than one week ago. Participants were asked to recall two situations that did not elicit strong negative or positive emotions at that time (i.e. two neutral memories) and two situations which made them feel very happy at that time (i.e. two positive memories). Cue words were then connected to each of the four situations, so that these could be used for instructions during the task in the scanner to indicate which of the situations had to be recalled and imagined. The participants then received an explanation of the differences between field perspective imagery (“as if you are there, seeing the situation through your own eyes”) and observer perspective imagery (“as if you are there, seeing what is happening

looking at yourself from the outside, watching yourself taking part in the situation"). Furthermore, participants completed two similar imagery practice tasks of cutting a lemon, once receiving instructions on adopting a field perspective and once receiving instructions on adopting an observer (based on Holmes, Coughtrey, & Connor, 2008). After the practice task, participants were explained how the fMRI paradigm would look like in the scanner. They received instructions on how to rate the Likert scales and were explained the procedure of the mental imagery task and visual search task. Participants were then prepared to enter the MRI scanner. Each scanning session started with an anatomical scan which lasted about 6 minutes, followed by the fMRI paradigm divided in two functional runs with a short break in between. After finishing the task in the scanner, the participant was asked to fill out the post-scan checklist. Finally, participants were fully debriefed about the experiment.

fMRI Data Acquisition

Scanning was performed with a Siemens Trio Tim 3T MRI scanner (Siemens Medical Systems, Erlangen, Germany), using a 32-channel head coil. After automatic shimming of the magnetic field on each participant, T1-weighted 3D high resolution MPRAGE images were acquired of the whole brain in the sagittal plane (176 slices, TR = 2550ms, TE = 4.18 msec, TI = 900 msec, acquisition matrix = 256 x 256, FoV = 256 mm, flip angle = 9°, voxel size = 1 x 1 x 1 mm). These anatomical images were used for coregistration with the functional images and normalization. During the fMRI paradigm, functional echo-planar images (EPIs) in the axial plane were acquired (34 interleaved slices, TR = 2000msec, TE = 28msec, acquisition matrix = 64 x 64, FoV = 224 mm, flip angle = 80°, voxel size = 3.5 x 3.5 x 3 mm, slice thickness = 3 mm, inter-slice gap = 0.5 mm).

Image Analysis

Data analysis was performed using BrainVoyager QX (Goebel, Esposito, & Formisano, 2006). Each participants' 3D anatomical data was normalized into Talairach standard space in two steps. The first step consisted of translating and rotating the cerebrum into the AC-PC plane (AC = anterior commissure, PC = posterior commissure). In the second step, the borders of the cerebrum were identified and in addition with the AC and PC point, the size of the brain was fitted into Talairach standard space using sinc interpolation. For the functional data of each participant, a standard sequence of

preprocessing steps was performed. Slice scan time correction was performed by means of sinc interpolation, 3D motion correction by spatial alignment to the first volume was performed by means of sinc interpolation, and temporal filtering was performed using linear trend removal and high pass filtering for low-frequency drifts of two or fewer cycles. Spatial smoothing using a Gaussian filter (FWHM = 6mm) was applied for the volume-based analysis. The functional data for each participant was then coregistered with the participants' 3D anatomical data and transformed into Talairach standard space.

For each subject, a protocol file was created representing the onset and duration of each 25sec imagery period of the mental imagery task for the four different experimental conditions and the onset and duration of each 14sec search display of the visual search task for the control condition. Factorial designs were automatically defined from the created stimulus protocols. The blood-oxygen-level dependent (BOLD) response in each condition was then modeled by convolving the neural functions with a canonical hemodynamic response function (two gamma HRF) to form covariates in a General Linear Model.

After the General Linear Models (GLM) had been fitted, group (random effects procedure) *t*-maps were generated to evaluate the effects of imagining memories from different perspectives, for which a brain tissue mask was applied. First, we determined voxel clusters showing significant increases in the BOLD response for each of the four experimental conditions separately, contrasting the effects of imagery of autobiographical memories from a certain perspective to the control condition (visual search): positive-field > visual search, neutral-field > visual search, positive-observer > visual search, and neutral-observer > visual search. In a second step, we directly contrasted adopting a field perspective versus an observer perspective collapsed over positive and neutral autobiographical memories: positive-field + neutral-field > positive-observer + neutral-observer and positive-observer + neutral-observer > positive-field + neutral-field. Finally we tested the interaction between Perspective (field vs. observer) and memory Valence (neutral vs. positive) with a factorial ANOVA, to investigate whether differential activity between imagery perspectives was different depending on the valence of the memory. The basic contrasts comparing experimental conditions to the control task were adequately described with a threshold of $p < .05$ corrected for

multiple comparisons using False Discovery Rate (FDR) correction (Genovese, Lazar, & Nichols, 2002). However, for the contrasts directly comparing field perspective to observer perspective this threshold required adjustment to describe subtle differences, but this is explicitly mentioned in the text and figure. Areas that showed significant activation were identified using the brain atlases of Mai, Paxinos, and Voss (2008), and Talairach and Tournoux (1988). Areas in the cerebellum that showed significant activation were identified using the Talairach deamon (Lancaster, et al., 1997; Lancaster et al., 2000)

Results

Preliminary analyses

Two participants were excluded from further analyses, based on results from 3D motion correction during preprocessing. The remaining sample consisted of 17 right-handed women, aged between 19 and 26 years (M = 21.88, SD = 2.26).

Behavioral data

Imagery perspective manipulation check. To investigate differences between the four experimental conditions in the extent to which participants adopted a field and observer perspective, a repeated measures ANOVA with within-subject factors Valence (positive memory, neutral memory) and Perspective (field, observer) was performed on the data from the Likert scales.

The repeated measures ANOVA on ratings of adopting a field perspective yielded a significant main effect of Valence, $F(1,16) = 5.25$, $p = .036$, $\eta_p^2 = .25$, and a main effect of Perspective, $F(1,16) = 167.35$, $p < .001$, $\eta_p^2 = .91$. These results indicated that participants generally reported to adopt a field perspective more when imagining positive memories (M = 5.31, SD = 0.56) than when imagining neutral memories (M = 5.02, SD = 0.75), regardless of instructions on imagery perspective. Furthermore, across both positive and neutral memories participants reported to adopt a field perspective more when instructions were to imagine the situation from a field perspective (M = 7.55, SD = 0.83) as compared to an observer perspective (M = 2.77, SD = 1.10).

The repeated measures ANOVA on ratings of adopting an observer perspective yielded a significant main effect of Perspective, $F(1,16) = 239.66$, $p < .001$, $\eta_p^2 = .94$. This indicated that as expected, across both positive and neutral memories participants reported to adopt an observer perspective more when instructions were to imagine the

situation from an observer perspective (*M* = 7.15, *SD* = 0.76) as compared to a field perspective (*M* = 2.16, *SD* = 0.75)[2].

Effects of perspective manipulation on mood. Throughout the task in the scanner, participants were also asked to rate how happy and sad they were feeling at that moment. Due to non-normality of the data, we performed non-parametric Wilcoxon Signed Rank tests. We tested our main predictions on the differences in happy and sad mood between the field perspective condition and observer perspective condition when participants imagined either positive or neutral memories. There were no differences in ratings of sadness between field perspective imagery and observer perspective imagery when imagining positive, *T* = 8.50, *p* = .242, *r* = -.23, or neutral memories, *T* = 8.00, *p* = .391, *r* = -.18. Neither was there a difference in ratings of happiness between field perspective imagery and observer perspective imagery when imagining neutral memories, *T* = 55.00, *p* = .506, *r* = -.12. However, there was a significant difference in ratings of happiness between field perspective imagery and observer perspective imagery when imagining positive memories, *T* = 17.00, *p* = .022, *r* = -.38, indicating that feelings of happiness were higher when imagining positive memories from a field perspective (*M* = 6.78, *SD* = 0.97), than from an observer perspective (*M* = 6.44, *SD* = 1.09).

Imaging data

Experimental conditions versus control task. In a first step we identified the regions that showed significant increases in BOLD-signal during recall of positive and neutral memories from a field and observer perspective (see Table 1-4; Figure 2A-D). Across the four experimental conditions compared to the control task we observed significant activity in mostly similar areas. Across all experimental conditions, when contrasted to the control task, areas of increased BOLD activity included dorsolateral, dorsomedial, ventrolateral, ventromedial and orbital parts of the prefrontal cortex (PFC) bilaterally although more extensive in the left hemisphere, middle/superior temporal gyrus extending to the angular gyrus bilaterally, hippocampus bilaterally (although for neutral observer memories only right hippocampus), and precuneus.

[2] Adding block order (i.e. starting with field perspective imagery or observer perspective imagery) as a between-subjects factor did not change the results of the manipulation check on imagery perspective.

Table 1.

Clusters showing significantly increased activity for positive memories imagined from a field perspective compared to the control task, based on a threshold of p < .05 (FDR) and a minimum cluster size of k ≥ 300 contiguous voxels (with voxel size 1x1x1mm). Coordinates are of peak activity, for clusters with multiple coordinates local maxima are also reported.

		Talairach coordinates left hemisphere			t_{max}	Talairach coordinates right hemisphere			t_{max}
Brain region	BA	x	y	z		x	y	z	
Frontal clusters									
Superior frontal gyrus	10					32	61	-6	5.38
Superior frontal gyrus	8	-19	22	45	5.33	20	22	42	3.81
Medial frontal gyrus	11	-7	58	-12	3.86				
Middle frontal gyrus	11	-31	52	-13	4.96				
Inferior frontal gyrus	45/47	-52	31	-6	7.89	50	31	6	5.43
Medial/ posterior orbital gyrus	11	-16	22	-9	6.88				
Insula						38	-14	6	4.58
Cingulate gyrus	24	-1	22	0	4.06				
Straight gyrus	25	-1	10	-12	7.33				
Temporal clusters									
Parahippocampal gyrus	20	-28	-11	-33	3.31				
Middle temporal gyrus	21	-55	-14	-12	6.24	53	-11	-9	6.37
Temporal parietal clusters									
Middle temporal gyrus (extending to superior temporal gyrus/ angular gyrus	39					53	-69	24	8.13
Angular gyrus (extending to middle/ superior temporal gyrus)	39	-43	-74	42	9.25				
Parietal clusters									
Precuneus	31	-4	-62	28	5.85				
Precuneus	7	0	-50	30	5.54	8	-53	33	6.71
Limbic clusters									
Hippocampus		-25	-44	6	7.08	23	-47	12	7.81
Hippocampus		-25	-14	-12	3.80				
Cerebellum									
Posterior lobe	Inferior semi-lunar lobule	-31	-83	-36	3.53				
Posterior lobe	pyramis					41	-78	-30	6.09

Table 2.

Clusters showing significantly increased activity for neutral memories imagined from a field perspective compared to the control task, based on a threshold of p < .05 (FDR) and a minimum cluster size of k ≥ 300 contiguous voxels (with voxel size 1x1x1mm). Coordinates are of peak activity, for clusters with multiple coordinates local maxima are also reported.

		Talairach coordinates left hemisphere			t_{max}	Talairach coordinates right hemisphere			t_{max}
Brain region	BA	x	y	z		x	y	z	
Frontal clusters									
Superior frontal gyrus	8	-19	22	42	5.42	20	22	39	3.94
Middle frontal gyrus	8	-34	7	51					
Inferior frontopolar gyrus	10					29	62	-6	4.83
Frontomarginal gyrus	11	-7	58	-12	4.02				
Inferior frontal gyrus	44/45/47	-52	31	-6	9.56	47	37	0	5.85
Lateral orbital gyrus	11	-31	52	-12	4.97				
Medial orbital gyrus	11	-16	22	-6	8.36				
Cingulate gyrus	24	-1	19	0	4.52				
Straight gyrus	25	-4	10	-15	7.84	8	16	-6	5.73
Temporal clusters									
Middle temporal gyrus	38	-43	4	-12	5.02				
Middle temporal gyrus	21					53	-8	-9	6.42
Temporal parietal clusters									
Middle temporal gyrus (extending to superior temporal gyrus/ angular gyrus	39					53	-69	24	8.94
Angular gyrus (extending to middle/ superior temporal gyrus)	39	-46	-71	36	8.37				
Parietal clusters									
Parietal operculum	40					47	-23	21	3.75
Precuneus	7	-4	-41	33	6.13				
Precuneus	18	-10	-62	27	5.08				
Limbic clusters									
Hippocampus		-25	-50	12	7.43	20	-44	9	11.59
Hippocampus		-22	-17	-12	3.89	23	-14	-12	4.25
Cerebellum									
Posterior lobe	pyramis	-12	-86	-30	3.63	41	-77	-33	5.81

Table 3.

Clusters showing significantly increased activity for positive memories imagined from an observer perspective compared to the control task, based on a threshold of p < .05 (FDR) and a minimum cluster size of k ≥ 300 contiguous voxels (with voxel size 1x1x1mm). Coordinates are of peak activity, for clusters with multiple coordinates local maxima are also reported.

		Talairach coordinates left hemisphere			t_{max}	Talairach coordinates right hemisphere			t_{max}
Brain region	BA	x	y	z		x	y	z	
Frontal clusters									
Superior frontal gyrus	8	-19	22	42	9.21	20	22	42	5.32
Middle frontal gyrus	8	-40	7	45	7.15				
Inferior frontopolar gyrus	10					29	61	-6	4.48
Frontomarginal gyrus	11	-7	58	-12	4.59				
Inferior frontal gyrus	45/47	-52	28	-6	7.35	47	34	-3	5.77
Lateral orbital gyrus	11	-31	52	-12	5.03				
Posterior/medial orbital gyrus	11	-19	19	-6	6.60	11	22	-6	6.51
Cingulate gyrus	24	-1	19	3	4.66				
Straight gyrus	25	-1	13	-15	5.62				
Frontal operculum						29	-20	27	4.21
Temporal clusters									
Middle temporal gyrus	21	-58	-11	-12	6.45				
Temporal parietal clusters									
Middle temporal gyrus (extending to superior temporal gyrus / angular gyrus	39					51	-71	27	9.36
Angular gyrus (extending to middle/ superior temporal gyrus)	39	-46	-71	36	9.76				
Parietal clusters									
Precuneus	31	-4	-62	27	7.34				
Limbic clusters									
Hippocampus		-25	-14	-12	4.74	23	-14	-12	5.29
Hippocampus		-25	-44	3	7.24	23	-47	12	10.48
Cerebellum									
Posterior lobe	Inferior semi-lunar lobule	-31	-83	-36	3.84				
Posterior lobe	pyramis					41	-78	-30	6.83

Table 4.

Clusters showing significantly increased activity for neutral memories imagined from an observer perspective compared to the control task, based on a threshold of $p < .05$ (FDR) and a minimum cluster size of $k \geq 300$ contiguous voxels (with voxel size 1x1x1mm). Coordinates are of peak activity, for clusters with multiple coordinates local maxima are also reported.

		Talairach coordinates left hemisphere			t_{max}	Talairach coordinates right hemisphere			t_{max}
Brain region	BA	x	y	z		x	y	z	
Frontal clusters									
Superior / middle frontal gyrus	8	-19	22	42	9.22	20	22	42	6.48
Superior frontal gyrus	9	-16	43	33	3.19				
Superior frontal gyrus	11					32	61	-10	4.76
Frontomarginal gyrus	11	-7	58	-12	4.23				
Inferior frontal gyrus	45/47	-52	31	-3	7.81	47	34	-3	6.78
Subcollosal area	25	-1	7	-6	7.95				
Medial orbital gyrus	25	9	19	-9	6.70				
Posterior orbital gyrus	11	-19	19	-6	4.74				
Frontal operculum						29	-17	27	4.05
Temporal clusters									
Middle temporal gyrus	21	-58	-11	-12	6.58				
Superior temporal gyrus	42					53	-11	-9	7.12
Temporal parietal clusters									
Middle temporal gyrus (extending to superior temporal gyrus / angular gyrus)	39					50	-71	27	9.01
Superior temporal gyrus (extending to angular gyrus / middle temporal gyrus)	39	-56	-62	30	10.69				
Parietal clusters									
Cingulate gyrus	31	-4	-44	33	7.13				
Precuneus	31	-9	-62	27	6.25				
Limbic clusters									
Hippocampus						17	-44	12	8.95
Cerebellum									
Posterior lobe	pyramis					41	-77	-30	7.04

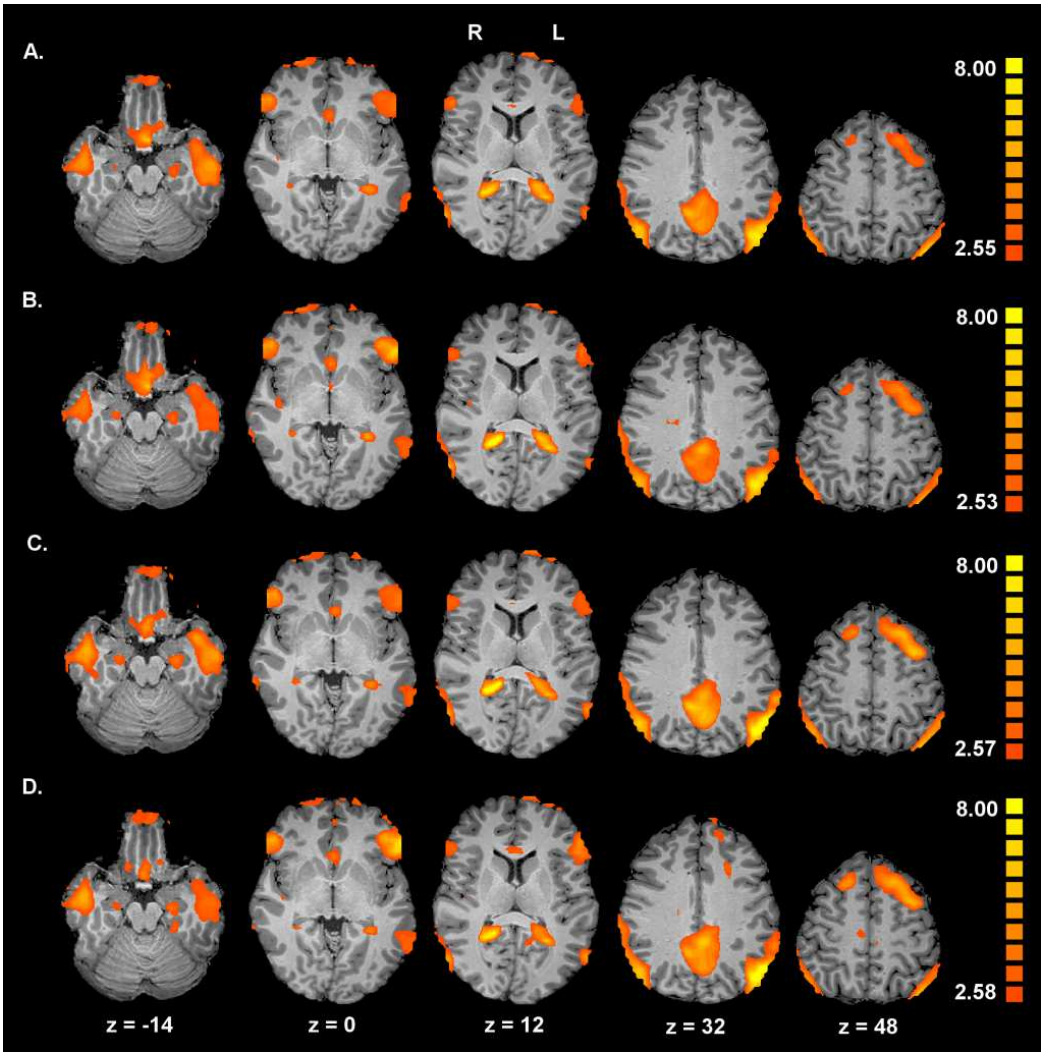

Figure 2. *A. Contrast for positive memories imagined from a field perspective versus the control visual search task. B. Contrast for neutral memories imagined from a field perspective versus the control visual search task. C. Contrast for positive memories imagined from an observer perspective versus the control visual search task. D. Contrast for neutral memories imagined from an observer perspective versus the control visual search task. Activation maps are at (FDR) p < .05. L = left hemisphere, R = right hemisphere.*

Field versus observer perspective. In a next step we directly compared adopting a field perspective versus an observer perspective collapsed over positive and neutral autobiographical memories. As we anticipated this to reflect subtle differences we adjusted the threshold to $p < .001$ (uncorrected), $t > 4.01$ and used the suggested minimum cluster size of BrainVoyager ($k \geq 300$ contiguous voxels with voxel size 1x1x1mm).

No regions showed a significant greater BOLD-response during a field perspective as contrasted to adopting an observer perspective ((positive-field + neutral-field) > (positive-observer + neutral-observer)). Compared to a field perspective, an observer perspective ((positive-observer + neutral-observer) > (positive-field + neutral-field); see Figure 3) was associated with a greater response in the right precuneus (x = 5, y = –62, z = 45; t-value: 5.79; p < 0.001 uncorrected). When increasing the threshold to p < .0001 (uncorrected), still 149 voxels survived the adjustment of threshold in this region.[3]

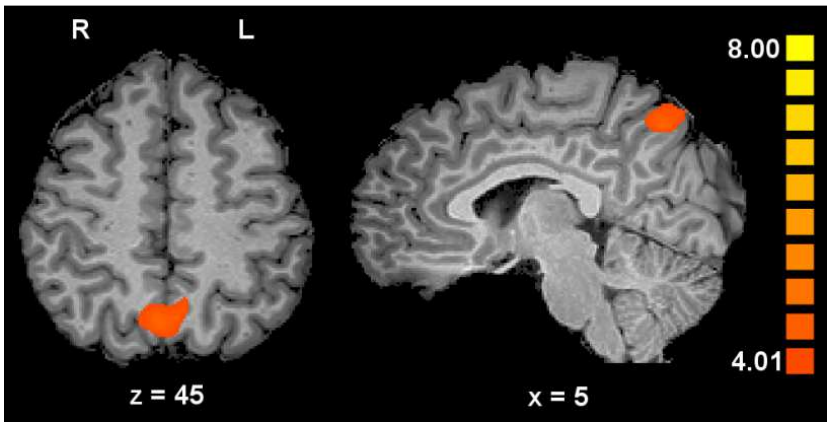

Figure 3. *Activation in the right precuneus was associated with observer perspective when compared to field perspective (peak activation at x = 5, y = -62, z = 45). Statistics were based on a threshold of p < .001 (uncorrected) and a minimum cluster size of k ≥ 300 contiguous voxels (with voxel size 1x1x1mm).*

Interaction imagery perspective with memory valence. A two-factor ANOVA was specified in order to test the interaction between imagery perspective and memory valence. The model consisted of two within-subject factors, Perspective (field vs. observer) and memory Valence (neutral vs. positive). We performed an F test for the Perspective x Valence interaction, using a threshold of (FDR) p < .05. However, no

[3] We also hypothesized differential activity for field and observer perspective in the amygdala. As activation in these structures are commonly in a small voxel range, we performed a ROI-analysis using a mask of the left and right amygdala according to the Talairach coordinates (Talairach & Tournoux, 1988). However, no significant activation was observed during the field > observer and observer > field contrasts, neither when testing the interaction between imagery perspective and memory valence in a factorial ANOVA.

significant activity was observed, neither when adjusting the threshold to $p < .001$ uncorrected to allow for investigation of more subtle differences.

Discussion

The present study was designed to examine differences in neural areas mediating autobiographical memory recall from a field perspective and observer perspective. Imagery perspective has shown to influence what is recalled (McIsaac & Eich, 2002), processing style (Libby & Eibach, 2011), and emotionality (Holmes et al., 2008). However, our understanding of possible mechanisms mediating these observed differences is still limited. By investigating what is underlying the differences between field perspective and observer perspective imagery at the neurobiological level, we aimed to improve our understanding of how imagery perspective can influence what is recalled, processing style, and emotionality. Therefore, we conducted a fMRI study comparing field perspective imagery to observer perspective imagery when imagining neutral and positive autobiographical memories.

First, behavioral data confirmed that our manipulation of imagery perspective had worked. Across both neutral and positive memories, participants adopted a field perspective more when instructions were to imagine the event from a field perspective, while participants adopted an observer perspective more when instructions were to imagine the event from an observer perspective. Furthermore, participants reported to adopt a field perspective more when they were imagining positive emotional memories as compared to neutral memories, regardless of perspective instructions. This could be explained by previous research suggesting that a field perspective is (automatically) adopted when a memory is more congruent with the current self-concept, while observer perspective is more adopted in the case of inconsistency with currently activated self-views (Libby & Eibach, 2002; Wilson & Ross, 2003). Healthy individuals often consider positive memories more in line with a current self, so positive memories are often recalled from a field perspective (Libby & Eibach, 2002; Wilson & Ross, 2003), while (sub-clinical) depressed individuals have a tendency to recall positive memories from an observer perspective (Lemogne et al., 2006; Nelis, Debeer, Holmes & Raes, 2013).

The behavioral results on the emotional response to imagery showed that there were no differences between imagery perspectives in the positive emotional response

for neutral memories, probably due to the non-emotional nature of the memories. However, when imagining positive autobiographical memories, feelings of happiness were slightly, but significantly higher when adopting a field perspective, than when adopting an observer perspective. This is consistent with previous research showing that observer perspective imagery is related to a reduced emotional response (Holmes et al., 2008). No differences were found for feelings of sadness between the two imagery perspectives, likely due to our focus on memories evoking neutral or more positive feelings.

Results from our imaging data showed that across all experimental conditions, when contrasted to the control task, areas of increased activity included dorsolateral, dorsomedial, ventrolateral, ventromedial and orbital parts of the prefrontal cortex (PFC) bilaterally although more extensive in the left hemisphere. Additionally we observed activity in the middle and superior temporal gyrus extending to the angular gyrus bilaterally, the hippocampus bilaterally (although for neutral observer memories in the right hippocampus), and the precuneus. This is in line with previous findings on autobiographical memory recall (Cabeza & St. Jacques, 2007; Eich et al., 2009; Svoboda et al., 2006). Interestingly, most of these areas are also part of the emotion regulation circuitry (Davidson, Pizzagalli, Nitschke, & Putman, 2002), suggesting that in healthy individuals similar brain networks are implicated in the re-activation of neutral and positive autobiographical memories and the regulation of emotions by prefrontal areas.

When directly contrasting field perspective imagery to observer perspective imagery, no regions showed significant activity and this did not interact with memory valence (neutral, positive). This is inconsistent with our predictions and previous research showing a field perspective, when compared to an observer perspective, to be associated with more activity in the amygdala, insula and somato-motor areas (Eich et al., 2009). Although it remains unclear exactly why our results did not confirm previous findings, a possible explanation could be related to the age of the memory. Previous research has indicated that remote memories, as compared to recent memories, were associated with more (automatically adopted) observer perspective and less field perspective, and this effect was explained by a loss of visual and sensory details for more remote memories (Rice & Rubin, 2009). Whereas Eich et al. (2009) used memories of physically engaging tasks performed the week before, the

autobiographical events in the current study had occurred *at least* one week before, with the result that participants recalled more remote memories as compared to the study of Eich et al. (2009). Thus, even though we manipulated imagery perspective, this may have had an influence on the visual and sensory details available in memory, which thereby might have attenuated differences between field perspective and observer perspective in the degree of (physically) reliving the situation or interoceptive awareness of feelings and affective monitoring (related to the insula, somato-motor areas, and amygdala).

When testing the opposite contrast, comparing observer perspective imagery to field perspective imagery, activity was observed in the right precuneus. No regions showed significant activity for the interaction between perspective and memory valence (neutral, positive), suggesting that the underlying neurobiological differences between observer perspective and field perspective are not different for neutral and (positive) emotional memories. These results on activity in the precuneus are in line with research comparing third-person (observer) perspective to first-person (field) perspective when imagining motor action (Ruby & Decety, 2001), observing social interaction as compared to being personally involved in the social interaction (Schilbach et al., 2006), and during self-distancing from neutral and negative pictures of social situations (Koeningsberg et al. 2010). Previous research has explained these findings with the role of the precuneus in processes important for assuming a distanced perspective (Koeningsberg et al., 2010) and self-representation (Ruby & Decety, 2001), also with regard to the spatial reference of oneself relative to others (Schilbach et al., 2006). Furthermore, many studies have linked the precuneus to self-referential/self-evaluative processes (for review, see Northoff et al., 2006) or as part of a network involved in evaluative processing more generally (Legrand & Ruby, 2009). This greater activity in the precuneus during observer perspective as compared to field perspective imagery, is therefore interesting in light of previously suggested mechanisms that could mediate the effects on emotional intensity between imagery perspectives. Previous behavioral research suggested that observer perspective imagery, as compared to field perspective imagery, is related to a reduced emotional response (Holmes et al., 2008). Alternatively, the idea emerged that imagery perspective might not directly influence the emotional response, but that this depends on whether considering the event in

relation to the self-concept – related to an observer perspective - decreases or increases emotional power (Libby & Eibach, 2011). Our findings at the neurobiological level seem to correspond with this latter idea.

However, if effects of observer perspective imagery on increasing or decreasing emotional intensity depend on how the event is perceived in relation to the self-concept, individual differences in general/current self-beliefs can lead to different meanings of events in relation to the self-concept, and thereby influence the evoked emotional response (Libby & Eibach, 2011). Provided that depression is associated with more negative self-evaluation and negative self-schema (Clark, Beck, & Alford, 1999), this increases the likelihood that the meaning of a past positive event in relation to the (current negative) self-concept results in unfavorable evaluation, dampening the positive emotional response (or leading to a contrast effect). Interestingly, behavioral studies investigating the role of imagery perspective in relation to depression, suggest that depression is related with a tendency to objectify the self (as falling short). This tendency is then suggested to prime observer memories in which the objectified self can be evaluated, which is likely to lead to unfavorable self-evaluations (Kuyken & Howell, 2006). However, future research should first aim to replicate these findings in (sub-clinically) depressed individuals, to clarify whether differences between imagery perspectives at the neurobiological level are not by itself influenced by the presence of depressive symptoms.

A possible limitation to this study is the lack of control over the content of the memories. However, the difference in content of memory across individuals could also be seen as an advantage as observed activity in the brain is less likely to be related to content aspects of the recalled memories instead of the mechanisms underlying imagery of autobiographical memory. Moreover, an event that is perceived to be positive or neutral for one person might not necessarily be perceived in the same way for another person. Therefore, in the current study participants decided themselves on past events that they perceived as neutral and positive. Secondly, we did not control for memory age, apart from that the event had to have taken place a minimum of one week ago. Previous research has shown that memory age is related to imagery perspective (Rice & Rubin, 2009). Even though we gave explicit instructions on imagery perspective, which might cause this to be less of a confound in the present study, it may

have had an influence on the visual and sensory details available in memory. Therefore, it would be good for future research to take memory age into account or limit memory age.

In conclusion, the behavioral results of our study showed that different ways of imagining positive autobiographical memories, from a field perspective or an observer perspective, can influence the emotional response to imagery. At the neurobiological level, observer perspective imagery was associated with greater activity in the right precuneus than during field perspective imagery. Provided that the precuneus has been involved in self-referential and evaluative processing (Legrand & Ruby, 2009; Northoff et al., 2006), this seems to correspond with the idea that observer perspective is related to more abstract thinking about events in terms of their broader context or meaning in an individuals' life, making its (in-)coherence with the self-concept more salient (Libby & Eibach, 2011). This would imply that effects of observer perspective imagery on emotional intensity (increasing/decreasing) depend on how the event is perceived in relation to the self-concept. Hence, individual differences in self-beliefs can qualify the perceived meanings of events in relation to the self-concept, and thereby influence the emotional response (Libby & Eibach, 2011). Therefore, It would be interesting for future research to further study in which contexts recall from a field perspective as compared to an observer perspective, or vice versa, is more adaptive in terms of emotion regulation or the self-generation of positive emotions, and how this might be influenced by (sub-clinical/former) depression.

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GENERAL DISCUSSION

The general aim of this doctoral dissertation was to improve our understanding of resilience. Despite the high recurrence of depression, still little is known about cognitive and neurobiological mechanisms underlying adaptive responding to stress, while this ultimately could improve our understanding of recurrence of depression and its prevention. We started from an emotion regulation perspective by studying the role of positive memory recall, influencing positive emotion, and how its cognitive and neurobiological effects can contribute to stress resilience. Positive memory recall has shown to play a role in the self-generation of positive emotions when faced with stress (Phillippe, Lecours, & Beaulieu-Pelletier, 2009) and in healthy participants positive memory recall can work as an effective strategy to improve mood after a negative mood induction (Joormann & Siemer, 2004; Joormann, Siemer, & Gotlib, 2007). Furthermore, the retrieval of happy memories has been related to activation in the left hippocampal region, medial brain areas, and the dorsolateral prefrontal cortex (Markowitsch, Vandekerckhove, Lanfermann, & Russ, 2003), which are areas also implicated in the emotion regulation circuitry (Davidson, Pizzagalli, Nitschke, & Putman, 2002).

A central theory on positive emotions is the broaden-and-build theory (Fredrickson, 1998; 2001), which describes the relation between positive emotions and resilience and proposes that effects of positive emotions on cognition may underlie this relationship. This makes the broaden-and-build theory an interesting theoretical framework from which we can experimentally investigate possible cognitive mechanisms in the relation between positive memory recall and resilience. We aimed to increase our current knowledge on resilience by further investigating the core principles derived from the broaden-and-build theory using experimental designs. First, after testing the effectivity of an autobiographical memory procedure in inducing positive mood (chapter 1), we focused on the influence of positive mood manipulation, through positive memory recall, on visuospatial attentional broadening, taking into account characteristics of the stimuli in attention such as self-relatedness and

emotional valence (chapter 2, 3, and 4) and how this relation is qualified by individual characteristics like the presence of depressive symptoms and trait resilience (chapter 3 and 4). On the other hand, we investigated how a maladaptive way of responding to stress, rumination, influenced visuospatial attentional breadth for self-related information and how trait rumination qualified this relation (chapter 5). Secondly we set out to investigate how the effects of positive memory recall on cognition might mediate the relation between positive memory recall and stress reactivity in both an unselected student sample (chapter 6) and a formerly depressed sample (chapter 7). Finally we examined the neurobiological underpinnings of (positive) memory recall. We used mental imagery to process the autobiographical memories, but different imagery perspectives (field vs. observer) can influence memory content, processing style, and the emotional response (Libby & Eibach, 2011). Therefore we investigated differences between imagery perspectives during memory recall at the neurobiological level (chapter 8), to further clarify how different ways of processing memories could affect the use of this strategy in the context of emotion regulation and self-generation of positive emotions.

We start this general discussion with a summary of the main findings related to the three research lines of this doctoral dissertation: 1) How is positive mood induction, through positive memory recall, related to visuospatial attentional broadening and how does this interact with stimulus characteristics and individual characteristics? 2) Do the effects of positive mood induction on cognition mediate the relation between positive mood and stress resilience? 3) Do different imagery perspectives during autobiographical memory recall (field perspective vs. observer perspective) engage different neural regions? Next, both theoretical and clinical implications will be discussed. Finally, several limitations of the present studies will be discussed followed by directions and challenges for future research.

Overview Of The Main Findings

Before discussing the effects of positive autobiographical memory recall, used to self-generate positive mood, we tested whether this procedure was effective in inducing positive mood also in individuals experiencing depressive symptoms at a sub-

clinical level (chapter 1). Previous research shows that depression and dysphoria are related to a tendency to retrieve memories from an observer perspective (Kuyken & Howell, 2006; Kuyken & Moulds, 2009; Nelis, Debeer, Holmes, & Raes, 2013) which could reduce the positive emotional response (Holmes et al., 2008). However, results showed that when individuals received explicit instructions and practice in the use of field perspective imagery, non-dysphoric and dysphoric individuals did not differ in the extent to which they adopted a field perspective and an observer perspective when imagining positive memories. Moreover, non-dysphoric and dysphoric individuals showed no differences in their positive emotional response and no longer differed in levels of positive affect afterwards, despite of baseline differences. However, when dysphoric individuals did not receive instructions or practice in field perspective imagery, allowing for a more automatic way of processing, they reported to adopt an observer perspective to a higher extent than dysphoric individuals receiving instructions. Furthermore, there were indications that those receiving instructions reported higher levels of positive affect afterwards. These findings show that mental imagery from a field perspective is an interesting technique to use for the self-generation of positive emotions through positive memory recall, in the context of studying psychological resilience.

How does positive mood influence visuospatial attentional breadth?

In a first research line we experimentally investigated the effects of positive mood induction on visuospatial attentional broadening. Given the potential role of these attentional broadening effects in the relation between positive emotions and resilience (Fredrickson, 1998; 2001), it is important to consider that in mood disorders, biases in information processing are often observed with specific types of information (e.g. self-related information, emotional information). Therefore, we investigated whether the effects of positive emotions on visual spatial attentional broadening would be influenced by characteristics of the information in the target of attention. Furthermore, we also investigated whether individual differences could qualify this relation. Depressive symptoms have been related to a local bias, or a more narrowed attentional scope (Basso, Schefft, Ris, & Dember, 1996; De Fockert, & Cooper, 2014), suggesting that the presence of depressive symptoms could hamper the effects of

positive mood on attentional broadening. On the other hand, the broaden-and-build theory predicts that the cognitive broadening effects of positive emotions underlie the relation with resilience (Fredrickson, 1998; 2001), thus it seems likely that especially those individuals who report high resilience levels can benefit from positive emotions at the level of cognitive functioning.

In our studies we used a performance-based measure to assess fluctuations in visuospatial attentional breadth related to centrally presented stimuli (based on Bosmans, Braet, Koster, & De Raedt, 2009), allowing us to manipulate the value of the stimuli in attention. The findings of the study presented in chapter 2 show that an increase in positive mood was associated with a broadening of visuospatial attention for self-related information when contrasted to not-self related information (Grol, Koster, Bruyneel, & De Raedt, 2014). In chapter 3 we examined the effects of positive mood induction on attentional breadth, manipulating the emotional valence of the stimuli in attention. Results revealed no direct relation between positive mood and attentional broadening. However, the presence of depressive symptoms, as measured with the Beck Depression Inventory (BDI; Beck, Steer, & Brown, 1996; Van der Does, 2002), qualified this relation. Moreover, this moderation of depressive symptoms on the relation between positive mood and attentional breadth further interacted with the emotional valence of the stimuli in attention. At low levels of the BDI, reflecting minimal depressive symptoms, a bigger increase in positive mood was related to more attentional broadening only when positive information was presented. At moderate levels of the BDI, no such relation between positive mood and attentional broadening was observed regardless of the emotional valence of the presented stimuli. Interestingly, at high levels of the BDI, reflecting mild depressive symptoms, an increase in positive mood was related to attentional narrowing when positive information was presented, although this tendency was also present when neutral and negative information was in the target of attention. Based on results from chapter 3, showing that the emotional valence of the presented stimuli also influences the relation between positive mood and attentional breadth, we investigated in chapter 4 whether the stimulus in attention influences attentional breadth depending on its *perceived* emotional valence (Grol & De Raedt, 2014). Affective evaluation of surprised facial stimuli was assessed using an affective priming paradigm. Surprised facial stimuli are

particularly interesting as they are valence ambiguous, meaning that individuals vary in whether they perceive surprised faces as having more negative or more positive valence. Furthermore, we investigated how trait resilience, as measured with the Dutch version of the Resilience Scale (Portzky, 2008), influenced this relation between stimulus evaluation and attentional broadening/narrowing for surprised stimuli. Results of this study showed no direct relation between automatic stimulus evaluation and attentional breadth for surprised facial stimuli. However, trait resilience, more specifically feelings of personal competence, qualified this effect. Only at high levels of trait resilience we found that a more positive evaluation of surprised stimuli was related to more attentional broadening when surprise stimuli were in the target of attention. While such a relation was absent at average levels of trait resilience, we observed a reversed relation at low levels of trait resilience, with a more positive evaluation being related to more attentional narrowing. Thus, the processing of surprise stimuli itself was not related to attentional broadening per se, but the effect of surprise stimuli on attentional breadth, relative narrowing or broadening, was depending on the interaction between levels of trait resilience and how the valence of surprise stimuli was perceived.

Whereas positive memory recall seems to be an effective way to cope with stress in healthy individuals (Joormann & Siemer, 2004; Joormann et al., 2007; Phillipe et al., 2009), rumination is considered to be a maladaptive mode of responding to distress which is consistently related to depression (Nolen-Hoeksema, 2000). In chapter 5 we conducted two experiments testing the relation between rumination and attentional breadth for self-related information. Based on the attentional scope model of rumination (Whitmer & Gotlib, 2013), we expected rumination to be related to a narrowing of visuospatial attention for self-related information. In the first experiment we found that trait rumination qualified the relation between induced rumination and attentional breadth, such that only at high levels of trait rumination, induced rumination was related to more attentional narrowing for self-related information. Moreover, this effect could not be explained by individual differences in the change in depressive mood due to the rumination induction. In the second experiment we observed a direct relation between higher trait rumination levels, more specifically

brooding, and more attentional narrowing for self-related information in general, when no thinking-style manipulation was performed.

To summarize, in chapters 2, 3, and 4 we investigated the relation between positive memory recall, inducing positive mood, and visuospatial attentional breadth. Findings of these chapters show that effects of positive mood on trial-by-trial fluctuations in visuospatial attentional broadening can interact with the value or meaning of the target in attention. Stimuli in the target of attention can even by itself influence attentional breadth, depending on their perceived emotional valence. However, these effects are dependent on individual characteristics such as the presence of depressive symptoms or trait resilience, which seem even to determine the direction of this relation between positive mood and attentional breadth. Rumination induction, a more maladaptive way of responding to stress, was shown to have opposite effects on attentional breadth for self-related information as compared to an increase in positive mood after positive memory recall, although this relationship was qualified by trait rumination. Implications of these findings are discussed below.

Do effects of positive mood on cognition mediate the relation between positive mood and stress reactivity?

In the second research line we investigated the predictions of the broaden-and-build theory (Fredrickson, 1998; 2001) that the effects of positive emotions on cognition are underlying mechanisms in the relation between positive emotions and resilience. We experimentally tested the effects of positive mood induction, through positive memory recall, on cognition and how this would mediate the response to a stress induction. Stress was induced using a visual oddball task in which individuals receive negative feedback on their performance (Baeken et al., 2014; Rossi & Pourtois, 2013). We assessed both the emotional response and the physiological stress response reflected by changes in heart rate variability.

In chapter 6, we conducted an experimental study in an unselected student sample testing the effects of positive mood induction, using memory recall, on affective flexibility and how this mediates stress reactivity. Affective flexibility was operationalized as the switching of attention from non-affective aspects to affective

aspects, or vice versa, of either positive or negative information (Genet, Malooly, & Siemer, 2013; Malooly, Genet, & Siemer, 2013). Results showed that the positive mood induction was related to less flexiblity when switching attention from non-affective aspects to affective aspects of negative information or vice versa. A direct relation between the mood induction and stress response revealed that a positive mood induction, as compared to a neutral induction, was related to a smaller increase in arousal and tenseness across the stressor. Mediation effects showed that the positive mood induction condition, compared to the neutral condition, showed a smaller increase in arousal across the stressful task via contribution of less efficient switching of attention towards the affective aspects of negative material. Moreover, the positive mood induction condition, as compared to the neutral condition, also showed a greater decrease in positive mood and greater increase in sad mood across the stress induction via contribution of less flexibility when switching attention towards non-affective aspects of negative material.

In chapter 7, we used a similar study design in a formerly depressed sample, as these individuals are especially at risk of developing new episodes of depression. We examined the effects of positive mood induction on one's tendency to interpret ambiguous information in positive or negative ways and how this mediates stress reactivity. Additionally we investigated how the presence of residual depressive symptoms qualified the effects of positive mood on the processing of ambiguous information. The Scrambled Sentence Task (SST; Van der Does, 2005; Wenzlaff, 1993) was used to assess the tendency to interpret ambiguous information in a more positive or negative way, with a higher positive index reflecting a greater tendency to process ambiguous information in a positive way. Findings from this study showed that only at low levels of depressive symptoms a greater increase in positive mood tended to be related to a higher SST positive index after mood induction, reflecting a more positive processing bias. A moderated mediation model then revealed that only at low levels of residual depressive symptoms, a greater increase in positive mood was related to a greater increase in arousal across the stress induction via contribution of a more positive processing bias.

In sum, the studies presented in chapter 6 and 7 provide some first indication that effects of positive mood on cognition can mediate the relation between positive mood and stress reactivity. In chapter 6 we find that depending on how positive mood influenced specific affective flexibility aspects, differential effects on stress reactivity were observed. Our study with formerly depressed individuals presented in chapter 7 reveals that the presence of residual depressive symptoms qualifies the effect of positive mood on the processing of ambiguous information as more positive. However, at low levels of depressive symptoms, a more positive processing bias mediated the relation between a greater increase in positive mood and a greater increase in arousal across the stress induction, implying a greater stress response. Implications of these findings are discussed below.

Do different ways of processing autobiographical memories engage different neural regions?

The third research line focused on the neurobiological underpinnings of (positive) autobiographical memory recall. More precisely, we aimed to investigate how different ways of processing autobiographical memories, imagining the memory from a field perspective versus an observer perspective, would be related to differences in neurobiological activation. This may shed further light on how different ways of processing autobiographical memories could affect the use of this strategy in the context of emotion regulation and self-generation of positive emotions.

In chapter 8 we used functional Magnetic Resonance Imaging (fMRI) to investigate differences between the use of field perspective imagery and observer perspective imagery when imagining both neutral and positive autobiographical memories, in a within-subjects design. Behavioral data of this study revealed that when positive memories were imagined, ratings of happy mood were higher after field perspective imagery than after observer perspective imagery. When imagining neutral memories there were no differences in ratings of happy mood between field perspective imagery and observer perspective imagery.

For the imaging data we first contrasted the experimental conditions (i.e. positive-field, neutral-field, positive-observer, neutral-observer) to a control task (based on Eich, Nelson, Leghari, & Handy, 2009), for each experimental condition separately.

This revealed greater activity in areas including dorsolateral, dorsomedial, ventrolateral, ventromedial, and orbital parts of the prefrontal cortex (PFC) bilaterally although more extensive in the left hemisphere, middle/superior temporal gyrus extending to the angular gyrus bilaterally, hippocampus bilaterally (although for neutral observer memories only right hippocampus), and precuneus. When we directly contrasted a field perspective to an observer perspective (field perspective > observer perspective), we found no areas showing greater activity during field perspective as compared to an observer perspective. However, when we directly contrasted an observer perspective to a field perspective (observer perspective > field perspective), an observer perspective was associated with greater activity in the right precuneus. No areas showed significant activity for the interaction between imagery perspective and valence of the memory.

Theoretical Implications Of The Findings

Based on the summary of our findings, several theoretical implications can be put forward. Clinical implications will be discussed in the next section.

Effects of positive mood on cognition

The idea that positive and negative emotions have distinct effects on cognition does not originate from the broaden-and-build theory. Previous research has shown that positive emotions are, amongst others, associated with increased cognitive flexibility in categorization tasks (Isen & Daubman, 1984) and increased creativity (Baas, De Dreu, & Nijstad, 2008), but also influence lower-level perceptual encoding such that positive emotions are associated with increased visual attentional breadth (e.g. Derryberry & Tucker, 1994; Fredrickson & Branigan, 2005). However, the effects of positive emotions on visual attentional broadening have produced mixed results with some studies not being able to replicate previous findings (Bruyneel, Van Steenbergen, Hommel, Band, De Raedt, & Koster, 2012). Most studies that investigated the effects of positive mood on attentional breadth have used tasks with neutral or meaningless stimuli. However, findings from our studies reveal that stimulus characteristics (i.e. self-related information, emotional valence) can interact with the effects of positive mood on visuospatial attentional breadth on a trial-by-trial basis. Besides the influence of

stimulus characteristics on the relation between positive mood and attentional breadth, individual characteristics also showed to have an influence. Across two studies, in both an unselected sample and in formerly depressed individuals, we observed that the level of depressive symptoms determined the presence and even direction of the effect of induced positive mood on cognition. Furthermore, consistent with our findings that the presence of mild depressive symptoms (which could be a proxy measure of lower resilience) hampered the relation between positive mood and cognition, levels of trait resilience, measured as a personality trait that enhances individual adaptation, also qualified effects on attentional broadening/narrowing.

Findings from our studies thus showed that both stimulus characteristics and individual characteristics have an influence on the relationship between positive mood and visuospatial attentional breadth. This could provide some explanation for why there have been mixed results in observing visual attentional broadening effects of positive emotions, as most previous studies used tasks with neutral or meaningless stimuli. Our results on attentional breadth for emotional information showed that, at low levels of depressive symptoms there was no significant relation between induced positive mood and attentional broadening when neutral (or negative) information was presented. Additionally, previous studies have not taken into account levels of depressive symptoms or trait resilience when examining the effects of positive emotions on attentional broadening. As variability in such characteristics already seems to qualify the relation between positive mood and visuospatial attentional breadth in unselected samples, not taking into account such characteristics might alleviate the observable effects of positive mood on attentional breadth. Provided previous null-findings on attentional broadening effects (Bruyneel et al., 2012) and our results on the influence of stimulus characteristics and individual characteristics, a refinement of the broaden-and-build theory (Fredrickson, 1998; 2001), specifically with regard to predictions on visual attentional broadening, might be required. Positive emotions do not seem to be unequivocally related to increased visual attentional breadth but describing such a link between positive emotions and visual attentional breadth should include possible moderating factors such as individual and stimuli characteristics.

The findings of hampered or reversed effects of positive mood on cognition, due to the presence of depressive symptoms or low trait resilience, could be viewed in light

of recent research proposing a more flexible link between affect and attentional breadth (Huntsinger, 2013). Affect is proposed to provide information on the most dominant attentional orientation at that moment. Whereas negative affect is believed to acts as a "stop signal", positive affect acts as a "go signal" for use of the momentarily dominant mode of attentional processing (Huntsinger, 2013). Depressive symptoms, which could reflect lower resilience, have been associated with a more narrowed attentional scope in general (Basso et al., 1996; De Fockert, & Cooper, 2014), and also a tendency to process ambiguous information in a more negative way (Gotlib & Joormann, 2010). Therefore, it is possible that being in a more positive mood, or the processing of more positively evaluated emotional stimuli encouraged the continuation of the more dominant processing mode. However, this 'affect-as-information' account (Huntsinger, 2013) for the differential relation between positive mood and cognition depending on individual characteristics does not completely account for the findings that at minimal levels of depressive symptoms, being in a positive mood was related to attentional broadening but only when positive information was presented. This suggests that individuals with minimal depressive symptoms, being in a positive mood, do not necessarily show general attentional broadening but display some kind of flexible adaptation of the attentional scope to the emotional context on a short, trial-by-trial basis. Even without positive mood induction, high levels of trait resilience were associated with fluctuations in attentional broadening/narrowing depending on how the emotional valence of surprise stimuli were perceived (Grol & De Raedt, 2014). Such flexible adaptation of the attentional scope to the emotional context in high resilient individuals or individuals with minimal depressive symptoms (who are in a positive mood) fits with research showing that higher trait resilience is associated with flexible adaptation of the emotional response across emotional contexts (Waugh, Thompson, & Gotlib, 2011).

In summary, our findings highlight the complexity of the effects of positive mood on cognition, which are influenced by both characteristics of the information present in the target of attention, individual characteristics, and their interplay. More specifically, we have demonstrated that effects of positive mood states on attentional broadening can be influenced on a trial-by-trial basis, due to the nature of the target in focal

attention. The perceived emotional valence of information in focal attention even has an influence on attentional breadth in itself. Moreover, certain individual characteristics, for example, the presence of depressive symptoms, can determine such effects of positive mood on cognition and may even change the direction of the relation between positive mood and attentional breadth. In line with previous suggestions (Rusting, 1998), this implies that taking into account relationships between mood states and personality traits (or more stable emotional characteristics) is probably a more realistic account for the way mood states can impact processing of emotional, or other specifically meaningful, information.

Positive mood, cognition, and stress resilience

Biases in information processing and impaired cognitive control observed in depression are likely underlying impairments in emotion regulation (Carl, Soskin, Kerns, & Barlow, 2013; De Raedt & Koster, 2010; Gotlib & Joormann, 2010), which makes it probable that resilience also depends on such cognitive mechanisms. The broaden-and-build theory (Fredrickson, 1998; 2001) also predicts that effects of positive emotions on cognition facilitate coping with distress. This *undoing hypothesis* (Fredrickson & Levenson, 1998) predicts that the broadening of one's thought-action repertoire may actually work as the mechanism in undoing the effects of negative emotions or stress on one's mind and body. However, there has been little experimental research on how the effects of positive emotions on cognition work as a mechanism in the relation between positive emotions and stress resilience.

In both an unselected student sample and a formerly depressed sample we empirically tested how the effects of positive mood on cognition mediated the emotional and physiological response to a stress induction. Although both studies give some first indication that indeed the effects on cognition may play a role in the relation between positive mood and stress resilience, findings also show that positive emotions do not 'unconditionally' lead to better stress resilience. In the study presented in chapter 6, results showed that positive mood induction through positive memory recall, as compared to neutral induction, was associated with a smaller increase in arousal across the stress induction via contribution of less efficient switching of attention towards affective aspects of negative information. Although this shows that effects on

cognitive processing may indeed underlie the relation between positive mood and stress reactivity, it does not fully comply with our predictions based on the broaden-and-build theory (Fredrickson, 1998; 2001) that effects of positive emotions on increased cognitive flexibility underlie increased stress resilience. Nevertheless, it seems consistent with previous research showing that difficulties disengaging attention away from negative material is related to depression (e.g. De Raedt & Koster, 2010; Gotlib & Joormann, 2010). Furthermore, affective (switching) inflexibility may not necessarily be maladaptive as inflexibility when switching attention towards non-affective aspects of positive information has been related to less rumination in daily life (Genet et al., 2013). This stresses the importance of taking into account (emotional) context (e.g. switching to or away from affective aspects of negative or positive information depending on situational demands). Interestingly, findings also revealed that positive mood induction through positive memory recall was related to an increased emotional stress response (i.e. larger increase in sad mood and decrease in positive mood) due to its effects on inflexibility when switching attention from affective aspects towards non-affective aspects of negative information. This could be explained by previous findings showing that increased flexibility when switching attention towards non-affective aspects of negative information is related to increased reappraisal effectiveness (Malooly et al., 2013). Moreover, decreased flexibility when switching attention from affective aspects towards non-affective aspects of negative information has been related to increased rumination in daily life (Genet et al., 2013). However, this does imply that positive mood can be associated with both an increased and milder emotional stress response depending on how and/or what specific cognitive processes are affected by positive mood. If we proceed in our reasoning, this could suggest that as positive emotions have complex effects on cognitive processing, which might interact with individual characteristics, that this may then also influence how positive emotions are indirectly related to stress resilience.

Findings from our study in formerly depressed individuals again suggest that positive emotions are not ‘unconditionally’ associated with better stress resilience. Results showed that only at low levels of residual depressive symptoms a relation was observed between an increase in positive mood and a more positive processing bias, as indicated by a greater tendency to process ambiguous information in a more positive

way. However, at low levels of depressive symptoms, this effect of a greater increase in positive mood on a more positive processing bias was then related to a stronger stress response reflected by a greater increase in arousal across the stress induction. Although we should be cautious in over interpreting this effect as it was observed on only one measure of the emotional stress response, it provides some first indication that in formerly depressed individuals effects of positive mood on processing bias can underlie stress reactivity, but that this may cause a contrast effect. This would be in line with previous findings showing that formerly depressed individuals show an impaired ability to use positive memory recall after a negative mood induction to regulate sad mood (Joormann et al., 2007). In the study of Joormann et al. (2007) independent raters showed that healthy controls and formerly depressed individuals did not differ in the number, valence or specificity of the positive memories. Nevertheless, the subjective positive emotional response to positive memory recall could have been different (Joormann et al., 2007). However, in our study within a formerly depressed sample, at low levels of depressive symptoms, a greater increase in positive mood was actually related to a more positive processing bias, but this still mediated a greater stress response. This could suggest that in formerly depressed individuals the encounter of stress, even when a positive mood state caused a momentarily more positive processing bias, could still cause a focus on deterioration during distress, increasing the risk of a contrast effect.

In conclusion, we argue that although we have showed some first evidence that effects of positive mood induction, by positive memory recall, on cognitive processes could underlie stress reactivity, positive mood does not seem to be unequivocally related to increased stress resilience. First, it seems that positive mood can be associated with both increased as well as decreased stress resilience depending on how and what specific cognitive processes are influenced by positive mood. Second, the effects of positive memory recall, also at the cognitive level, might have a different impact in never-depressed individuals and (formerly) depressed individuals in the midst of distress.

Different ways of processing autobiographical memories

In this dissertation we used mental imagery of positive memories, as mental imagery has shown to have a strong impact on emotion (Holmes & Mathews, 2005; 2010) which could strengthen the self-generation of positive emotions. Within mental imagery a distinction is made between taking a field-perspective (i.e. first-person perspective) and an observer perspective (i.e. third-person perspective). Imagery perspective has shown to influence what is recalled (McIsaac & Eich, 2002), processing style (Libby & Eibach, 2011), and emotionality (Holmes et al., 2008). The influence of these different ways of processing autobiographical memories seems relevant for the effectiveness of positive memory recall in the context of emotion regulation and the self-generation of positive emotions.

Behavioral results from our study presented in chapter 8 confirmed previous findings (e.g. Holmes et al., 2008) that imagery perspective can influence emotional intensity by showing that positive memory recall was associated with greater positive mood when imagined from a field perspective. In chapter 1, we also demonstrated that dysphoric individuals who received no instructions on how to process their positive memory showed higher reports of adopting an observer perspective than those who were instructed on the use of field perspective imagery. This was accompanied by higher ratings of positive mood after positive memory recall in the dysphoric individuals receiving instructions and practice on field perspective imagery. Despite many behavioral studies that have investigated the influence of imagery perspective on emotional intensity and processing style (e.g. Holmes et al., 2008, Libby & Eibach, 2011), little is known about the underlying mechanisms of these differential effects of imagery perspective. Investigating underlying differences between field perspective and observer perspective imagery at the neurobiological level, could improve our understanding of what is underlying the observed differences at the behavioral level.

First results of our fMRI study in healthy individuals, presented in chapter 8, showed that imagining neutral and positive emotional memories, regardless of imagery perspective, was related to increased activity in dorsolateral, dorsomedial, ventrolateral, ventromedial and orbital parts of the prefrontal cortex (most outspoken in the left hemisphere), middle/superior temporal gyrus extending to the angular gyrus, hippocampus, and precuneus. Interestingly, most of these areas are also part of the

emotion regulation circuitry (Davidson et al., 2002), which suggests that – in healthy individuals - similar networks are implicated in the re-activation of neutral and positive autobiographical memories and the regulation of emotions by prefrontal areas. This provides extra support for the idea that positive autobiographical memory recall can be used as an emotion regulation strategy (in healthy individuals).

However, the question remains whether different perspectives when processing (positive) autobiographical memories, relate to underlying neurobiological differences that could be relevant in the context of using positive memory recall for emotion regulation. A direct comparison between adopting a field- and an observer perspective when processing (neutral and positive) autobiographical memories, revealed that an observer perspective was associated with greater activity in the right precuneus. Greater activity in the precuneus during a third-person perspective (i.e. an observer perspective) has previously been linked to representation of the self (Ruby & Decety, 2001; Schilbach et al., 2006). There are many studies associating the precuneus with self-referential/-evaluative processing (for review, see Northoff et al., 2006), or evaluative processing in general (Legrand & Ruby, 2009). This supports the idea that observer perspective is associated with thinking about a recalled event in terms of its broader context or meaning in an individuals' life, with the meaning of such events in relation to the self-concept becoming more salient (Libby & Eibach, 2011). Similarly, research on imagery perspective in depression has proposed that adopting an observer perspective promotes evaluative thinking about the self, which could result in unfavorable self-comparisons (e.g. with an ideal self) reducing the positive affective response (Kuyken & Howell, 2006; Kuyken & Moulds, 2009). This could indicate that considering the event in relation to the self-concept (highlighting coherence or incoherence), works as an underlying mechanism influencing whether an observer perspective, as compared to field perspective, decreases or increases emotional impact (Libby & Eibach, 2011). Considering an autobiographical event to be incoherent with the current self-concept or self-beliefs could then attenuate the emotional response to re-activation of past autobiographical events.

In sum, in healthy individuals, imaging neutral and positive autobiographical memories, regardless of imagery perspective, seems to involve similar neural networks

that are also implicated in emotion regulation. At the neurobiological level observer perspective imagery, as compared to field perspective imagery, was associated with greater activity in the right precuneus, an area that has often been linked to self-referential and evaluative processes (Legrand & Ruby, 2009; Northoff et al., 2006). This finding reinforces the idea that imagery perspective does not have a direct impact on emotionality, but that this depends on whether considering the event in relation to the self-concept (related to observer perspective) decreases or increases the emotional power (Libby & Eibach, 2011).

Clinical Implications Of The Findings

Over the last decade there has been a great development in the study of positive emotions – summarized under the term positive psychology - which has also found its way into clinical science, aiming to enable people to have positive emotional experiences with the accompanying benefits (Seligman & Csikszentmihalyi, 2000; Seligman, Steen, Park, & Peterson, 2005). Provided that depression is not only characterized by impairments in the down-regulation of negative emotions but also in the up-regulation of positive emotions (Carl et al., 2013; Dunn, 2012), it has been emphasized that therapy should not only focus on the negative emotional experience but also on promoting positive emotions (e.g. Dunn, 2012; Wood & Tarrier, 2010). Several interventions have been proposed to enhance positive emotional experiences and/or its accompanying benefits. For example, loving-kindness meditation to cultivate positive emotions, mindfulness meditation to broaden awareness, encouragement to process positive information more fully to amplify the affective experience (e.g. with imagery), and training to recall positive memories more extensively using imagery (e.g. Garland et al., 2010; Holmes, Lang, & Shah, 2009; Johnson, Gooding, Wood, Fair, & Tarrier, 2013). However, a recent meta-analysis on positive psychology interventions shows small effect sizes of interventions on subjective well-being (d = 0.34), psychological well-being (d = 0.20), and depressive symptoms (d = 0.23), although effects seem to be quite sustainable (Bolier et al., 2013). Furthermore, underlying mechanisms of how these positivity interventions work need to be better investigated (Dunn, 2012).

Ability to benefit from positive emotional experiences

The broaden-and-build theory (Fredrickson, 1998; 2001) describes the relation between positive emotions and resilience and proposes effects of positive emotional experiences on cognition to be a mechanism in this relation. However, through chapter 2 to 7 we have demonstrated that effects of positive mood (or rumination) on visuospatial attentional broadening, affective flexibility, and (interpretative) processing bias, are influenced by the value of information in the target of attention and individual characteristics such as the presence of depressive symptoms. These observations may have consequences for positive psychology interventions in clinical settings. We have observed a hampering and even reversal of the relation between positive mood and visuospatial attentional broadening or a more positive processing bias, at lower levels of trait resilience and at mild depressive symptoms. This suggests that additionally to the association of depressive symptoms with a more narrowed attentional scope in general (Basso et al., 1996; De Fockert & Cooper, 2014), the presence of depressive symptoms or lower trait resilience is also associated with an impaired ability to benefit from positive emotional experiences at the level of cognitive functioning. Similarly, we have shown that higher levels of trait rumination, specifically brooding, which has often been related to depression (Nolen-Hoeksema, 2000), was related to more narrowed attention for self-related information in general. Additionally, a rumination induction was related to more attentional narrowing for self-related information, in line with predictions from the attentional scope model of rumination (Whitmer & Gotlib, 2013), but only at high levels of trait rumination. This shows that higher levels of depressive symptoms and trait rumination are generally already associated with more narrowed attention (for self-related information), but also influence attentional responses to positive mood states and momentary rumination episodes in a maladaptive manner. Although the role of processes such as attentional broadening, as a mechanism underlying resilience needs to be further clarified, it would imply that such individual differences in the ability to benefit from positive emotions at the cognitive level then also affect the ability to benefit from positive emotions in relation to stress resilience.

In addition to the finding that factors such as the presence of (mild) depressive symptoms could influence the ability to benefit from positive mood at the cognitive level, it is also possible that how cognitive effects of positive emotions mediate stress

resilience differs between people. It is believed that positive emotions through its effects on cognition facilitate positive reappraisal of stressful situations (Garland et al., 2010). However, results from our study in formerly depressed individuals (chapter 7) show that at low levels of depressive symptoms, a more positive processing bias as a result of a greater increase in positive mood, mediated a greater increase in arousal across the stress induction. This suggests the occurrence of a contrast effect in this formerly depressed sample. That is, in formerly depressed individuals, the encounter of stress while being in a more positive mindset, could lead to a focus on deterioration when confronted with stress, as opposed to facilitating positive reappraisals, which perhaps cancels out the beneficial effects of being in a positive mood state and having a more positive processing bias. Although we did not compare formerly depressed individuals to never-depressed individuals it seems to be in line with previous findings showing that, as opposed to never-depressed individuals, formerly- and currently depressed individuals show an impaired ability to use positive memory recall to regulate stress (Joormann et al., 2007). From our findings this does not seem to be purely due to a reduced positive emotional response to positive memory recall or hampered effects of positive mood on cognition (at least not at low levels of residual depressive symptoms). Therefore, future research should further clarify what other factors in (formerly) depressed individuals could influence the ability to benefit from being in a positive mood state and having a more positive processing bias when encountering a stressful situation.

In sum, our results seem to indicate that individual characteristics such as the presence of depressive symptoms or lower trait resilience are associated with an impaired ability to benefit from positive emotional experiences at the level of cognitive functioning. In addition, the effects of positive memory recall, also at the cognitive level, might have a different impact in never-depressed individuals and (formerly) depressed individuals when encountering stress. These findings might explain some variability between people in their ability to become resilient.

Although most positive psychology interventions are more extensive than the procedure we used in this dissertation, based on recall of one positive memory to enhance positive mood, our results could still have implications for the effectiveness of

such interventions that aim to promote positive emotions in subclinical and (formerly) depressed individuals. Even if positive affectivity is enhanced, this does not automatically imply that accompanying benefits at the cognitive level will follow. Therefore, we believe that interventions should not only target the enhancement of positive affectivity, but also more directly promote a more broad and flexible cognitive processing style. Hence, understanding the mechanisms underlying adaptive responding to stress or the development of resilience, could further optimize such interventions and point out target processes for intervention.

Imagery perspective and self-referential/evaluative processes

In this dissertation we used mental imagery to amplify the affective experience in response to memory recall. However, different imagery perspectives seem to influence how imagined events are processed (Libby & Eibach, 2011), which could have an influence on the effectiveness of this strategy for emotion regulation and self-generation of positive emotions. Thinking about past events in terms of the experiences evoked by features of the event has been proposed to be related to a field perspective, while thinking about the event in terms of its broader meaning in an individuals' life, with the meaning of such events in relation to the self-concept becoming more salient, is related to an observer perspective (Libby & Eibach, 2011). Similarly, it has been proposed that adopting an observer perspective promotes evaluative thinking about the self (Kuyken & Howell, 2006; Kuyken & Moulds, 2009). This idea fits with findings of chapter 8, showing that at the neurobiological level adopting an observer perspective, as compared to a field perspective, was related to increased activity in the right precuneus. The precuneus has been linked to self-referential/-evaluative processing (for review, see Northoff et al., 2006), although the precuneus might be part of a network involved in evaluative processes in general, not specifically for self or others (Legrand & Ruby, 2009).

These findings could indicate that imagery perspective does not directly influence the intensity of the emotional response, but that this depends on whether considering the event in relation to the self-concept decreases or increases emotional power (Libby & Eibach, 2011). However, this implies that individual differences in general self-beliefs can then lead to different meanings of events in relation to the self-

concept, and should moderate the effect of imagery perspective on the evoked emotional response (Libby & Eibach, 2011). Thus, observer perspective is not necessarily related to reduced emotional intensity, but this depends on how the event is regarded in relation to the self-concept, which by itself depends on general self-beliefs. This is relevant when using imagery for clinical purposes, provided that depression is associated with more negative self-schema (Clark, Beck, & Alford, 1999), increasing the likelihood that the meaning of a past positive event in relation to the current (negative) self-concept results in unfavorable evaluation, dampening the positive emotional response. Thus, if this highlights a discrepancy between the present (negative) self-concept and imagined (past, positive) selves, adopting an observer perspective could indeed lead to a detachment of the event from the present self-concept, possibly dampening the emotional response (or leading to a contrast effect).

To conclude, our findings on differences between imagery perspectives when processing autobiographical memories seem to be consistent with the idea that an observer perspective is more likely to promote self-evaluative thinking and thinking about the past event in relation to the self-concept. This implies that differences in general self-beliefs can then lead to different meanings of events in relation to the self-concept, and therefore moderate the effect of imagery perspective on the evoked emotional response (Libby & Eibach, 2011). Provided that depression is related to more negative self-evaluation and self-schema, it is possible that in (formerly) depressed individuals imagining a positive memory from an observer perspective highlights a discrepancy between present (or ideal) self and imagined past selves, leading to a dampening of the emotional response or even a contrast effect. This underlines that different ways of processing/imagining emotional information, in interaction with individual characteristics can lead to different outcomes (e.g. the affective experience in response to the imagined event). Hence, understanding how this works, is a first step in further optimizing positive psychology interventions that aim to enhance positive affective experiences (e.g. thinking about positive life experiences, positive future thinking).

Limitations

There are a number of limitations to the studies presented in this dissertation that deserve some consideration. A first issue concerns the different possibilities of how resilience can be conceptualized and operationalized. The broaden-and-build theory (Fredrickson, 1998; 2001) describes the relation between positive emotions and resilience, making predictions about both immediate stress resilience and the development of resilience as a trait-like characteristic. The experience of positive emotions is believed to undo the acute effects of negative emotions and stress, as predicted by the undoing hypothesis (Fredrickson & Levenson, 1998). Additionally, positive emotions are also believed to contribute to the development of psychological resilience as a trait by building lasting personal resources that can be called upon in future situations (Fredrickson, 1998; 2001). In chapter 4, we assessed trait resilience with the Dutch Resilience Scale (Portzky, 2008) as a personality trait that enhances individual adaptation, and investigated how this influenced the relation between perceived emotional valence of stimuli and attentional breadth for those stimuli. Nevertheless, in this dissertation we focused on how effects of positive mood induction on cognition influenced acute stress resilience (chapter 6 and 7). Next to the need for continued research on mechanisms of acute stress resilience, future studies should therefore also investigate how positive affective experiences (in daily life) relate to the development of resilience as a trait across time, or personality traits that facilitate adaptation.

A second point is our focus on cognitive and neurobiological effects of positive memory recall and how cognitive effects of induced positive mood mediate stress reactivity. Therefore, we cannot draw conclusions about effects of positive memory recall on social processes such as interpersonal trust and social connectedness which have previously also been implicated as possible underlying mechanisms in the relation with increased well-being (Burns et al., 2008; Kok et al., 2013). It is likely that effects of positive mood on social factors (that may influence feelings of social support) also account for variability in the development of resilience. It would be useful to clarify the relations between possible cognitive, neurobiological, and social mechanisms underlying resilience and investigate whether certain mechanisms can better account for variability in resilience.

Third, the studies in this dissertation rely solely on self-report measures of positive mood to indicate the effects of positive memory recall, which have the issue of social desirability. Although this applies to most emotion research, future studies could extend this to multiple response measures. Furthermore, in our studies we have measured positive mood as a unitary construct by assessing how "happy" people are feeling, while no distinction was made with other kinds of positive affective experiences (contentment, gratitude, etc.). It is possible that different kinds of positive affective experiences have different effects on cognitive processes. Additionally, we have investigated effects of positive mood manipulation, while it could be useful to include measurements of positive emotional experiences in daily life (e.g. experience sampling) that give information about their temporal dynamics and how this relates to cognitive processing and resilience.

Another issue that should be raised is that this dissertation research was placed in the context of depression, while the influence on the relation between positive mood, cognition, and resilience by related psychopathology such as anxiety levels has not been explored. However, the overlap of features of anxiety and depression is well-known (Mineka, Watson, & Clark, 1998). At the same time, this means that making a clear separation between anxiety and depression is difficult not only at the conceptual level, but also when attempting to statistically control for anxiety levels as measurements of anxiety and depression tend to be highly correlated. Therefore, future research could clarify to what extent hampering effects on the ability to benefit from positive emotions at the cognitive level are observed across mood disorders, or are more a characteristic of depressive symptoms specifically.

A final limitation of our studies is the small sample sizes. When further investigating the mechanisms of stress resilience, also in subclinical or formerly depressed individuals, we should aim to replicate our findings in larger study samples.

Directions And Challenges For Future Research

The aim of this dissertation was to experimentally investigate the cognitive and neurobiological effects of positive memory recall, as a way to self-generate positive emotions, and how this relates to stress resilience. We have provided both theoretical and possible clinical implications of our findings. The above mentioned limitations will

need to be addressed, however, there remain a number of other challenges and directions for future research that could advance our understanding of adaptive responding to stress and how we can increase stress resilience.

First, our research indicates that vulnerability factors such as the presence of mild depressive symptoms or lower trait resilience even in an unselected sample can already influence the ability to benefit from positive emotions at the level of cognitive functioning. Additionally, especially people who report high levels of trait rumination, which has consistently been associated with (vulnerability for) depression (e.g. Nolen-Hoeksema, 2000), seem to be more sensitive to momentary rumination at the attentional level, as reflected in attentional narrowing for self-related information. Although the role of attentional broadening, affective flexibility, or a positive processing bias as a mechanism underlying resilience needs to be further investigated, findings of moderating effects of individual characteristics could suggest that certain individuals may not be able to (fully) benefit from the experience of positive emotions in relation to stress resilience. That is, our finding that individual differences can hamper and even determine the direction of the relation between positive mood and cognitive processing, might explain some of the variability between people in their ability to become resilient. Yet, these individuals who experience mild depressive symptoms and report lower levels of trait resilience - whom might not benefit from the experience of positive emotions at the cognitive level and thereby possibly not fully benefit from positive emotions in relation to stress resilience - are exactly those individuals in whom we ultimately aim to increase resilience in order to prevent (recurrence of) depression. Therefore, future research should reveal whether directly targeting underlying cognitive (and neurobiological) processes related to positive emotions, instead of indirectly through the enhancement of positive affectivity, could be a better way to strive for development and increase of stress resilience. Furthermore, it would be interesting to examine how different processes that have been proposed to underlie resilience (e.g. attentional broadening, flexibility, positive processing bias, but also social factors such as increased personal connectedness) relate to each other, or to what extent certain processes might have a greater influence on stress resilience than others.

Second, in this dissertation we have focused on the cognitive and neurobiological effects of the up-regulation of positive emotions through positive

memory recall and how that relates to stress resilience. However, it seems unlikely that encouraging a universal positive mindset is neither realistic, nor beneficial. Notwithstanding that depression, or mood disorders in general, are related to a loss of pleasure and interest and impairments in the up-regulation of positive emotions which demand attention, it is likely that flexibility to respond to changing situational demands (which requires control) is a better reflection of resilience. It has been shown before that higher trait resilience is not associated with the unconditional experience of positive emotions, but that higher trait resilience is characterized by a flexibility of emotional responses to the demands of the context (Waugh et al., 2013). Similarly, it has been argued that flexibility in emotion regulation is essential, meaning both sensitivity to demands and opportunities from the context, the ability to use a wide repertoire of different strategies, and response to feedback about efficacy of a chosen strategy (Bonanno & Burton, 2013). However, flexibility in information processing or cognitive control combined with a sensitivity to contextual needs and opportunities might be a prerequisite for this regulatory flexibility and emotional flexibility, and thereby resilience. Indeed, our own studies on the effects of positive mood on visuospatial attentional breadth, taking into account the value of the information in attention, reveal fluctuations in attentional broadening/narrowing on a trial-by-trial basis. We have observed that at minimal depressive symptoms an increase in positive mood was not necessarily associated with general attentional broadening, but fluctuations in attentional broadening/narrowing in response to the emotional valence of the information in attention ('the emotional context'). Similarly, at high levels of trait resilience, perceiving a stimulus in the target of attention as more positive was related to more attentional broadening (and more negative evaluation related to more narrowing). Thus, an attentional sensitivity to both mood state and information in the target of attention that could work as signals of, for example, safety or threat. This could denote that we should not focus on training broader attention or a more positive attentional bias per se, but focus on attentional flexibility and control, taking into account situational demands (e.g. task demands, emotional context). Thus, for example fluctuations in attentional broadening/narrowing depending on the (emotional) context, or the ability to switch attention between affective and non-affective aspects of emotional material (or between positive and negative material), but also to maintain

attention on (non-)affective aspects of emotional material when in function of the context. Therefore, it would be interesting for future research to further clarify how training attentional/cognitive control, including the ability to identify situational demands or opportunities and respond to this in a flexible manner, relates to emotion regulation, regulatory flexibility, and resilience.

Third, a wealth of research has investigated psychosocial factors associated with resilience and research has now started to focus on clarifying the cognitive mechanisms underlying more adaptive responding to stress and the protection against depressive responding to stress. Only more recently have studies begun to also examine neurobiological factors associated with more adaptive stress regulation and resilience (for a review, see Van der Werff, Van den Berg, Pannekoek, Elzinga, & Van der Wee, 2013). However, as has been mentioned before in the context of vulnerability models for depression (De Raedt & Koster, 2010), cognitive and neurobiological factors associated with resilience are likely to relate to each other and the challenge for future research would be to integrate these findings to improve our understanding of mechanisms of resilience. Furthermore, most studies investigating cognitive and neurobiological factors related to adaptive emotion regulation and stress resilience have investigated these factors in relation to emotional and/or physiological responses during or after stressful events. However, emotions and stress responses do not only occur during or after emotion-eliciting or stressful events, but also arise during the anticipation of such events (Gramer and Reitbauer, 2010; Waugh, Panage, Mendes, Gotlib, 2010). This implies that adaptive stress regulation would already start during anticipation of emotion-eliciting or stressful events, requiring proactive control and regulation, and depression reveals to be related to dysfunctional proactive control (Vanderhasselt et al, 2014). Investigating factors related to 'cognitive and neurobiological preparatory processes' in the anticipation of stressful events and how that relates to the stress response during the actual event would be an interesting avenue for future research.

In sum, insight into both cognitive and neurobiological mechanisms of adaptive responding to stress – and their integration – may open new avenues for developing more sophisticated treatment/training strategies to boost resilience.

Final Conclusion

This research project set out to investigate the cognitive and neurobiological effects of positive memory recall and how these effects could relate to stress resilience. The findings of this dissertation, together with recent findings in the literature, point out the complexity of the relation between positive mood and visual attentional breadth and flexibility (or information processing more broadly), being influenced by characteristics of the information in attention and individual differences. Furthermore, although it is likely that positive emotional experiences can contribute to resilience through effects on information processing, positive mood might not unequivocally lead to increased (acute) stress resilience. In addition, when using positive memory recall as an emotion regulation strategy and to stimulate self-generation of positive emotions, one should consider that different ways of processing past events, possibly in interaction with individual characteristics, can lead to different outcomes (e.g. influence the affective experience).

Our work contributes to an increasing body of research focusing on mechanisms underlying the adaptive responding to stress and the contribution of positive emotions to stress resilience. The findings of this dissertation offered some new insights into underlying mechanisms in the relation between positive emotions and stress resilience, but also highlight the complexity of this relation with its possible moderating factors. At the same time, this provides several directions and challenges for future research on (cognitive and neurobiological) mechanisms underlying stress resilience, which could facilitate development of more sophisticated strategies to improve adaptive responding to stress and protection against a depressive responding to stress. Only by improving our knowledge of mechanisms underlying both vulnerability and resilience, can we ultimately improve our understanding of recurrent depression and its prevention.

"Be like the bird that, pausing on her flight awhile on boughs too slight, feels them give way beneath her, and yet sings, knowing that she hath wings."

Victor Hugo

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NEDERLANDSTALIGE SAMENVATTING

Depressie is een psychiatrische aandoening die niet alleen gevoelens beïnvloedt maar ook de manier waarop we onszelf en onze omgeving waarnemen. Het is één van de meest voorkomende psychiatrische aandoeningen (Wittchen et al., 2011). Metingen laten zien dat zo'n 19% van de populatie minstens één maal gedurende het leven te maken krijgt met een depressie (Kessler et al., 2009; Wittchen et al., 2011). Ondanks dat er verschillende farmacologische en psychologische interventies beschikbaar zijn die effectief zijn gebleken op de korte termijn (e.g. Hollon & Ponniah, 2010), laten studies zien dat tot 85% van de personen die herstellen van een depressie, terugvallen over een periode van 15 jaar (Mueller et al., 1999).

Ondanks de hoge herval cijfers is onderzoek rond neurobiologische en cognitieve mechanismen van weerbaarheid nog beperkt. Inzicht in zulke mechanismen zou echter essentieel kunnen zijn voor ons begrip van terugkerende depressie en hervalpreventie. Derhalve was dit doctoraatproject gericht op het vergroten van ons begrip van weerbaarheid, uitgaande van een emotieregulatie perspectief. We bestudeerden de cognitieve en neurobiologische effecten van het ophalen van positieve herinneringen en hoe deze effecten gerelateerd zouden kunnen zijn aan stress weerbaarheid. Eerder werd aangetoond dat het ophalen van positieve herinneringen een rol speelt in de opwekking van positieve emoties wanneer men geconfronteerd wordt met stress (Philippe, Lecours, & Beaulieu-Pelletier, 2009). Daarnaast blijkt bij gezonde personen het ophalen van positieve herinneringen een effectieve strategie om een negatieve stemming te verbeteren (Joormann & Siemer, 2004; Joormann, Siemer, & Gotlib, 2007).

Onze hypotheses over de onderliggende mechanismen in de relatie tussen positieve emoties en weerbaarheid zijn gebaseerd op literatuur rond cognitieve en biologische risico factoren voor depressie, daarom volgt eerst een korte beschrijving van enkele van deze risico factoren. Een verhoogde emotionele reactiviteit op stress, of een verstoorde emotieregulatie, werd geobserveerd in verschillende biologische systemen. Op het neurobiologisch niveau heeft onderzoek uitgewezen dat depressie

gepaard gaat met afwijkingen in het emotieregulatie netwerk (Davidson et al., 2002). Depressie werd geassocieerd met hyperactiviteit van de amygdala, een subcorticale regio die betrokken is bij het sturen van aandacht naar affectief belangrijke informatie. Deze verhoogde amygdala activiteit werd gerelateerd aan een verstoorde regulerende (of cognitieve) controle van prefrontale gebieden zoals de dorsolaterale prefrontale cortex, de ventromediale prefrontale cortex en de anterieure cingulate cortex (Davidson et al., 2002).

De ontregeling van biologische processen bij depressie, is gerelateerd aan cognitieve risico factoren voor depressie (De Raedt & Koster, 2010). Depressie is gerelateerd aan problemen met het loslaten van negatieve, zelfrelevante informatie wanneer het de aandacht heeft getrokken (De Raedt & Koster, 2010; Gotlib & Joormann, 2010). Daarnaast wordt depressie ook gekenmerkt door een verhoogde beschikbaarheid van negatieve informatie in het expliciete geheugen, de neiging om zeer algemene herinneringen op te halen (Williams et al., 2007) en de neiging om ambigue informatie op een negatieve manier te interpreteren (Gotlib & Joormann, 2010). Deze verstoring in het kunnen loslaten van negatieve, stressvolle informatie duidt waarschijnlijk op problemen met cognitieve controle (voor emotionele informatie), wat zich ook uit in een ruminatieve denkstijl (De Lissnyder, Derakshan, De Raedt, & Koster, 2011; De Lissnyder, Koster, Everaert, Schacht, Van den Abeele, & De Raedt, 2012). De biologische en cognitieve factoren gerelateerd aan deze processen lijken ook aanwezig te blijven na remissie (Joormann & Gotlib, 2007; Nolen-Hoeksema, 2000; Vanderhasselt, De Raedt, Dillon, Dutra, Brooks, & Pizzagalli, 2012).

De verstoringen in het verwerken van emotionele informatie en verminderde cognitieve controle, hebben zeer waarschijnlijk ook invloed op het vermogen van mensen om hun emoties te reguleren (Ochsner & Gross, 2007). Emotieregulatie kan als een reeks van processen worden beschouwd om de spontane stroom van emoties te beïnvloeden (Koole, 2009). Emotieregulatie is een essentieel onderdeel van mentaal welzijn (Gross, 1998; Gross & Munoz, 1995) en depressie is gerelateerd aan problemen met het reguleren van zowel negatieve als positieve emoties (Carl, Soskin, Kerns, Barlow, 2013). Deze problemen met emotieregulatie lijken ook aanwezig te zijn in voorheen depressieve personen (Ehring, Fischer, Schnülle, Bösterling, & Tuschen-Caffier, 2008; Ehring, Tuschen-Caffier, Schnülle, Fischer, & Gross, 2010; Joormann et al.,

2007). Eerder onderzoek laat dus zien dat verstoringen in emotieregulatie bij depressie gerelateerd zijn aan afwijkingen in het emotieregulatie netwerk op het neurobiologisch niveau (Davidson et al., 2002) en afwijkingen in cognitieve processen en cognitieve controle (Carl et al., 2013). Hierdoor lijkt het waarschijnlijk dat weerbaarheid ook afhankelijk is van dergelijke cognitieve en neurobiologische mechanismen.

Er is een schat aan onderzoek naar psychosociale factoren die samenhangen met weerbaarheid en hierin wordt ook de rol van positieve emoties naar voren gebracht. Een centrale theorie rond positieve emoties is de "broaden-and-build" theorie (Fredrickson, 1998; 2001) welke de relatie beschrijft tussen positieve emoties en weerbaarheid, en stelt dat positieve emoties actief bijdragen aan weerbaarheid. De broaden-and-build theorie (Fredrickson, 1998; 2001) stelt dat positieve en negatieve emoties verschillende functies hebben, evenals verschillende cognitieve en fysiologische effecten. Negatieve emoties worden geassocieerd met een vernauwd denk-en-actie repertoire, wat een adaptieve functie heeft als men geconfronteerd wordt met een bedreigende situatie die directe actie vereist. Positieve emoties worden juist geassocieerd aan een verbreding van het denk-en-actie repertoire (Fredrickson, 1998; 2001). Eerder onderzoek heeft aangetoond dat positieve emoties, onder andere, geassocieerd zijn met verhoogde cognitieve flexibiliteit in categorisatie taken (Isen & Daubman, 1984), verhoogde creativiteit (Baas, De Dreu, & Nijstad, 2008), als ook een verbreding van de visuele aandacht (e.g. Derryberry & Tucker, 1994; Fredrickson & Branigan, 2005).

Deze verbreedde denk-en-actie repertoires worden verondersteld bij te dragen aan de opbouw van zowel psychologische, fysieke, intellectuele als sociale hulpbronnen. Deze persoonlijke hulpbronnen, opgebouwd tijdens ervaringen van positieve emoties, zouden dan gebruikt kunnen worden tijdens toekomstige (stressvolle) situaties. Eerdere studies rond de relatie tussen positieve emoties en weerbaarheid laten zien dat personen die positieve video fragmenten bekijken na een negatieve stemmingsinductie (Fredrickson & Levenson, 1998, study 1; Fredrickson, Mancuso, Branigan, & Tugade, 2000, study 1), of personen die spontaan glimlachen gedurende een negatieve stemmingsinductie (Fredrickson & Levenson, 1998, study 2), achteraf een sneller herstel van de fysiologische (cardiovasculaire) stress respons laten zien. Vooral bij personen die hoog scoren op een trek weerbaarheid vragenlijst, lijkt de

ervaring van positieve emoties bij te dragen aan het fysiologisch stress herstel na een negatieve stemmingsinductie (Tugade & Fredrickson, 2004), en het emotionele stress herstel in reactie op natuurlijke stressoren (Ong, Bergeman, Bisconti, & Wallace, 2006).

Onderzoeksdoelstellingen

De broaden-and-build theorie stelt dat door positieve emoties iemands denk-en-actie repertoire wordt *verbreed,* wat adaptief is door bij te dragen aan het *opbouwen* van persoonlijke hulpbronnen. Hierdoor is de broaden-and-build theorie een interessant theoretisch kader, van waaruit we experimenteel onderzoek kunnen doen naar mogelijke cognitieve mechanismen in de relatie tussen het ophalen van positieve herinneringen en stress weerbaarheid. We beoogden onze huidige kennis rond weerbaarheid te vergroten door het verder experimenteel onderzoeken van de kernprincipes, voorgesteld in de broaden-and-build theorie (Fredrickson, 1998; 2001).

Allereerst testten we de effectiviteit van het ophalen van autobiografische herinneringen als positieve stemmingsinductie (hoofdstuk 1). In een *eerste onderzoekslijn* onderzochten we het effect van positieve emoties op visuospatiële aandachtsbreedte en gingen we na hoe kenmerken van de informatie in de aandachtsfocus, zoals zelfgerelateerde- of emotionele informatie (hoofdstuk 2-4) dit effect beïnvloeden. Tevens onderzochten we de invloed van individuele kenmerken, zoals de aanwezigheid van depressieve symptomen en trek weerbaarheid (hoofdstuk 3 en 4), op de relatie tussen positieve emoties en aandachtsbreedte. Daarnaast onderzochten we de relatie tussen een ruminatieve denkstijl, een maladaptieve manier van reageren op stress, en aandachtsbreedte voor zelfgerelateerde informatie en of individuele verschillen in trek ruminatie, trek weerbaarheid of depressieve symptomen, deze relatie kwalificeren (hoofdstuk 5).

In een *tweede onderzoekslijn* beoogden we de hypothese te testen, gebaseerd op de broaden-and-build theorie, dat effecten van positieve emoties op cognitieve processen als een mechanisme kunnen werken in de relatie tussen positieve emoties en weerbaarheid. Dit onderzochten we door te testen of de effecten van positieve stemming op cognitieve processen, de relatie mediëren tussen positieve stemming en stress reactiviteit in zowel een ongeselecteerde steekproef van studenten (hoofdstuk 6), als een steekproef van voorheen depressieve personen (hoofdstuk 7).

In een *derde onderzoekslijn* onderzochten we de neurobiologische effecten van het ophalen van (positieve) autobiografische herinneringen met behulp van 'functional Magnetic Resonance Imaging' (fMRI). We gebruikten mentale verbeelding van autobiografische herinneringen, omdat mentale verbeelding een sterk effect heeft op emoties (Holmes & Mathews, 2005). Gedragsmatig onderzoek laat echter zien dat verbeeldingsperspectief (veldperspectief vs. observatorperspectief) een invloed heeft op wat men zich herinnert, de verwerkingsstijl en de intensiteit van de emotionele respons (Holmes, Coughtrey, & Connor, 2008; McIsaac, & Eich, 2002; Libby & Eibach, 2011). We onderzochten de verschillen tussen verbeeldingsperspectieven bij het ophalen van herinneringen op neurobiologisch niveau, om de geobserveerde verschillen tussen verbeeldingsperspectieven op het gedragsmatig niveau verder te kunnen verklaren. Tevens zou dit kunnen verduidelijken hoe inname van een verschillend verbeeldingsperspectief bij het ophalen van positieve herinneringen het gebruik van deze strategie kan beïnvloeden in de context van emotieregulatie en het opwekken van positieve emoties.

Overzicht Van De Belangrijkste Bevindingen

Allereerst onderzochten we of het ophalen van positieve autobiografische herinneringen ook effectief is als positieve stemmingsinductie bij individuen die depressieve symptomen ervaren op een subklinisch niveau (hoofdstuk 1). We gebruikten mentale verbeelding van herinneringen aangezien mentale verbeelding een sterk effect heeft op emoties (Holmes & Mathews, 2005). Bij mentale verbeelding wordt er onderscheid gemaakt tussen een veldperspectief (de persoon beeldt de situatie in door de eigen ogen, alsof hij/zij het op dit moment ervaart) en een observatorperspectief (de persoon kijkt als toeschouwer naar hoe hij/zij deelneemt in de situatie). Voorgaand onderzoek laat zien dat depressie en dysforie geassocieerd zijn met de neiging om herinneringen op te halen vanuit het observatorperspectief (Kuyken & Howell, 2006; Kuyken & Moulds, 2009; Nelis, Debeer, Holmes, & Raes, 2013) wat de positieve emotionele respons zou kunnen verminderen (Holmes et al., 2008). Wij vonden echter dat als niet-dysfore en dysfore individuen expliciet instructies en oefening kregen in het gebruik van verbeelding vanuit een veldperspectief, zij geen verschillen rapporteerden in de mate waarin zij een veld- en observatorperspectief

innamen bij het inbeelden van herinneringen. Daarnaast waren er geen verschillen tussen niet-dysfore en dysfore individuen in de positieve emotionele respons en verschilden zij achteraf niet langer in het niveau van positief affect, ondanks verschillen vooraf. Dysfore individuen die geen instructies of oefening kregen in verbeelding vanuit het veldperspectief, waardoor een meer automatische manier van verwerken mogelijk was, rapporteerden meer een observatorperspectief in te nemen dan de dysfore individuen die wel instructies rond inname van een veldperspectief hadden gekregen. Daarnaast waren er ook indicaties dat de dysfore personen die wel instructies kregen, achteraf hogere niveaus van positief affect rapporteerden dan de dysfore personen die geen instructies kregen. Uit onze resultaten blijkt dat mentale verbeelding vanuit het veldperspectief een interessante techniek is om te gebruiken bij het opwekken van positieve emoties via het ophalen van positieve herinneringen.

Hoe beïnvloed positieve stemming visuospatiële aandachtsbreedte?

In onze studies rond visuospatiële aandachtsbreedte gebruikten we een taak om fluctuaties in visuospatiële aandachtsbreedte voor centraal gepresenteerde stimuli te meten (gebaseerd op Bosmans, Braet, Koster, & De Raedt, 2009). Deze taak laat het toe om de centrale stimuli te manipuleren. In de studie gepresenteerd in hoofdstuk 2, vonden we dat een verhoging in positieve stemming geassocieerd was met een verbreding van visuospatiële aandacht voor zelfgerelateerde informatie in contrast tot niet-zelfgerelateerde informatie (Grol, Koster, Bruyneel, & De Raedt, 2014). In hoofdstuk 3 onderzochten we het effect van positieve stemming op aandachtsbreedte voor emotionele stimuli (positief, neutraal, negatief) en of de aanwezigheid van depressieve symptomen, gemeten met de Beck Depression Inventory (BDI; Beck, Steer, & Brown, 1996; Van der Does, 2002) dit effect kwalificeerde. Bij lage waarden van de BDI (in de steekproef), welke minimale depressieve symptomen reflecteerden, was een grotere toename in positieve stemming gerelateerd aan meer aandachtsverbreding, maar enkel wanneer positieve informatie gepresenteerd werd. Bij gemiddelde waarden op de BDI (in de steekproef) werd geen significante relatie geobserveerd tussen positieve stemming en aandachtsbreedte, ongeacht de emotionele valentie van de gepresenteerde stimuli. Bij hoge waarden op de BDI (in de steekproef), welke milde depressieve symptomen reflecteerden, was een toename in positieve stemming

gerelateerd aan aandachtsvernauwing wanneer positieve informatie werd gepresenteerd (deze trend werd ook geobserveerd wanneer neutrale of negatieve informatie gepresenteerd werd). In hoofdstuk 4 onderzochten we of de gepresenteerde stimulus in de aandachtsfocus, aandachtsbreedte kan beïnvloeden afhankelijk van de (automatisch) waargenomen emotionele valentie. Daarnaast onderzochten we de invloed van trek weerbaarheid, gemeten met de Nederlandse versie van de Resilience Scale (Portzky, 2008), op deze relatie (Grol & De Raedt, 2014). We onderzochten aandachtsbreedte voor verraste gezichten aangezien deze ambigue zijn in valentie, dus individuen verschillen in het waarnemen van verraste gezichten als meer negatief of meer positief. Affectieve evaluatie van de stimuli werd gemeten via een affectieve priming taak, een impliciete taak. We vonden dat enkel bij hoge waarden van trek weerbaarheid, specifiek gevoelens van persoonlijke competentie, een meer positieve evaluatie van verraste gezichten gerelateerd was aan meer aandachtsverbreding als verraste gezichten gepresenteerd werden. Bij gemiddelde waarden van trek weerbaarheid werd geen significante relatie geobserveerd. Bij lage waarden van trek weerbaarheid werd een omgekeerde relatie geobserveerd; een meer positieve evaluatie van verraste gezichten was gerelateerd aan meer aandachtsvernauwing voor verraste gezichten.

Terwijl het ophalen van positieve emoties bij gezonde personen als adaptieve manier wordt gezien om met stress om te gaan (Joormann & Siemer, 2004; Joormann et al., 2007; Phillipe et al., 2009), wordt rumineren beschouwd als een maladaptieve reactie op stress en is gerelateerd aan depressie (Nolen-Hoeksema, 2000). In hoofdstuk 5 werd er in twee studies gefocust op de relatie tussen rumineren en aandachtsbreedte voor zelfgerelateerde informatie. Gebaseerd op het “attentional scope model” van rumineren (Whitmer & Gotlib, 2013), verwachtten we dat rumineren gerelateerd zou zijn aan een vernauwing van de visuospatiële aandacht voor zelfgerelateerde informatie. In de eerste studie vonden we dat enkel bij hoge waarden van trek ruminatie (in de steekproef), een ruminatie inductie gerelateerd was aan meer aandachtsvernauwing voor zelfgerelateerde informatie wanneer er gecontrasteerd werd met niet-zelfgerelateerde informatie. Bovendien kon dit effect niet verklaard worden door individuele verschillen in de verandering van depressieve stemming, veroorzaakt door de ruminatie inductie. In de tweede, cross-sectionele studie

observeerden we een directe relatie tussen hogere waarden van trek ruminatie, meer specifiek de brooding component, en meer aandachtsvernauwing voor zelfgerelateerde informatie wanneer gecontrasteerd met niet-zelfgerelateerde informatie.

Mediëren de effecten van positieve stemming op cognitie de relatie tussen positieve stemming en stress reactiviteit?

In de tweede onderzoekslijn onderzochten we de effecten van positieve stemmingsinductie, via het ophalen van positieve herinneringen op cognitie en hoe dit stress reactiviteit medieert. Stress werd geïnduceerd via een visuele *oddball* taak waarbij individuen gemanipuleerde negatieve feedback kregen op hun prestatie (Baeken et al., 2014; Rossi & Pourtois, 2013). We bekeken zowel de emotionele stress respons, als de fysiologische stress respons waargenomen via veranderingen in hartslag variabiliteit.

In hoofdstuk 6 voerden we een experiment uit in een ongeselecteerde steekproef van studenten, waarbij we de effecten van een positieve stemmingsinductie op affectieve flexibiliteit onderzochten en of dit een mediëerende factor was in de relatie tussen positieve stemming en stress reactiviteit. Affectieve flexibiliteit werd geoperationaliseerd als het wisselen van aandacht tussen niet-affectieve aspecten en affectieve aspecten van ofwel positieve ofwel negatieve informatie (Genet, Malooly, & Siemer, 2013; Malooly, Genet, & Siemer, 2013). De resultaten toonden een relatie tussen positieve stemmingsinductie en minder flexibiliteit bij het wisselen van aandacht van niet-affectieve aspecten naar affectieve aspecten van negatieve informatie, of vice versa. Verder was de positieve stemmingsinductie, in vergelijking met een neutrale inductie, direct gerelateerd aan een kleinere verhoging van opwinding en gespannenheid gedurende de stress inductie. Mediatie analyses toonden dat positieve stemmingsinductie, in vergelijking met neutrale inductie, gerelateerd was aan een kleinere verhoging in opwinding gedurende de stress inductie, via minder flexibiliteit bij het wisselen van aandacht naar de affectieve aspecten van negatieve informatie. Mediatie analyses toonden echter ook dat positieve stemmingsinductie gerelateerd was aan een grotere verhoging in droevigheid en een grotere daling in positieve stemming gedurende de stress inductie (i.e. een sterkere stress respons), via minder flexibiliteit bij het wisselen van aandacht naar de niet-affectieve aspecten van negatieve informatie.

In hoofdstuk 7 onderzochten we, in een steekproef van voorheen depressieve personen, de effecten van positieve stemming op de neiging om ambigue informatie als positief of negatief te interpreteren en of dit een mediërende factor was in de relatie tussen positieve stemming en stress reactiviteit. Daarnaast onderzochten we de invloed van de aanwezigheid van (rest) depressieve symptomen op de effecten van positieve stemming op het verwerken van ambigue informatie. De neiging om ambigue informatie te interpreteren als meer positief of negatief werd gemeten via de Scramble Sentence Task (SST; Van der Does, 2005; Wenzlaff, 1993), waarbij gevraagd wordt om vervormde zinnen om te zetten naar goedlopende zinnen. Dit kan altijd op twee mogelijke manieren, de oplossing impliceert ofwel een positieve ofwel een negatieve uitkomst. Een hogere positiviteitsindex op de SST reflecteert een grotere neiging om ambigue informatie op een positieve manier te verwerken. Enkel bij lage waarden van depressieve symptomen, was een grotere toename van positieve stemming gerelateerd aan een hogere SST positiviteitsindex (i.e. een meer positieve verwerkingsbias) na de stemmingsinductie. Een gemodereerd mediatie model liet zien dat enkel bij lage waarden van depressieve symptomen, een grotere stijging in positieve stemming gerelateerd was aan een grotere stijging van opwinding tijdens de stress inductie, via een meer positieve verwerkingsbias. Dit resultaat lijkt te duiden op een contrast effect waarbij een grotere stijging in positieve stemming via een meer positieve verwerkingsbias gerelateerd was aan een negatief effect op opwinding tijdens de stress inductie.

Gaan verschillende manieren van het verwerken van autobiografische herinneringen gepaard met activiteit in verschillende neurale regio's?

De derde onderzoekslijn richtte zich op de neurobiologische effecten van het ophalen van (positieve) autobiografische herinneringen. In hoofdstuk 8, beoogden we te onderzoeken hoe inname van verschillende perspectieven (veldperspectief en observatorperspectief) bij het inbeelden van herinneringen, gerelateerd zou zijn aan verschillen in hersenactiviteit. Allereerst lieten de gedragsmatige data van de studie zien dat het inbeelden van een positieve herinnering vanuit een veldperspectief, in vergelijking met het inbeelden vanuit een observatorperspectief, gepaard ging met een hogere positieve stemming. Als neutrale herinneringen werden ingebeeld waren er

geen verschillen in de gerapporteerde waarden van positieve stemming tussen de verbeeldingsperspectieven in de gerapporteerde waarden van positieve stemming.

Voor de fMRI data testten we eerst het contrast tussen de experimentele condities (positief-veld, neutraal-veld, positief-observator, neutraal-observator) en een controle taak (gebasseerd op Eich, Nelson, Leghari, & Handy, 2009), voor elke experimentele conditie apart. Deze contrasten toonden meer bilaterale activiteit (alhoewel meer uitgesproken in de linker hersenhelft) in dorsolaterale, dorsomediale, ventrolaterale, ventromediale, en orbitale gebieden van de prefrontale cortex. Daarnaast toonden deze contrasten meer bilaterale activiteit in de midden/superieure temporale gyrus wat zich uitstrekte tot de angulaire gyrus, bilaterale activiteit in de hippocampus (alhoewel voor neutrale observator herinneringen enkel in de rechter hippocampus) en de precuneus. Wanneer we direct een veldperspectief vergeleken met een observatorperspectief (veldperspectief > observatorperspectief) waren er geen gebieden die significant meer activiteit vertoonden tijdens het innemen van een veldperspectief in contrast met een observatorperspectief. Echter, wanneer we direct het contrast testten tussen een observatorperspectief en een veldperspectief (observatorperspectief > veldperspectief) was een observatorperspectief geassocieerd met meer activiteit in de rechter precuneus. Er waren geen gebieden die significante activiteit toonden voor de interactie tussen valentie van de herinnering (neutraal versus positief) en verbeeldingsperspectief (veld- versus observatorperspectief).

Implicaties Van De Onderzoeksbevindingen

Positieve emoties, cognitie en stress weerbaarheid

Onze bevindingen benadrukken de complexiteit van de relatie tussen positieve stemming en cognitie, welke beïnvloed wordt door zowel kenmerken van de gepresenteerde informatie in de aandachtsfocus, individuele kenmerken, als hun interactie. We hebben aangetoond dat de effecten van positieve stemming op aandachtsverbreding beïnvloed kunnen worden op een ‘trial-by-trial’ niveau, vanwege de aard van de informatie in de aandachtsfocus. De waargenomen emotionele valentie van informatie in de aandachtsfocus heeft ook op zichzelf een invloed op aandachtsbreedte. Daarnaast hebben individuele kenmerken, zoals de aanwezigheid van depressieve symptomen, een invloed op het effect van positieve stemming op

cognitie en kunnen zelfs de richting van het effect van positieve stemming op aandachtsbreedte bepalen. Bij het onderzoeken van de effecten van emotionele gemoedstoestand op het verwerken van emotionele of andere specifiek betekenisvolle informatie, zou dan ook rekening gehouden moeten worden met de relatie tussen emotionele gemoedstoestand en individuele kenmerken (zie ook, Rusting, 1998). Eerdere nulbevindingen (Bruyneel et al., 2012) en onze bevindingen over de invloed van stimulus- en individuele kenmerken op de relatie tussen positieve stemming en aandachtsbreedte, lijken aan te geven dat een verfijning van de broaden-and-build theorie (Fredrickson, 1998; 2001) nodig is, specifiek met betrekking tot de predictie over visuele aandachtsverbreding.

De studies gepresenteerd in hoofdstuk 6 en 7 zijn een van de eerste studies die laten zien dat de effecten van positieve stemming op cognitie een rol kunnen spelen in de relatie tussen positieve stemming en stress reactiviteit. Positieve stemming lijkt echter niet ondubbelzinnig gerelateerd te zijn aan een verhoogde stress weerbaarheid. Allereerst lijkt het erop dat een positieve stemming geassocieerd kan zijn met zowel een verhoogde, als een verlaagde stress weerbaarheid afhankelijk van hoe en welke specifieke cognitieve processen beïnvloed worden door positieve stemming. Ten tweede, de effecten van het ophalen van positieve herinneringen, ook op het niveau van cognitief functioneren, hebben bij confrontatie met stress mogelijk een verschillende invloed op personen die nog nooit depressief waren en (voorheen) depressieve personen.

De bevindingen lijken aan te geven dat bepaalde individuele kenmerken, zoals de aanwezigheid van milde depressieve symptomen, geassocieerd zijn met een verminderd vermogen om voordelen te halen uit positieve emoties op het niveau van cognitief functioneren. Daarnaast zouden de effecten van het ophalen van positieve herinneringen, ook op het niveau van cognitief functioneren, bij confrontatie met stress een verschillende invloed kunnen hebben in personen die nog nooit depressief waren en (voorheen) depressieve personen. Deze bevindingen zouden verschillen tussen personen kunnen verklaren in hun vermogen om weerbaar te worden. De meeste interventies die beogen de positieve affectiviteit te bevorderen in subklinische en (voorheen) depressieve personen zijn echter meer omvattend dan onze gebruikte procedure op basis van het inbeelden van één positieve herinnering. Onze resultaten

zouden echter nog steeds implicaties kunnen hebben voor de effectiviteit van zulke interventies. Zelfs als het mogelijk is om positieve affectiviteit te verhogen betekent dit namelijk niet automatisch dat de bijkomende voordelen op het niveau van cognitief functioneren volgen. Daarom zijn wij van mening dat interventies zich niet enkel moeten richten op het versterken van positieve affectiviteit, maar ook op meer directe wijze een bredere en meer flexibele cognitieve verwerkingstijl (of cognitieve controle) zouden moeten bevorderen. Door verder te onderzoeken wat de doel processen zouden moeten zijn van zulke interventies kunnen deze verder ontwikkeld en geoptimaliseerd worden. Dit betekent dat toekomstig onderzoek zich verder moet richten op het beter begrijpen van de mechanismen die ten grondslag liggen aan stress weerbaarheid.

Verschillende manieren van het verwerken van autobiografische herinneringen

Bij gezonde personen lijken tijdens het verbeelden van neutrale en positieve autobiografische herinneringen, ongeacht verbeeldingsperspectief, neurale netwerken actief te zijn welke ook betrokken zijn bij emotieregulatie. Dit versterkt het idee dat, bij gezonde personen, het ophalen van neutrale of positieve herinneringen als emotieregulatie strategie gebruikt zou kunnen worden. Op neurobiologisch niveau was het innemen van het observatorperspectief, ten opzichte van het veldperspectief, geassocieerd met meer activiteit in de rechter precuneus, een gebied dat eerder is gerelateerd aan zelfreferentieel denken en evaluatie processen (Legrand & Ruby, 2009; Northoff et al., 2006). Dit ondersteunt het idee dat een observatorperspectief geassocieerd is met het denken aan een gebeurtenis in termen van de bredere context of betekenis van deze gebeurtenis in het leven van de persoon. Hierbij wordt de betekenis van een dergelijke gebeurtenis met betrekking tot het zelfconcept meer benadrukt (Libby & Eibach, 2011). Het is ook consistent met ander onderzoek rond verbeeldingsperspectief bij depressie, wat suggereert dat het innemen van een observatorperspectief evaluatief denken over zichzelf bevordert (Kuyken & Howell, 2006; Kuyken & Moulds, 2009).

De resultaten zouden er op kunnen wijzen dat verbeeldingsperspectief geen directe invloed heeft op emotionaliteit. Het effect van verbeeldingsperspectief op de emotionele respons zou afhankelijk kunnen zijn van of het verwerken van een

gebeurtenis in relatie tot het zelfconcept (geassocieerd met het observatorperspectief) de emotionele impact verhoogt of verlaagt (Libby & Eibach, 2011). Dit impliceert echter ook dat verschillen in zelfbeeld kunnen leiden tot een verschillende betekenis van gebeurtenissen in relatie tot het zelfconcept, en daardoor ook het effect van verbeeldingsperspectief op de emotionele respons kunnen modereren (Libby & Eibach, 2011). Depressie is gerelateerd aan een meer negatief zelfbeeld of een negatief zelfschema (Clark, Beck, & Alford, 1999). Hierdoor is het mogelijk dat bij (voorheen) depressieve personen het inbeelden van een positieve herinnering vanuit het observatorperspectief kan resulteren in een verminderde positieve emotionele respons als deze positieve gebeurtenis (die in het verleden heeft plaatsgevonden) vanuit een negatief zelfbeeld verwerkt wordt. Onze bevindingen op neurobiologisch niveau en eerder gedragsmatig onderzoek lijken te suggereren dat verschillende manieren van het inbeelden van (emotionele) informatie, mogelijks in interactie met individuele kenmerken, kunnen leiden tot verschillende resultaten (e.g. de affectieve ervaring). Het vergroten van ons begrip over hoe verschillende verbeeldingsperspectieven tot verschillende uitkomsten kunnen leiden, is een eerste stap in het verder optimaliseren van interventies die gericht zijn op het bevorderen van positieve affectieve ervaringen (e.g. denken over positieve levensgebeurtenissen).

Algemene Conclusie

De studies in dit proefschrift dragen bij aan een groeiend onderzoeksveld dat zich richt op de mechanismen onderliggend aan het adaptief reageren op stress en de bijdrage van positieve emoties aan stress weerbaarheid. De bevindingen bieden een aantal nieuwe inzichten in de onderliggende mechanismen in de relatie tussen positieve emoties en stress weerbaarheid, maar benadrukken ook de complexiteit van deze relatie met mogelijke modererende factoren. Tegelijkertijd biedt dit verschillende uitdagingen voor toekomstig onderzoek naar (cognitieve en neurobiologische) mechanismen van stress weerbaarheid. Enkel door het verbeteren van onze kennis over factoren die ten grondslag liggen aan zowel kwetsbaarheid voor depressie als weerbaarheid, kunnen we uiteindelijk ons begrip vergroten van terugkerende depressiviteit en de preventie ervan.

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