I can't let go: Personality, Behavioral, and Neural Correlates of Persistent, Intrusive Thought in Depression

by

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Abstract

Though a major illness in modern society, depression is still not completely understood. A number of empirical observations point to the importance of basic cognitive processes as well as personality variables as antecedents of a depressive disorder. In this work it is argued that "state orientation", a personality style characterized by the inability to actively influence one's focus of thought, plays an important role in the development of at least some forms of major depressive disorder. In the present work, it is suggested that (1) state-oriented cognitions are equivalent to sustained information processing, that (2) depressed individuals are characterized in particular by state-oriented cognitions related to prior failure experiences, that (3) sustained processing of affective information will interfere with normal executive cognitive functioning in depressed individuals resulting in impairments of normal behavior, and that (4) both sustained information processing and "affective interference" will be associated with specific dysfunctional patterns of brain activity in depressed individuals. In the first chapter of this thesis, theorizing pertaining to "action control" and the relationship between action control and state orientation are reviewed. After having established the potential functional significance of state-oriented cognitions, their possible link to depression is developed by introducing the "degenerated-intention hypothesis". Afterwards, the role of state orientation in the advent of the depressive state is discussed against the background of the "functional helplessness" model of depression. Next, recent empirical findings related to executive dysfunction associated with state-oriented cognitions in major depressive disorder and related dysfunctional patterns of brain activity are reviewed. By considering evidence from studies on executive functioning, brain imaging, and neurophysiological studies, support is found for a possible frontocingulate dysfunction associated with a state-oriented cognitive style underlying a major depressive disorder. Consistent with the proposed link between depression and state orientation, in the second chapter of the thesis, Studies 1a – 1c demonstrate that subclinically and clinically depressed individuals are specifically characterized by failure-related state orientation. Moreover, the results of Study 2, described in Chapter 3, reveal that sustained processing of affectively valenced information may indeed interfere with subsequent executive cognitive functioning, especially in individuals demonstrating relatively high levels of depression. Finally, in line with the idea that sustained information processing and affective interference will be related to an individual's level of state orientation and will be reflected in specific patterns of neural activity, Study 3, presented in Chapter 4, provides considerable evidence for disturbed brain function in clinically depressed individuals during processing of affective information as well as subsequent executive cognitive functioning and its relation to state-oriented thought. The

current research supports the idea that state orientation, in particular its failure-focused form, is a crucial process involved in the development and maintenance of a depressive disorder. Specifically, the present findings suggest that certain forms of major depressive disorder are associated with sustained processing of affective information and with the resulting affective interference with executive cognitive functioning. Findings further suggest that sustained information processing is experienced by affected individuals as ruminative, state-oriented thought on past aversive experiences, and that both sustained information processing and affective interference are associated with distinct patterns of brain activity, which are related to early stimulus evaluation, conflict monitoring, and conflict resolution. The processes possibly underlying some forms of depression, as proposed in this thesis, comprise what may be called “the spinning mind”, whose important functional significance is to hinder an individual from adaptive behavior by impairing the ability to direct thought. Although state orientation may therefore appear to be maladaptive per se, it may be argued instead that this mode of action control is also an adaptive process as long as critical limits of certain parameters are met and the spinning mind is prevented. These and similar considerations are addressed in the concluding discussion in Chapter 5.

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Die ZEIT: Bastian Schweinsteiger hat gesagt, dass er immer noch an freien Tagen ins Grübeln kommt, wenn das Stichwort Championsleague fällt. Sie auch?

Philipp Lahm: Seitdem wir hier sind, geht mein Blick nach vorn. Ich habe neue Ziele, es geht weiter. Die Niederlage war bitter, aber ich bin zuversichtlich, dass wir in den nächsten Jahren noch mal die Chance bekommen werden, die Championsleague zu gewinnen.

Die ZEIT: Sind Sie da anders gestrickt als Bastian Schweinsteiger?

Philipp Lahm: Schwer zu sagen. Ich bin eben so, ich kann schnell nach vorn schauen, einen neuen Anlauf nehmen.

Die ZEIT: Sie wirken, als hätten Sie keinerlei Hang zum Zweifeln.

Philipp Lahm: Wieso auch? Ich spiele in zwei tollen Mannschaften mit sensationellen Kadern. Da muss ich weder Zweifel noch Angst um die nächsten Jahre haben.

Interview in: Die ZEIT, Nr. 27, 28.06.2012, p. 21

Ich bin eine grosse Zweiflerin. Deshalb schreibe ich auch so schnell. Ich muss schneller sein als die Zweifel, die wie Hunde hinter mir her sind.

Felicitas Hoppe

Chapter 1: Introduction

Major depressive disorder (MDD) is clinically defined as a multidimensional syndrome, involving disruption of mood, cognition, sensorimotor functions, and homeostatic or drive functions, respectively. Though a major illness of modern society, MDD is still not completely understood. MDD is a widespread affective disorder and has a large influence on willful action in those affected. A number of empirical and theoretical observations point to the importance of basic executive processes, as well as personality styles as antecedents of a depressive disorder. The study of the determinants of MDD still constitutes one of the most vigorous research areas of psychiatry and clinical psychology (Cabello et al., 2011; Heim & Binder, 2012; Maletic & Raison, 2009; Riso et al., 2002). Cognitive, behavioral, personality, neurophysiological, and genetic studies in clinical and non-clinical populations have all examined a wide range of possible risk factors of MDD. Topics include genetic risk, familial transmission, alterations in brain structures, neurochemical processes, sleep dysregulation, cognitive schemas, attention and memory, optimism and pessimism, negative cognitive style, ruminative response style, social problem solving, early attachment experiences, and life events and stress. Recently, scientists have increasingly focused on brain imaging and genetic investigations of MDD (e.g., Cohen-Woods et al., 2012; Rigucci et al., 2010) and the study of psychological factors and their impact on the development of the disorder has been pushed to marginal role. Although the study of the psychological factors associated with the illness are as relevant as ever (Bulmash et al., 2009; Marshall et al., 2008; Ryder et al., 2010), experimental studies on, and theorizing about, the relation between psychological processes and depressive symptoms have been relatively rare in the last decade.

Cognitive impairments can have a severe impact on depressed individuals' ability to cope with the demands of daily living. Indeed, cognitive impairments, particularly when they interfere with work performance or family life, may be a major cause for seeking treatment for major depressive disorder. One aspect of cognition relevant to one's capacity to negotiate daily life is "executive cognitive functioning", which can be defined as that aspect of cognition affording the ability to deviate from a "default mode" of automatic, stereotyped behavior associated with environmental stimuli. Some of the most troubling aspects of depression related to executive control involve prolonged involuntary information processing, particularly of emotionally valenced information, in the form of elaboration

(MacLeod & Matthews, 1991) or rumination (Nolen-Hoeksema, 1998) on negative topics. Such sustained involuntary information processing has been related in particular to inhibitory deficits with regards to negative information (Joormann, 2004) and to other processing biases commonly observed in depression such as: memory biases operating at the retrieval stage that facilitate the recall of mood-congruent emotionally negative information (MacLeod et al., 1986), preferential attention to negative information (Williams & Oaksford, 1992), and preferential processing of negative over positive stimuli (Joormann, 2006).

Some studies in the field of personality psychology have demonstrated that features of "state orientation" are closely linked to features of the depressive state. State orientation is a cognitive style, which is defined by the inability to actively influence one's focus of thought (Kuhl, 1994a). State-oriented cognition is in particular characterized by repetitively focusing on internal negative emotional states without actively making plans or taking steps to relieve distress. Findings obtained from studies investigating the cognitive processes underlying state orientation have led to the idea of "degenerated intentions". A degenerated intention is defined as the exaggerated maintenance of an unrealistic intention, which is supposed to lead to uncontrollable, state-oriented thought. It has been suggested that degenerated intentions may play a crucial part in a developing depressive disorder and that MDD can be productively re-conceptualized in light of this idea (Kuhl & Helle, 1986).

State orientation, regarded as a style of thought rather than just the process of focusing on negative content, is characterized by individuals getting mentally stuck in a mind set and thus being unable to adapt to changes in the environment. Thus, a state-oriented cognitive style might be related to deficits in the inhibition of irrelevant material, in particular of material of negative valence. Furthermore, since individuals differ in their tendency to show a state-oriented cognitive style in response to negative life events and negative mood states irrespective of depressive symptomatology (Joormann, 2006), it could be argued that state orientation is not merely a symptom of depression; a state-oriented cognitive style can be considered a stable personality marker that increases an individual's vulnerability to depression.

The neural basis of executive control appears to be the prefrontal cortex. Studies aimed at addressing issues of executive or prefrontal function have typically taken one of three approaches. The majority have either employed tests of executive functioning sensitive to prefrontal function, or employed brain imaging methods such as positron emission tomography, or functional magnetic resonance imaging (fMRI). The first approach allows evaluation of executive function, but affords only indirect inferences of underlying brain dysfunction. The second approach allows more direct placement of functional or anatomical brain abnormality, but the relationship between these and executive control is obscured. An increasing number of studies have combined these two methods within a single-experimental setting in the third approach, so that the respective strengths of each method compensate for the weakness of the other. Brain imaging and electroencephalographic studies of cognitive processing in depression can be used to investigate the biological mechanisms underlying executive dysfunction in terms of neural information processing. Such data can provide information about the association between the clinical picture of depression with specific patterns of brain function and executive dysfunction. Ultimately, these methods can also provide data that can be investigated in terms of cognitive styles which moderate dysfunctional patterns of brain activation in MDD. The recording of potential changes related to events (ERPs; cf. electroencephalogram (EEG)) and the measure of blood oxygenation level dependent signals (cf. fMRI) allow, to a certain degree, a characterization of the functional state of the brain as it is related to cognitive processing. The psychological relevance of brain imaging and electroencephalographic correlates of state orientation in depression comes from the the possibility to answer a key research question: Are differences in executive control between depressed individuals and healthy controls associated with specific patterns of brain function and are these associations related to individual differences in cognitive style? Noteworthy is the fact that data on brain function may help differentiate between different states of mind and different cognitive styles in depression. Furthermore, the meaning of stable differences in brain function between depressed and nondepressed individuals might be determined by associated psychological correlates, and an attempt can be made to further clarify the meaning of brain imaging data. In short, concurrently assessing brain function, measures for executive functioning, and measures of state orientation in depression provides the means to check which brain functions are actually involved in the task under study and how differences in brain function between depressed and nondepressed individuals relate to individual differences in cognitive style, whether performance differences are observed or not.

The present research was designed to examine the the link between four domains: (i) brain function, (ii) executive dysfunction, (iii) state orientation, and (iv) depression. In the following paragraphs, the theoretical foundations of state orientation are outlined. More specifically, the assumed role of state orientation in the genesis of a depressive illness is explained by providing a summary of the “degenerated-intention hypothesis” and the “functional helplessness” model of depression. In the subsequent paragraphs existing literature on the associations between the four domains mentioned above is reviewed. Next, the work of selected researchers is presented, each of which attempted to integrate findings on the four different domains in comprehensive models of depression. After this, in Chapters 2 – 4, five empirical studies are presented which tested hypotheses and used methodologies derived from the preceding theoretical analysis. In these five studies, the relevance of a state-oriented cognitive style in MDD is investigated using correlational as well as experimental designs. The five studies investigate single aspects of the link between depression, executive dysfunction, brain function, and state orientation, as well as multiple variables in one setting.

Intention-Behavior Inconsistency: A Theory of Action Control

Consider a scenario in which you are preparing to complete your tax declarations. You would like to spend some leisure time with your family during the weekend, thus at the beginning of the week, you set yourself a Friday deadline to finish the taxes. You try to work on your tax declaration form nearly every evening of the week, but somehow each time something distracts you. In some instances, you cannot motivate yourself to sit down and work on the declaration. You imagine how lovely your weekend off will be, which only sometimes helps you. You consider postponing the whole thing until the following week but you remember that, after doing the same thing last year, you received a dunning letter from the tax office. In the end, you sit down with your partner who tells you not to worry too much and not to be too demanding on yourself. Together you manage to finish the tax declaration on Friday evening. The following year, you remember your partner's support and subsequent success. This leads you not to worry too much, but rather to focus on the work step by step.

This fictional scenario illustrates what can be called an intention-behavior inconsistency: an individual is well prepared and motivated, that is, has a firm intention to act, but in some way or other he or she fails to enact the intention. Though the nature of this "explanatory gap" predestinates cognitive psychologists to investigate the phenomenon, personality researchers, neuroscientists, and even philosophers are similarly concerned with a solution to this problem. In 1972, Julius Kuhl put forward a theory of "action control" to explain intention-behavior inconsistencies such as the one described above (Kuhl, 1994b). Kuhl wanted to provide an explanation to close the gap between action-related cognitions and their enactment, between motivation and performance, between choice and action. In his theory, Kuhl was concerned with volitional mediators of intention-behavior inconsistencies. Beswick & Mann (1994) summarized Kuhl's idea as follows:

> When a person intends to perform an action he or she is often subject to various external and/or internal forces which arouse alternative or competing action tendencies. The current intention has to be protected and strengthened against competing action tendencies, until it is performed. (p. 391)

Action Versus State Orientation

To account for these protective and strengthening functions, Kuhl postulated a process of action control that was assumed to be composed of mechanisms that mediate the initiation and enactment of intended actions. Kuhl argued that whether or not a current intention is enacted depends on (i) the obstacles that are opposed to this current intention and (ii) the efficiency of volitional processes needed for action control. He described obstacles as “difficulty of enactment”, or put simply: effort. Effort was proposed to be a function of (a) the amount of external pressure against the enactment of the current intention and (b) the number and strength of competing action tendencies. Kuhl hypothesized that the ratio of enacted compared to intended actions is also a function of the efficiency of volitional processes underlying action control. He postulated that an efficient mode of action control should be characterized by selective attention, encoding control, emotion control, motivation control, environmental control, and parsimony of information-processing (Kuhl, 1985). Impairment of those volitional processes were assumed to be the second reason for the failure to enact intended actions. *Active attentional selectivity* is assumed to facilitate the process of information meant to support the current intention, while inhibiting the processing of information of competing tendencies; thus the individual can focus on the information relevant to optimal execution. *Encoding control* presumably facilitates the protective function of volition by selectively encoding those features of a stimulus that are related to the current intention. *Emotion control* ensures the inhibition of emotional states that might undermine the enactment of the current intention. *Motivation control* aims to strengthen the motivational basis of the current intention and therefore assures a change in the hierarchy of intentions when needed. *Environmental control* may be used to influence emotional and motivational states. Finally, *parsimony of information-processing* optimizes the length of the decision-making process by providing “stop-rules” for the search for information; processing of information not necessary for arriving at a decision is avoided. In sum, Kuhl’s theory of action control is based on the idea that the enactment of intentions is critically mediated by volitional processes that enable an individual to (1) selectively attend to information supporting his or her current intention, (2) selectively encode goal-related features of incoming information, (3) activate positive emotions and enhance the motivational basis for his or her current intention by manipulating his or her (4) internal or (5) external incentive structure, and (6) by avoiding lengthy decision making (Kuhl, 1985).

Kuhl adapted the idea of action control to specific mechanisms involved in personality functioning and wanted to explain why different people react differently to the same situation; why some individuals fail to enact intended actions and others do not, suggesting individual differences in action control. Thus, e.g. worries can, but do not necessarily, lead to intention-behavior inconsistencies. Crucially, on this basis, Kuhl further theorized that what modulates the difficulty of enactment, are factors that support a "change-preventing", versus factors that support a "change-promoting", mode of action control. Or in other words: efficiency of action control will also be determined by the state an individual is currently in (Kuhl, 1985). Thus, Kuhl wanted to give an explanation for the functional significance of different mental states of an individual for volitional control of behavior. In this respect, Kuhl assumed that one category of cognitive processes would render enactment of an intention especially difficult, namely cognitive processes that center around past, present, or future states of an individual rather than around actions that would transform a present state into a desired future one. Such "state-oriented cognitions" result in a change-preventing rather than a change-inducing mode of control (Kuhl, 1985). Based on this reasoning, Kuhl introduced the personality variable "action versus state orientation" that was supposed to be associated with either a state-oriented or an action-oriented mode of action control. Hence, these orientations described two modes of action control which mediate the protection and implementation of intended actions. Action orientation was postulated to enhance an effective operation of volitional processes, whereas state orientation was assumed to hinder them. Action orientation was therefore regarded as a necessary condition for the development of a change-promoting mode of action control.

An early description of action versus state orientation gave the following definition: "An organism is said to be action-oriented if attention is focused on a fully developed action structure. If attention is focused on some internal or external state, the organism is said to be state-oriented." (Kuhl, 1985, p. 108). Thus, whereas Kuhl thought of action orientation as cognitive activities focusing on action alternatives and plans that serve to overcome a discrepancy between a present state and an intended future one, he thought of state orientation as being characterized by persevering cognitions related to some present, past, or future state of an individual, not attending to any action plan (Kuhl, 1981). Because state-oriented individuals are assumed to be unable to disregard thoughts centering around previous failures, state orientation denotes a "catastatic", in other words, change-preventing mode of action control (cf. Beswick & Mann, 1994). Kuhl assumed that both situational and personality variables determine whether an individual is state-oriented or action-oriented in a particular situation, or in other words, "the actual degree of action versus state orientation is a function of situational and dispositional factors" (Hautzinger, 1994, p. 209). Thus, each of us moves back and forth between action and state orientation, and dispositional differences influence the relative balance of both pols (cf. also Rholes et al., 1989).

Kuhl considered perceived incongruence between two pieces of information to be an antecedent of state orientation. State orientation, he assumed, would occur, if perceived incongruence exceeded a critical level. In this case, attention would focus on the incongruence-producing information and the cognitive-emotional state accompanying it. Additionally, Kuhl assumed that the extent to which an individual had developed "degenerated intentions" would also be an antecedent of state orientation (Kuhl, 1985). Put simply, degenerated intentions are cognitive representations in which one or more elements of an intention are ill-defined, weakly activated, or not specified at all (cf. below). Crucially, Kuhl distinguished three kinds of state orientation, each of which make it unlikely for an individual to fulfill his or her intention, despite motivation and ability being present: (1) *Failure-related* state orientation (SOF; Disengagement versus Preoccupation) is characterized by ruminating about past failures; (2) *Decision-related* state orientation (SOD; Enactment versus Passivity) is defined as the difficulty to initiate the enactment of intentions an individual is capable and willing to perform; (3) *Performance-related* state-orientation (SOP; Persistence versus Volatility) is related to the inability to concentrate on an ongoing task and the premature initiation of alternative activities.

In his the theory of action control, Kuhl postulates rumination (cf. preoccupation), procrastination (cf. passivity), and alienation (cf. volatility) as behavioral consequences of state orientation. Thus the most typical indicators of state orientation are its phenomenal consequences: "[the most] immediate and consciously accessible consequences of state orientation are perseverating ruminations about aversive experiences (especially failures), indecisiveness before and procrastination after forming an intention" (Kuhl & Kazen, 1994, p. 25). Thus, the crucial difference between state- versus action-oriented individuals is the ability of action-oriented individuals to exert control over the content of their thought processes, such that they are able to disengage from loss or failure experiences (Rholes et al., 1989). As state-oriented individuals are not able to control, and in particular to terminate, ruminations on positive and especially on negative states, and because these ruminations are generally assumed to be in incompatible with the current intention (cf. Beswick & Mann, 1994), state-oriented individuals will experience inhibitory effects on behavior, that is, they will suffer from inefficient action control. In short, dispositional state orientation makes it difficult for an individual to deal with new challenges or to follow through a newly formed intention to its realization (Hautzinger, 1994). As a result, state-oriented individuals may develop a tendency to perform routinized, well-learned and externally controlled, or socially expected behaviors to avoid heavy demands on their relatively low self-regulatory capacities (Kuhl, 1985). In contrast, action-related mental structures such as intentions, motives, or attitudes, are more likely to be behaviorally expressed when an individual is action-oriented rather than state-oriented.

Theorizing on Ruminative Thought in Differential Psychology

Since the introduction of Kuhl's theory of action control, the idea of state-oriented cognitions and their effects on behavior has been taken up, adopted, or refined in several other approaches related to personality functioning. One of these more recent approaches is the concept of *dysphoric rumination*, which was defined as behaviors and thoughts that focus one's attention on one's depressive symptoms and on the implications of these symptoms (Nolen-Hoeksema, 1991). In dysphoric rumination, individuals constantly go over past events exercising an analytical focus on a key theme of loss that is perceived as certain and uncontrollable (Nolen-Hoeksema et al., 2008). Dysphoric rumination is associated with cognitive inflexibility, difficulty in switching attention from negative stimuli, performance deficits, difficulties in concentration and attention, poor problem solving, and impaired solution implementation (Nolen-Hoeksema, 1991). Another concept, *self-reflection*, or introspection, was introduced to describe cognitive processes of two kinds: (a) analyzing reasons for one's feelings, or (b) focusing on one's attitudes (Wilson & Dunn, 1986). It was shown that self-reflection – depending on its specific character – fosters self-insight, improves intention-behavior consistency, and may be predictive of psychological well-being (Harrington & Loffredo, 2011; Hixon & Swann, 1993; Wilson & Dunn, 1986). *Brooding* was meant to describe a passive comparison of one's current situation with some unachieved standard, while focusing on abstract issues and obstacles (Gonzalez et al., 2003). Brooding predicts the development of depressive symptoms over time and is related to maladaptive coping strategies. Closely related to the idea of brooding, *pondering* was defined as a purposeful turning inward to engage in cognitive problem solving in order to alleviate one's depressive symptoms (Gonzalez et al., 2003). Pondering is supposed to be a problem-solving oriented, self-reflective tendency that is related to adaptive primary and secondary coping strategies (Armey et al., 2009). *Worry* was defined as distinctively involving a predominance of negatively valenced verbal thoughts whose function appears to be the cognitive avoidance of threat (Borkovec et al., 1998). When worry becomes uncontrollable and chronic, it may result in a generalized anxiety disorder. Research suggests that worry is very similar to rumination as the two phenomena seem to involve similar processes and appraisals. However, both concepts may differ in their content, presumably as a result of different goal orientation (Watkins et al., 2005). Empirical studies found that worry is uniquely associated with anxious and depressive symptoms whereas rumination is uniquely related to depression only (Hong, 2007). However, although there is evidence for the idea that worry and rumination are distinguishable constructs, it can still be considered that rumination and worry are part of the same theoretical construct of repetitive thought (D'Hudson & Saling, 2010). Cognitive theories of *anxiety* posit that self-concern, as an attentionally demanding activity, distracts individuals from goal-directed problem solving and impairs solution-oriented information processing capacities (Brunstein, 1994). Thus, what may distinguish best anxiety from rumination is anxiety's focus on future-oriented, uncertain, potentially controllable events. *Procrastination* was established to characterize situations in which individuals who have the will, the means, and the opportunity to complete their intentions still fail to enact their intentions. Procrastination includes failing to perform an activity within the desired time frame or postponing actions one ultimately intends to complete until the last minute (Wolters, 2003). This behavior can be regarded as a self-regulatory failure. Procrastination is strongly related to task aversiveness, task delay, self-efficacy, impulsiveness, and achievement motivation (Steel, 2007). State orientation (cf. passivity) and (decisional) procrastination are assumed to bee closely related but not identical (Beswick & Mann, 1994). *Mourning* has recently been conceptualized as a process that affects both the images of the self and of the object in the mourner's inner world. It involves the transformation of an attachment into a sustaining internal presence, "which operates as an ongoing component in the individual's internal world" (Baker, 2001, p. 55). The chronic stage of mourning is characterized by the individual's attempt to integrate an experience of loss with reality so that he or she can continue with his or her life (Thomas & Siller, 1999).

In sum, the idea of a personality construct "state orientation", as originally proposed by Kuhl (Kuhl, 1985), has been taken up by, or is related to, several other research approaches of differential psychology. As can be seen from this short review, state orientation and its related concepts may be brought together under a common heading, which could be termed the "spinning mind", indicating that the common feature of all concepts mentioned above is the tendency for uncontrollable, change-preventing cognitions going around in circles. It is quite obvious that the spinning mind may be a crucial psychological determinant of major depressive disorder.

State Orientation and Depression: A Psychological Model of MDD

Depression is one of the most frequent mental disorders with a strong impact on people's daily lives. Besides a persistent negative, sad mood, depressed individuals often experience a loss of interest, a loss of the ability to enjoy things, and a loss of the ability to experience pleasure in achievement. Kuhl (1994b) proposed that intrusive and persevering thoughts focusing on a state previously experienced inhibit volitional control of action and pointed to the possible significance of state-oriented cognitions to explain psychological manifestations of depression. He suggested that chronic and global forms of state orientation may be a cause and/or result of major depressive disorder, and therefore state orientation could be a key psychological process underlying the development and maintenance of this illness (Kuhl, 1994b).

The Degenerated-Intention Hypothesis

To explain individual differences in the reaction to distal determinants of depression, such as loss of important objects, separation, psychodynamic conflict, loss of reinforcement, or loss of control, Kuhl wanted to find a psychological process that could particularly explain the chronicity of depressive affect. Kuhl believed that there is a "final common pathway", a psychological process that might be common to various forms of major depressive disorder and that may even be linked to a common neurophysiological determinant (Kuhl & Helle, 1986). In his view, only the maintenance of intentional states could explain the chronicity of the depressive state. Additionally, Kuhl assumed that the overmaintenance of intentional states is a function of (i) situational factors causing the "degeneration" of uncompleted intentions and (ii) state orientation (Kuhl & Helle, 1986). The basic idea of degenerated intentions as mediating depressive states is that the exaggerated maintenance of unrealistic intentions leads to *uncontrollable ruminative thought*. Kuhl suggested that depression can be productively re- conceptualized in light of this idea. According to his model, "the (over)maintenance of unrealistic intentions 'freezes' depressive emotional states" (Kuhl & Helle, 1986, p. 287). Thus, against this background, depression may be regarded as an extreme case of the frequent occupation of cognitive resources by degenerated intentions (Kuhl, 1985). Kuhl & Helle (1986) summarized their idea as follows:

> Our central hypothesis, then, is that the psychological mechanism common to all types of severe depression involves one or several persevering motivational states, especially intentional states which are the most self-committing and persistent motivational states.

> According to our view, a distal antecedent of depression such as separation, object loss, loss of control, etc., does not result in a depressive disorder unless it leads to a persevering intentional state (...). (p. 285)

Put differently, distal determinants of depression have the potential to cause a depressive episode if they create a chronic and degenerated intentional state that aims at regaining access to the lost object or to meet introjected standards (Kuhl & Helle, 1986). One factor among others that may lead to degenerated intentions is persisting conflict such as single traumatic experiences (Kuhl & Helle, 1986). Persisting conflicts may be caused by incomplete self-integration of experiences. Incomplete self-integration, in turn, may result from a tendency towards “false internalization”, or from impaired self-discrimination (Kuhl & Kazen, 1994). Likewise, dispositional state orientation is considered to be a factor producing degenerated intentions because – as argued above – state orientation is associated with sticking to intentions even if these may be unattainable or unrealistic. Hautzinger (1994) explained the appeal of the degenerated-intention hypothesis as follows:

> [T]his hypothesis of degenerated intentions strikes me as a plausible psychological ‘final common pathway’ to depression for the very reason that state orientation can be viewed as the common final path or the common denominator of personality traits typically associated with depression, such as neuroticism, dependency, insecurity, shyness, low self-esteem, over-correctedness, rigidity, and the need for control. These are all aspects which, on the level of information processing, predestinate an individual to engage in a comprehensive information search, to repeat information processing, to procrastinate intentions, to let motivational and emotional processes interfere with overt action, in sum, to evince degenerated action control. (p. 210)

Functional Helplessness

“Learned helplessness” is a well-known psychological model of depression Miller & Seligman (1975). This model is based on findings of failure-induced performance effects. More specifically, the concept is based on the finding that individuals display performance deficits on a test task following exposure to uncontrollable aversive stimulation on a training task. Learned helplessness theory holds that perceived uncontrollability of performance in the training task will decrease the perceived probability of success in subsequent tasks. The reduced individual’s expectation of success will decrease the individual’s motivation to engage in a new task. This way, learned helpless theory postulates a transfer of the belief of uncontrollability from training to the test task. Thus, individuals who are exposed to uncontrollable failure are assumed to develop the expectation that none of their activities will produce success in the future. This expectation undermines their motivation to make any effort to solve a new tasks. This expectancy-mediated motivational deficit is proposed to explain generalized performance-deficits following a failure pretreatment. In other words, learned helplessness theory tries to explain why performance deficits will occur in a broad range of tasks and will occur over an expanded time period. Miller & Seligman (1975) proposed learned helplessness to be a crucial psychological process underlying depression. In their model of depression, an individual's expectancy that events are uncontrollable based on his or her experience with prior uncontrollable events may result in the clinical picture of MDD (cf. Kammer, 1994). The learned helplessness model of depression was refined to also include a variety of cognitive parameters, in particular a depressive attributional style (Abramson et al., 1978). The refined model fits with the "vulnerability-stress model" of depression that postulates an acquired depressogenic cognitive construct, which is latent in the individual for most of the time and actualized by certain experiences of loss. Importantly, however, whereas some motivational deficits seen in depressed people seem to be due to learned, or motivational helplessness, other symptoms are more likely to be a result of excessive state-oriented cognitions, that is, the result of "functional helplessness" (Kuhl, 1981).

Kuhl (1981) argued that the theory of learned helplessness places too much emphasis "on reduced expectation of control as the assumed mediator of performance deficits following exposure to an uncontrollable task" (p. 155). In particular, he argued that individuals may not generalize experiences of uncontrollability extensively. In contrast, individuals may be perfectly confident and fully motivated to perform well on the test task, but the facilitating effect of this extra amount of motivational energy comes to nothing because they may be suffering from an additional *functional* deficit. Empirical results were in favor of this argument, as performance effects could be demonstrated without any evidence of generalization of the belief of uncontrollability (Kuhl, 1981). The alternative, or additional explanation, given by Kuhl (1981), explored the functional significance of state-oriented cognitions and postulated a mediating role of capacity-reducing effects of uncontrollable, task-irrelevant thoughts. Kuhl proposed that, since state orientation is characterized by cognitive activities that are preoccupied with a particular failure, its causes, its consequences, as well as with the emotional state created by the failure, state-oriented cognitions represent task- and solution-irrelevant cognitive activities which interfere with task-oriented attention and information processing and will therefore hinder effective problem-solving (cf. Stiensmeier-Pelster & Schürmann, 1990). Thus action versus state orientation could serve as an additional determinant of performance because it could explain why participants, even if they had not transferred a feeling of helplessness to, and were sufficiently motivated for, the test task, still demonstrated performance deficits (Kuhl, 1981).

Whereas effects of *motivational helplessness* that are mediated by a belief in uncontrollability should be limited to situations in which training and test task are similar, *functional helplessness* could explain a more generalized cognitive effects. In the functional helplessness model of depression, increasing exposure to uncontrollability beyond a critical amount should increase the tendency to engage in state-oriented cognitions, which will – when excessive – interfere with optimal performance. Kuhl assumed, however, that for state-oriented cognitions to interfere with proper cognitive functioning, the test task must reach a high level of difficulty (Kuhl, 1981). In each event, in light of the functional helplessness model of depression, a key to cognitive impairments may be task-irrelevant, self-related cognitions: an individual is preoccupied with the state created by a previous aversive experience and cognitions emerging from this experience impact ongoing executive cognitive functioning (Kuhl, 1981). In short: "Impaired performance attributable to cognitive interference caused by state cognitions may be described as functional helplessness, as opposed to motivational helplessness, which is mediated by a belief in uncontrollability" (Kuhl, 1981, p.160).

Experimental support exists for the functional helplessness hypothesis. Brunstein (1994) demonstrated that state orientation is a factor that increases an individuals' vulnerability to develop and generalize symptoms of helplessness, especially cognitions about the loss of the sense of control over outcomes. Findings further demonstrated that, if state-oriented cognitions are induced experimentally (e.g. by instructing individuals to make attributions or to describe their emotional state) after individuals have been exposed to uncontrollable failure, measures of resistance against interference are decreased, irrespective of the generalization of uncontrollability from training to the test task or motivation and effort in the test task (Kuhl, 1981). Likewise, it could be shown that preventing state-oriented individuals from engaging in state-oriented cognitions apparently minimized the interfering effects of excessive state orientation and produced facilitated performance (Kuhl, 1981).

Refining Kuhl's idea of functional helplessness, Stiensmeier-Pelster & Schürmann (1990) argued that not only the overall frequency of state-oriented cognitions matters, but also the kind of attribution made by an individual confronted with failure. The underlying hypothesis was that failure causes an increasing level of state orientation as a function of the importance individuals attach to the failure and the level to which they believe the failure had been uncontrollable and unavoidable (Stiensmeier-Pelster & Schürmann, 1990). Performance deficits in a subsequent task would then depend on the amount of state orientation and the amount of effort expended.

Stiensmeier-Pelster & Schürmann (1990) also provided empirical evidence for their claims. They demonstrated that failure increased state-oriented thoughts only when it was attributed to internal, stable, and global causes. At the same time, failure increased state-oriented thoughts the more the failure was perceived to be personally important. Results also indicated that individuals increased their effort in the test task after failure in the training task. This effect was smaller, if the failure was attributed to stable and global causes. Most importantly, Stiensmeier-Pelster & Schürmann (1990) found that subjects showed the best performance when they failed on the training task and attributed their failure to external, unstable and specific causes. Together with additional experimental data, the authors postulated a link from the experience of failure, via internal, stable, and global attributions, to greater personal importance, and finally to enhanced levels of state orientation. In conclusion, the authors defined the role of state-oriented cognitions to be uncontrollable intrusions from processes unrelated to a current goal, which impair self-regulatory planning, initiative, and maintenance of realistic intentions as well as disengagement from unrealistic intentions (Stiensmeier-Pelster & Schürmann, 1990). Importantly, their research demonstrated that "once state-oriented reflection on their misfortunes is interrupted, individuals can develop consistent action-oriented experiences and behavior" (p. 338).

Integrating the degenerated-intention hypothesis and the model of functional helplessness, it may be assumed that depressed individuals display impaired enactment of current intentions to the extent that they have developed a state-oriented mode of control, which results from attentional demands associated with persevering degenerated intentions. Thus, functional helplessness may describe "causes of depression that may exert a considerable influence on the severity and the specific symptoms of a depressive disorder" (Kuhl, 1981, p. 168). Similar to Stiensmeier-Pelster & Schürmann (1994), Kuhl (1981) emphasized that depressed individuals may be supported by encouraging them "to act rather than think", by teaching individuals "to disregard state thoughts in favor of action-related thoughts and overt performing behaviors" (p. 169). There are of course other determinants of depression that are not related to state orientation. Nevertheless, a psychological analysis of any case of depression should carefully distinguish between motivational and functional helplessness as possible determinants of behavioral deficits (cf. Kuhl, 1981).

There are further theories used in the research into the psychological determinants of depression that are related to Kuhl's idea of state orientation, degenerated intentions, and functional helplessness. Nolen-Hoeksema (1991) introduced the *theory of response styles* to describe the way individuals deal with depression, and the effects the specific way of dealing with the disorder has on its duration. In this model, ruminative response style is a mode of responding to distress that involves repetitively and passively focusing on symptoms of distress and on the possible causes and consequences of these symptoms (Nolen-Hoeksema et al., 2008). In this type of repetitive thinking, an individual steadily focuses on himself or herself and the nature and implications of his or her negative feelings. A ruminative response style is a cognitive style that is assumed to produce stimulus-independent thoughts with a self- and emotion-focus related to symptoms and feelings (Watkins & Brown, 2002). Similar to Kuhl (1994b), in the description of Nolen-Hoeksema et al. (2008), people who are ruminating remain fixated on problems and on their feelings about them without taking action. Nolen-Hoeksema et al. (2008) claimed that of self-focused attention, the ruminative response style is the form most strongly related to depressive symptoms. They assumed that the ruminative response style has a unique relationship to depression over and above its relationship to negative cognitive styles. Indeed, there is empirical evidence that the ruminative response style continues to be related to depression after statistically controlling for neuroticism, pessimism, perfectionism, and several other negative cognitive styles (Nolen-Hoeksema et al., 2008). These authors hypothesized that rumination maintains and exacerbates depressive symptoms by enhancing negative mood and thinking about the past, the present and the future. Both negative mood and state-oriented thinking – they postulated – interfere with motivation and with initiative in implementing instrumental behavior. Nolen-Hoeksema et al. (2008) found that even when a ruminator generates worthwhile solutions to a problem, the ruminative response style hinders him or her from implementing it. Like Kuhl (1985) suggested for state-oriented individuals, Nolen-Hoeksema et al. (2008) assumed that in ruminators attention is easily redirected to personal concerns or irrelevant information and that ruminators specifically have difficulties in inhibiting negative information. They hypothesized that a ruminative response style is a relatively stable personality variable and demonstrated that it is associated with prolonged periods of depression. Moreover, they found the ruminative response style to increase the likelihood of developing a depressive disorder when individuals are confronted with distress. Interestingly, however, data suggested that the ruminative response style predicts the onset of depression more consistently than the duration of a depressive disorder.

Specifying in more detail the conditions under which rumination may be maladaptive, the *Interacting Cognitive Subsystems Framework* was introduced (Teasdale, 1999; Watkins, 2004). In this framework it is assumed that the consequences of self-focus are not just determined by the content of ruminative thinking, but also by the precise manner in which individuals attend to these aspects of self-experience. Extending the response-style theory (Nolen-Hoeksema, 1991), Teasdale's framework (Teasdale, 1999) postulated two distinct modes of self-focused attention: (a) the implicational and (b) the propositional mode. These two modes of self-focused attention to moods and problems were assumed to have distinct functional properties. The propositional mode is defined by conceptual, analytical, evaluative thinking about the self and by focusing on discrepancies between current and wanted outcomes. This definition closely resembles Kuhl' s characterization of state orientation. In contrast, the implicational mode of self-focused thinking – according to Teasdale – is characterized by non-evaluative, intuitive, direct awareness of experience. The significant advancement found in Teasdale's framework is the idea that changes in current emotional states require effective emotional processing, which in turn depends on changes in affect-related "mental models". Teasdale assumes that changes in these mental models are facilitated by processing on the implicational level (cf. experiential mode), whereas processing on the propositional level (cf. conceptual-evaluative mode) is assumed to hinder effective emotional processing (Teasdale, 1999).

In sum, today the idea of a specific psychological process, which may be associated with a variety of depressive symptoms, is reasonably well established and the concept of *state orientaiton* as introduced by Kuhl (1981) defines the key characteristics of this psychological process.

Neural Correlates of Depression and State Orientation

The advances in brain imaging techniques in the last two decades have especially made it possible to investigate the link between cognitive processes and brain function. Likewise, affective neuroscience started to examine the brain circuitry underlying affective disorders such as depression (Davidson et al., 2002). In this context, imaging studies which investigate so-called "resting states" in depression typically employ a condition in which participants are asked to simply rest or relax. Most of these studies have been done using positron emission tomography to measure glucose metabolism. A number of findings show that depressed individuals have reduced lateral prefrontal metabolism and increased medial prefrontal cortex metabolism (e.g. Mayberg, 2003; Videbech, 2000). In depressed individuals, the subgenual anterior cingulate cortex (ACC) in particular has been shown to demonstrate increased metabolism compared to nondepressed individuals. These findings appear to be quite robust in so far as they have been replicated across a number of studies. Greicius et al. (2007) measured resting-state functional connectivity in a MDD group and a group of nondepressed controls. Depressed individuals showed increased network functional connectivity in the subgenual ACC, the thalamus, the orbitofrontal cortex, and the precuneus. Additionally, the authors found the length of the current depressive episode to be positively correlated with functional connectivity in the subgenual ACC. Thus, in this study, the subgenual ACC was a prominent node in the so-called “default-mode network” in the MDD group and absent in the default-mode network in the control group. The default-mode network is a set of brain regions that activate in unison during off-task or “rest periods”. This network is assumed to include the posterior cingulate cortex, portions of lateral parietal cortex as well as portions of the medial temporal lobe and medial prefrontal cortex. Greicius et al. (2007) argued that the default-mode network functional connectivity in depression, which – in their study – was disproportionately driven by activity in the subgenual ACC, may be related to internally-generated thought processes characteristic of the depressive disorder.

As of today, only few studies have investigated the brain processes underlying state-oriented cognitions. In an early study, Haschke et al. (1994) found clear-cut differences between action- versus state-oriented individuals in the amplitude of a slow wave ERP component in EEGs recorded during an arithmetic task in the absence of any differences in task performance. Thus, the groups showed comparable performance under different functional brain states. During the task, in both the experimental and the control condition, the amplitude of the slow wave ERP component was more positive in state-oriented compared to action-oriented individuals. Likewise, the amplitude of a positive-going component evoked by a feedback signal was significantly higher in state-oriented compared to action-oriented individuals. Notably, the shapes of the slow wave ERP components following failure compared to the shapes of the components following success did not show any differences in action-oriented subjects. In contrast, the higher positive amplitude of the slow wave ERP component during task-performance observed in state-oriented subjects was enhanced during trials that were preceded by a failure. Recently, Bornas et al. (2012) tested for associations between preferred emotion regulation strategies and complexity of resting EEG signals, measured by fractal dimension. Emotion regulation strategies are assumed to differ in the degree to which they focus on self-related issues versus situation- or other-related issues. Relatively more adaptive emotion regulation strategies may include positive refocusing, positive reappraisal, putting into perspective, refocusing on planning, and acceptance. Relatively more maladaptive emotion regulation strategies may comprise rumination, self-blame, blaming others, and catastrophizing, where rumination and self-blame are typical state-oriented cognitive styles. Hence, in their study, Bornas et al. (2012) conceptualized rumination, or state orientation, as a self-focused emotion regulation strategy. As depression had previously been associated with lowered EEG complexity, and because higher complexity is supposed to reflect more neurons and higher firing rates and thus a higher level of adaptivity of the underlying neural network, Bornas et al. (2012) predicted and found that rumination and self-blaming were associated with lowered complexity in EEGs. Ray et al. (2005) used a reappraisal task in combination with fMRI to test whether state-oriented cognitions may draw upon some of the same cognitive processes that are used to consider and maintain alternative interpretations in reappraisal coping strategies. In this study, participants were instructed to either cognitively increase negative affective responses to neutral and negative photographs, to view negative and neutral photographs and respond naturally, or to reappraisal

negative stimuli in order to decrease their negative effect. When participants looked at negative pictures without instructions to regulate, the magnitude of activity in the left ventrolateral prefrontal cortex and left amygdala was greater for individuals which showed a tendency for a state-oriented cognitive style. Moreover, state orientation, in terms of trait rumination, correlated positively with activity in the left amygdala and the left ventrolateral prefrontal cortex during unregulated responses to negative events. These findings suggested that state orientation contributes to heightened encoding of the affective relevance of stimuli and that therefore state-oriented cognitions are associated with activity in brain regions involved in bottom-up encoding and representation of affective properties.

Altered Brain Function and its Relation to Ruminative Thought in Depression

In numerous studies, decreased relative left anterior prefrontal cortex activity has been reported in individuals with a current depressive episode (cf. Allen et al., 2004; Coan & Allen, 2004). Putnam & McSweeney (2008) suggested that this prefrontal asymmetry may be related to symptoms of depression that are associated with specific behaviors and cognitions, rather than to the general concept of depression. In their study, Putnam & McSweeney (2008) used the EEG alpha-band as an inverse measure of neural activation to investigate the relation between depression, brain activity, and state orientation. They found that a significant difference existed only in depressed individuals between left and right frontal alpha-band activity. In depressed individuals more activity was evident in the right frontal region compared to the left frontal region. However, in their study, self-reported state orientation, measured as the tendency to ruminate, was associated with decreased activity in the prefrontal cortex bilaterally. Keune et al. (2011) also based their research on the assumption that alpha asymmetry, indicative of stronger relative right-hemispheric anterior cortical activity, may reflect an endophenotype for depression. These authors acknowledged that stronger relative right-hemispheric anterior activity is related to the tendency for withdrawal-related, aversive responses often found in MDD groups in comparison to control groups. However, they also noted that depressed individuals are not necessarily characterized by a stronger pattern of frontal asymmetry when compared to nondepressed individuals. In this context, Keune et al. (2011) hypothesized that rumination, or state orientation, is a factor of depressive vulnerability and designed a longitudinal study to investigate the impact of mindfulness-based cognitive therapy on rumination and mindfulness as indicators of global cognitive style, while at the same time assessing EEG alpha-band asymmetry. They could demonstrate that mindfulness correlated negatively with symptom-focused rumination, as well as with depression. They also found that both depression and rumination were associated with stronger relative right-hemispheric cortical activity. Contrary to expectations, however, an increase in relative right-hemispheric cortical activity over time was not only associated with higher rumination, but also with higher mindfulness. For this reason, the authors could not draw any firm conclusions concerning the link between depression, state orientation, and brain function.

State orientation, as described above, supposedly involves a broad range of cognitive and affective sub-processes. These sub-processes are likely associated with activation in diverse regions of the brain. In line with the link – as explained above – between MDD and the difficulty inhibiting and subsequently disengaging from negative information, M. K. Johnson et al. (2009) reasoned that depression may be especially associated with difficulty disengaging from self-focus, particularly from negative self-relevant thoughts. They further speculated that, because the anterior medial cortex and posterior medial cortex show increased activity during self-referential processing, in depression, activity in these brain regions may be related to state orientation. In their study, M. K. Johnson et al. (2009) assessed brain function using fMRI while participants were cued to either think about hopes and aspirations, duties and obligations, or concrete objects. The first two conditions were previously shown to differentially engage anterior and posterior medial cortex in nondepressed individuals. In this study, both a group of MDD patients and a group of nondepressed controls showed greater activity in the anterior medial cortex, including the ACC, when cued to think about hopes and aspirations compared to duties and obligations and greater activity in the posterior medial cortex when cued to think about duties and obligations. In addition the MDD group showed higher activation than controls during distraction trials in an area of medial frontal gyrus and the ACC. Interestingly, and contrary to expectations, depressed individuals did not show less activity than controls during hope and aspiration trials. M. K. Johnson et al. (2009) interpreted these results as having two main implications. First, they argued that it seems as if depressed individuals are relatively successful in engaging in positive self-referential processing when cued to do so (cf. no difference in activity of the anterior medial cortex between MDD and control group). Second, depressed individuals seem to be less successful in disengaging from self-referential processing (cf. depressed individuals show less deactivation in the anterior medial cortex during distraction trials compared to nondepressed individuals). Crucially, scores of state orientation – measured here in terms of trait rumination scores – were associated with less activity in anterior medial cortex during hope trials and with more activity in posterior medial cortex during distraction trials. During duties trials, rumination scores did not correlate with activity in any of the areas. Because of the latter finding, in a second experiment, M. K. Johnson et al. (2009) – again using fMRI – investigated brain function while participants engaged either in self-evaluation ("analytic self-focus"), or were instructed to think about their current state ("experiential self-focus"), or instructed to think about concrete objects ("distraction") respectively. Analytic self-focus and experiential self-focus had been previously shown to differentially induce state-oriented cognitions in depressed individuals. In depressed individuals relative to nondepressed individuals, sub-regions of the anterior medial prefrontal cortex showed less activity during the analytic condition and were less likely to be deactivated during the distraction condition. Similar to the results of their first experiment, in this experiment state orientation, again measured in terms of participants' proneness to ruminate, was also associated with less activity in anterior medial cortex during analytic trials, and with more activity in the anterior medial cortex during distraction trials. Thus, during analytical self-focus the tendency to ruminate was correlated with greater activation in brain regions, which are typically deactivated during cognitive tasks. This suggested that depressed individuals have a persisting self-focus when it may not be appropriate. M. K. Johnson et al. (2009) additionally found a group difference in specific thought content. The groups did not differ in *how much* they were thinking in the experimental conditions, but rather in *what* they were thinking. Therefore the authors concluded that depressed compared to nondepressed individuals may show reduced activity in the medial prefrontal cortex during analytic self-focus, because they are less likely or less able to generate positive thoughts. Alternatively, they suggested, this effect could be due to negative thoughts offsetting the impact of positive thoughts. Thus, when engaging in analytic self-reflection without being specifically cued to produce positive thoughts, depressed individuals seem to generate less positive thoughts than nondepressed individuals, which is reflected in a relatively reduced activation of anterior medial brain regions. Authors concluded that, when guided, depressed individuals are able to generate positive memories and thoughts but they have difficulties generating them on their own.

Cooney et al. (2010) used an experimental design that was similar to the design applied by M. K. Johnson et al. (2009) to investigate the brain correlates of state orientation in depression. They used a rumination induction task, in which they compared self-focused thoughts with thoughts about a concrete object ("concrete distraction") and with thoughts about abstract concepts ("abstract distraction"). Comparing the rumination and the abstract distraction condition in depressed individuals, fMRI revealed significantly greater activation in the dorsal ACC, the rostral ACC, the inferior parietal lobule, the middle frontal gyrus, the middle occipital gyrus, the parahippocampus, the amydgala, the posterior cingulate cortex, and the middle and superior temporal gyri. Authors concluded that state orientation in depression, here in terms of ruminative self-focus, is associated with enhanced recruitment of limbic and medial and dorsolateral prefrontal brain regions.

Brain Activity Underlying Executive Dysfunction in Depression

Abnormalities in brain activation have been identified in MDD patients in a number of different experimental paradigms targeting both cognitive as well as affective information processing. As shown above, there is evidence that patients with MDD are characterized by attenuated glucose metabolism in prefrontal and increased metabolism in cingulate brain areas. Based on this finding, Wagner et al. (2006) hypothesized that, relative to nondepressed individuals, hyperactivity would be found in depressed individuals performing a Stroop Color Naming Task, in particular in the ACC. Using fMRI to accordingly measure brain activity during a Stroop task, they found increased left lateralized activation in the rostral part of ACC and in the ventrolateral prefrontal cortex when comparing depressed individuals with nondepressed controls. Furthermore, in the MDD group, they observed a highly significant correlation between Stroop interference and activity in the rostral ACC. The latter finding suggested that deactivation of the rostral ACC is necessary to allocate resources for effective cognitive performance. Importantly, a failure to suppress activity in this brain region seemed to be directly associated with MDD. The observed hyperactivity in the rostral part of the ACC, which is supposed to be responsible particularly for the processing of affective information, was interpreted as inefficiency to suppress task-irrelevant, internal emotional states and was proposed to be functionally related to a compensatory hyperactivation of the dorsolateral prefrontal cortex (DLPFC) in depressed individuals. In a similar vein, Diener et al. (2009) based their research on the assumption that *hypoactivity* in prefrontal brain areas found in depressed individuals during resting states translates into *hyperactivity* during cognitively demanding tasks when patients show performances that are similar to the performances of nondepressed individuals. These authors also postulated a compensatory activation in depressed individuals in order for them to maintain adequate levels of performance. Diener et al. (2009) hypothesized that the degree of behavioral control modulates the impact of environmental stressors and therefore measured brain activity during uncontrollability over aversive events in depressed versus nondepressed individuals. They used the "post-imperative negative variation", an

EEG parameter that is suppose to depict frontal brain activity associated with response evaluation in situations of stressor uncontrollability or in situations of uncertainty about the appropriate response. During loss of control, depressed individuals showed an enhanced post-imperative negative variation over frontal sides and maintained this activation pattern in the subsequent condition when control was re-established. Diener et al. (2009) concluded that increased prefrontal activity during loss of control reflects a compensatory mechanism in order to resolve task-induced ambiguity. Krompinger & Simons (2011) argued to have found further evidence for the "cortical inefficiency hypothesis". Measuring ERPs in a Stroop task, they demonstrated a larger overall amplitude of the N450 ERP component and a smaller overall amplitude of the P3 ERP component in nondepressed compared to subclinical depressed individuals. Crucially, however, they additionally found that subclinical depressed individuals exhibited a large Stroop effect in the amplitude of the N450 ERP component that was absent in nondepressed individuals. Krompinger & Simons (2011) interpreted this EEG pattern as inefficiency of brain areas responsible for conflict detection and regulation demonstrating that depressed individuals require more cognitive resources than do nondepressed individuals to support normal executive functioning.

Providing a slightly different perspective, Eugène et al. (2010) worked on the assumption that mood-congruent selective attention plays a central role in the etiology, maintenance, and recurrence of depression. As documented before, depressed individuals often have difficulty with disengaging their attention from some current information, especially from negative information. Eugène et al. (2010) argued that this attentional deficit observed in depression, which is one of the hallmarks of a state-oriented cognitive style, may be based on specific inhibitory deficits. In line with Kuhl's theorizing (Kuhl & Helle, 1986; Kuhl, 1981), they argued that inhibitory processes that keep irrelevant stimuli from entering working memory may be impaired in MDD and that, in particular, the ACC, which is implicated in normal inhibitory processes such as conflict monitoring or solving interference from irrelevant material, may be impaired in depressed individuals. To measure the degree to which individuals are able to inhibit irrelevant (emotional) stimuli, Eugène et al. (2010) used a selective attention task, namely a negative priming task, in an fMRI setting. In this task, nondepressed individuals demonstrated increased activation in the rostral ACC when they inhibited positive, but not when they inhibited negative words. The opposite pattern was found in MDD patients: increased activation in the rostral ACC was associated with inhibition of negative words, but not with inhibition of positive words. Thus, increased activation in the rostral ACC seemed to be specific to demanding inhibition of negative information in depressed individuals and suggested an inhibitory dysfunction in MDD, rather than a missing bias for the preferential processing of positive stimuli. The negativity bias just described was the starting point of a study conducted by Deldin, Deveney, et al. (2001). These authors based their investigation on the biased memory for negative relative to positive information that had been reliably found in MDD. They investigated a slow wave ERP component in a delayed matching to sample paradigm. In their study, nondepressed individuals exhibited a significantly more negative amplitude of the slow wave ERP component in response to positive stimuli than in response to negative stimuli. In contrast, the MDD group exhibited a more negative amplitude of the slow wave ERP component for negative stimuli compared to positive stimuli. In addition, the MDD group demonstrated negative correlations between depressive severity and slow wave amplitude for positive and negative stimuli. Thus, Deldin, Deveney, et al. (2001) could demonstrate both a memory processing bias for positive information in nondepressed individuals and a depressive cognition that was characterized by a deficit in the processing of positive information, as indexed by a larger negativity of a slow wave ERP component during working memory, in response to negative information compared to positive information.

Krompinger & Simons (2009) also focused on the assumed biased processing of negative information in depression. They hypothesized that negative biases in attribution and judgement, implicit memory, and autobiographical memory, which are all concomitant with depression, are associated with particular difficulty in inhibiting negative information. They further reasoned that the inability of depressed individuals to properly disengage from negative information may support the “affective interference hypothesis”, which states that depression will be associated with facilitated performance in tasks that emphasize attention to emotional aspects of negative stimuli, but that performance will be impaired when depressed individuals are asked to perform a task that requires shifting attention away from negative information. Finally, Krompinger & Simons (2009) speculated that difficulty in disengaging from negative information may also be, to an extent, related to initial excessive attention for negative stimuli. Lending support for the proposed role of impaired inhibition of negative information in depression, in an affective Go/Nogo task, Krompinger & Simons (2009) found decreased amplitudes of the N2 ERP component in response to negative compared to positive stimuli only in depressed individuals. Furthermore, the amplitude of the P3 ERP component was significantly larger in response to negative stimuli than in response to positive stimuli in depressed individuals. Thus, again, it was shown that depressed and nondepressed individuals differentially categorize positive and negative (emotional) stimuli. In particular, the significantly enhanced amplitude of the P3 ERP component in response to negative stimuli seemed to point to a possible explanation of difficulties inhibiting negative information seen in depression.

There is also evidence from brain imaging studies for a bias in the processing of negative information in depression. Based on the finding that depressed individuals seem to be characterized by biases in memory, with depressed individuals demonstrating better memory for negative material than do nondepressed individuals, J. P. Hamilton & Gotlib (2008) designed a study to investigate the brain processes underlying such biases in depression. Applying a picture encoding task together with a subsequent incidental recognition memory task – while conducting fMRI – they found greater right amygdala activity during successful relative to unsuccessful encoding of negative stimuli in depressed compared to nondepressed individuals. These results fit well with the idea of a relatively higher initial sensitivity to negative information in depression previously proposed, because, indeed, in terms of amygdala reactivity, depressed individuals showed higher sensitivity for negative stimuli than nondepressed individuals. Moreover, J. P. Hamilton & Gotlib (2008) demonstrated that during successful encoding of negative stimuli the functional interaction of the amygdala with the hippocampus was greater in depressed than in nondepressed individuals. This additional finding suggested that an over-active amygdala-hippocampus system may underlie enhanced memory for negative information in depression. Finally, the findings of a number of studies (e.g. Liao et al., 2012) suggest in particular that the association between the activity in the amygdala and the activity of other brain regions, especially of those brain regions implicated in executive control (e.g. the DLPFC), biases information processing in depression.

Integrative Models of Depression

Findings of altered resting state brain function, cortical inefficiency, and preferential processing for negative information in MDD, along with evidence for impaired inhibition of, and corresponding difficulty disengaging from, task-irrelevant information, asymmetry in prefrontal cortex activation, hyperactive prefrontal cortex activity, and findings of over-active on-task activity in the default-mode network, in particular in the ACC, have helped inform integrative neural models of depression. These models try to relate patterns of altered brain activation described in brain imaging or neurophysiological studies of the depressive state to both specific executive deficits found in depression and to stable cognitive styles. Of particular interest for the purpose of the present research, these models suggest a moderating role of state orientation for some of the characteristics of depressive cognition.

Mayberg (2009) proposes a limbic-cortical dysregulation model of depression. In Mayberg's model, depressive symptoms may arise as a result of interruptions of information processing within a functional network formed by specific brain areas. A major depressive episode would then reflect the failure to appropriately regulate activity in this multi-area network under circumstances of cognitive, emotional, or somatic stress. Although Mayberg (2009) notes “consistent inconsistencies” with respect to brain imaging findings related to depression, she proposes that the frontal cortex, the cingulate cortex, the basal ganglia, the amygdala, and the hippocampus are involved in the brain network, the function of which may be defective in depression. Mayberg (2009) puts forward the hypothesis that the reciprocal interaction between ventral limbic brain regions and dorsal cortical brain regions determines brain dysfunction associated with MDD. Specifically, in her model, the function of the prefrontal cortex, the activity of which shows an inverse relation to depressive severity and a relations to amygdalar hyperactivity, is assumed to be at the core of brain dysfunction found in depressed individuals. In addition, based on the finding that subgenual ACC activity is linked to the regulation of negative emotional states, and that clinical antidepressant effects are associated with a marked reduction in subgenual ACC blood flow as well as changes in blood flow in downstream limbic and cortical brain regions, Mayberg (2009) suggests that the subgenual ACC may have an especially prominent role within the brain network underlying depressive symptomatology.

Expanding on the idea that the ACC has a prominent role in the dysfunctional patterns of brain activity found in depression, in a second important model of depression, Pizzagalli (2011) elaborates on the finding that increased resting glucose metabolism in the rostral ACC before onset of pharmacological treatment predicts better treatment response in MDD. Given the link previously described between self-reflection and increased activation of the default-mode network, including the rostral ACC, Pizzagalli (2011) hypothesizes that increased resting rostral ACC activity is linked to state-oriented cognitions. As has been stated above, adaptive regulation of cognition appears to include suppression of the resting rostral ACC activity during demanding tasks. Therefore, the model of depression put forward by Pizzagalli (2011) assumes that disruption of the coupling between the default-mode network and the task-positive network, specifically, the inability to reduce activity in the default-mode network and/or dominance of the default-mode network over the task-positive network, possibly coupled with impairments in modulating amygdalar activity, will result in excessive negative self-focused information processing and a maladaptive state-oriented cognitive style. The tendency to engage in maladaptive state-oriented information processing, Pizzagalli (2011) further reasons, will in turn interfere with or deplete cognitive resources needed to perform other primary cognitive tasks. In the model of depression advocated by Pizzagalli (2011), deficits in executive control are a key mechanism underlying the development and maintenance of depressive cognition. In line with Kuhl’s reasoning (Kuhl, 1981), he believes that in MDD engagement in self-focused, maladaptive, ruminative thought depletes or interferes with ongoing executive cognitive functioning. In this context, he assumes that executive cognitive functioning can be decomposed into an *evaluative* and an *executive* component. The evaluative component is assumed to be subserved by the dorsal ACC and has been hypothesized to monitor whether events or outcomes are worse than expected. The executive component is assumed to rely on the DLPFC and has been hypothesized to use evaluations provided by the dorsal ACC to implement adaptive behavioral adjustments. Thus, in the model of Pizzagalli (2011), the dysregulated interplay among rostral ACC, dorsal ACC, and DLPFC is the reason for maladaptive forms of rumination and other important psychological facets of depression, including prolonged negative affect, increased elaboration of negative information, impaired ability to disengage from negative cues, and reduced cognitive control when challenged with negative information.

Bar (2009) offers an integrative neuroscientific approach to mood and depression, which has a focus that is a little different from that of Mayberg's model (Mayberg, 2009) and the model of Pizzagalli (Pizzagalli, 2011). Bar's starting point is the idea that information processing during positive mood is characterized by broad associative activation. He assumes that in a single moment in time, not only one specific concept is activated in the brain, but, simultaneously, a broad range of related concepts is activated, if an individual is in a positive emotional state. Crucially, Bar (2009) claims that the reverse relation also holds: broad activation of associations, he postulates, will result in improved mood. Associations, according to Bar, provide the means by which thoughts advance from one representation to another. Accordingly, narrow associative thinking surround a narrow focus. Broad associative activations, by contrast, involve more remote associations and, crucially, activate associations that make thought processes advance from one context to another. Therefore, Bar claims, broad associative activation prevents persistent information processing by "distracting" the thought process away from dwelling on a single theme. In other words, broad associative activation helps gain a broader perspective. He further argues that a preoccupied, self-focused thinking pattern, or the tendency of individuals to ruminate on a single, usually negative theme respectively (cf. state orientation), is a common concomitant of depression. Therefore promoting broad associative thinking may be a means for helping depressed individuals to disengage from state-oriented cognitions. With respect to the brain processes underlying a narrow associative cognitive style, Bar (2009) starts with acknowledging that – as described above – the medial prefrontal cortex and the neighboring ACC in particular exhibit abnormal activity during periods of "rest" in individuals suffering from depression compared to nondepressed individuals. He additionally notes that there is a close relationship between depression and the functional and structural integrity of the medial temporal lobe (i.e., hippocampus and parahippocampus). In particular, Bar refers to those studies demonstrating an enlarged and hyperactive amygdala in depression. Integrating these findings, he suggests that narrow associative processing, the defining feature of state-oriented cognitions, may stem from excessive inhibition of the medial temporal lobe by the medial prefrontal cortex through hyper-connectivity between these two brain regions. In Bar's terms, inhibition has the critical role of limiting the extent of connected representations that are activated at a given instance. Thus, in his view, excessive inhibition of the medial temporal lobe by an abnormally activated medial prefrontal cortex would explain the inability of depressed patients to disengage from debilitating rumination. Bar (2009) concludes that activating associations broadly and frequently, while still being able to focus more narrowly when necessary, provides a mechanism that promotes adaptive behavior in normal functioning, an idea Kuhl (2000) characterized earlier as the interactions of personality systems modulated by affective states.

Overview of the Present Research

The purpose of the present study was to examine the relationship between state orientation and sustained information processing in depression and the functional significance of persistent information processing, in particular of negatively valenced information, for impaired executive cognitive functioning in depression. In the present research the link between a state-oriented cognitive style and MDD, which has been suggested by previous research, was investigated in several steps through a series of correlational, quasi-experimental, and experimental studies. The correlational analyses employed a measure of state orientation developed by Kuhl (Kuhl, 1994a). The experimental studies utilized an experimental paradigm originally designed to assess volitional facilitation and inhibition (Kazén & Kuhl, 2005; Kuhl & Kazen, 1999). In Studies 1a to 1c, state orientation was measured in normal control participants and in patient groups to test for the associations between depression and state orientation. As Kuhl (Kuhl, 1994b) distinguished between different subtypes or dimensions of state orientation, it was necessary to first explore which subtype of state orientation in particular is related to depression. Therefore, in the first three studies, the type of state orientation most strongly related to depression was determined. In Study 2, it was investigated whether depression is related to specific impairments in executive cognitive functioning that may result from sustained information processing, and whether these impairments are in turn related to the level of state orientation. In Study 3, measures for state orientation, executive cognitive functioning, and brain function – in terms of ERPs – were simultaneously assessed in a sample of inpatients suffering from MDD and in a group of matched controls to investigate brain correlated of sustained information processing and affective/cognitive interference in depression and their relation to state orientation. On the basis of Kuhl's theory of state orientation (Kuhl, 1994b), his idea of degenerated intentions, and the functional helplessness hypothesis in combination with recent findings on the link between executive dysfunction and brain function in depression, it was hypothesized that state orientation is closely connected to sustained, uncontrollable information processing, in particular with respect to the processing of negative information. Furthermore, the difficulty disengaging from particular thoughts (cf. degenerated intentions) observed in depressed individuals, was postulated to be a crucial process underlying uncontrollable ruminative thought, the capacity-reducing effect of which would eventually lead to impaired executive cognitive functioning (cf. functional helplessness). Likewise, sustained information processing as well as cognitive/affective interference effects of this sustained information processing, were predicted to be associated with distinct patterns of brain function in depression. Therefore, finally, altered activity in the ACC and the DLPFC was expected to be related to both interference effects of sustained information processing and to a state-oriented cognitive style.

Chapter 2: State Orientation and Depression

Depressed individuals, according to the degenerated-intention hypothesis, will often be dominated by uncontrollable, ruminative thoughts resulting from the overmaintenance of unrealistic intentions (Kuhl & Helle, 1986). In this context, Kuhl predicted that depressed individuals will also manifest a certain, stable personality style, namely a cognitive style focusing on state-oriented thoughts (cf. state orientation). In line with this assumption of the degenerated-intention hypothesis, a review conducted in 1990 that examined increased self-focused attention in various clinical disorders, came to the conclusion that depression is strongly associated with an increased, and perhaps prolonged, level of self-focused attention (Ingram, 1990). Likewise, a prospective study that followed 137 individuals over a time period of 2.5 years concluded that ruminative thinking may act as a general proximal mechanism through which other vulnerability factors affect depression (Spasojević & Alloy, 2001). Empirically, the status of state orientation in relation to depression, however, is somewhat unclear due to partially inconsistent findings. In an early study, Rholes et al. (1989) found that in a sample of subclinically depressed individuals state orientation was associated with higher scores on the Beck Depression Inventory (BDI; Beck et al., 1961), an instrument that measures the severity of depressive symptoms. In this study, the link between state orientation and depressiveness was especially prominent under current high levels of perceived stress. In addition, researchers showed that for people high on BDI, state orientation could predict future depressiveness: state orientation was associated with an increase in BDI score and action orientation was associated with a decline in BDI score. In accordance with these findings, Kuhl & Helle (1986) reported a positive correlation between BDI score and state orientation in clinically depressed individuals. In a study conducted by Keller et al. (1994), however, depressed individuals' scores on the Self-Rating Depression Scale, but not BDI scores, correlated with SOF (r = .37) and SOD (r = .28) at admission. In this study, at the point of admission, trait anxiety was also associated with SOF (.28) and SOD (.34). In a study conducted by Hautzinger and coworkers (Hautzinger, 1994) depressed patients were more state-oriented than healthy individuals as well as more state-oriented than schizophrenic, neurological, and oncological patients. Patients with psychosomatic problems, with phobias and with anxieties and compulsions, however, did not differ in their state orientation from depressive patients. Hautzinger (1994) additionally reported that scores for SOF and SOD were significantly correlated with scores for depressiveness, as well as with scores for anxiety. In their study, depressed patients could successfully be distinguished from healthy control participants by both SOF and SOD score (67% or 73% correct discrimination). Finally, Hautzinger (1994) reported a decrease in state orientation in depressive patients when in remission. Notably, however, despite their improvement, formerly depressed individuals were still more state-oriented than healthy control participants, while also still showing higher depressiveness.

In an attempt to determine which kind of state orientation is most typical for depressed individuals, in a series of studies, Kammer (1994) found associations between SOF and BDI scores in a sample of male students ($r = .43$), in male psychiatric ward inpatients ($r = .58$), in male inpatients of a sanatorium for psychosomatic illnesses ($r = .58$), and in female psychiatric ward inpatients ($r = .36$). Likewise, SOD was associated with BDI score in these samples: male students ($r = .29$); male psychiatric ward inpatients ($r = .42$); male psychosomatic inpatients ($r = .37$); female psychiatric ward inpatients ($r = .53$). Male students, categorized by their BDI score, showed a stronger tendency for a state-oriented cognitive style after failure in relatively more depressed individuals. However, no consistent results were found in this respect for the group of female psychiatric ward patients. Kammer (1994) also made efforts to study the association between state orientation and depression in relation to other relevant personality variables. In a factor analysis, she examined SOF, SOD, SOP, BDI, test anxiety, worry, and self-consciousness in a sample of 81 university students. BDI, SOF and SOD loaded on the same factor. Test anxiety loaded on the second factor, private self-consciousness on the third factor, and SOP on the fourth factor. Public self-consciousness and social anxiety could not be uniquely attributed to a single factor. The results suggested that SOF and SOD are more typical of depression than anxiety or the degree of self-consciousness.

One strong, recurrent finding has emerged from this research, namely that state orientation is associated with increased levels of depressive severity. However, despite the relative abundance of information linking state orientation to depression, there is still only little data on which type of state orientation is most typical for MDD. The purpose of Studies 1a, 1b, and 1c was therefore to investigate which of the dimensions originally introduced by Kuhl (Kuhl, 1994b) is most typical of depression. Building on the findings of Kammer (1994), it was investigated which measure for state orientation, assessed by the Action Control Scale (ACS; Kuhl, 1994a), and corresponding scores for the Volitional Component Inventory (VCI; Kuhl & Fuhrmann, 1998), is most strongly linked to depressive symptomatology. The present research therefore aimed to replicate and add to the findings of the few existing studies in order to lay the foundations for the subsequent investigations described in Chapters 3 and 4, namely the impact of state orientation on sustained information processing and impaired executive cognitive functioning in depression as well as the associated altered patterns of brain function. The prevailing research design indicated for this initial research question was a multiple regression analysis in non-experimental designs, and a multivariate analysis of variance (MANOVA) in combination with a discriminant analysis in a quasi-experimental design. More specifically, multiple regression analysis allows to test whether measures of state orientation can predict scores for depressiveness and which of the different types of state orientation has the largest influence in this prediction. MANOVAs, or discriminant analyses, both allow to decide whether two groups of individuals can be distinguished from each other based on a number of independent variables.

On the basis of the theoretical work and the empirical evidence cited earlier, the study hypotheses were developed. To date, no study has reported the relationship between depressiveness and the different types of state orientation proposed by Kuhl (1994b) in subclinically depressed individuals. Nevertheless, in accordance with comparable studies (cf. e.g., Rholes et al., 1989), it was predicted that (1) in nondepressed individuals depressiveness is associated with elevated levels of state orientation and most strongly related to measures of SOF (cf. Study 1a). Since in the few studies to date investigating the relationship between state orientation and depressiveness in MDD, depressive symptoms were in particular associated with higher scores for SOF (cf. e.g., Kammer, 1994), Study 1b and 1c tested complementary hypotheses. It was anticipated that (2) measures of state orientation, in particular scores for failure-related state orientation, are associated with depressive severity in clinically depressed individuals (Study 1b) and that (3) these scores are able to distinguish between clinically depressed and nondepressed individuals (Study 1c). The latter hypotheses were in line with previous findings on the relation between rumination and MDD (cf. e.g., Nolen-Hoeksema, 1991; Nolen-Hoeksema et al., 2008). For the purpose of the current analyses, state orientation and depressiveness were assessed in a sample of male university students at different stages of their academic education (Study 1a). Next, relevant data were analyzed in existing data sets of subclinical and clinical samples (Study 1b and Study 1c; courtesy of IMPART and S. C.)

State Orientation and Depressiveness in Healthy Individuals (Study 1a)

Prediction of vulnerability to depression from personality variables has been extensively explored. However, evidence from investigations examining the link between a state-oriented cognitive style and depression suggests that specific kinds of ruminative thoughts may be especially related to depressive symptomatology (Kammer, 1994). As a starting point for further investigations, the purpose of Study 1a was to test whether in “normal” – i.e., subclinically depressed – individuals the amount of depressive symptoms could be predicted by different kinds of state orientation.

Method

Participant characteristics and sampling procedure. Participants were 36 male university students ranging in age from 20 to 37 years (*M* = 26, *SD* = 4). Involvement in the study was voluntary; four participants received partial course credit as compensation for their time and effort. Participants were recruited for the study by personal contact. Prior to inclusion, potential participants were contacted and screened for existing psychiatric disorders using a short screening questionnaire closely modeled on the screening procedure of the structured clinical interview for the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV) (SCID; Wittchen et al., 1997).

Measures.

State orientation. As shown earlier, action control can be defined as the specific type of cognitive activities an individual focuses on when confronted with different types of environmental situations and demands. An individual can be action-oriented, i.e., his or her focus is on action alternatives and plans that serve to overcome a discrepancy between his or her present state and an intended future one. In contrast, an individual who is state-oriented focuses on present, past, or future states. Individual differences in state orientation can be assessed using the written version of the Action Control Scale (ACS; Kuhl, 1994a). The ACS is a self-report measure that was developed to assess individual differences in the level of action control. The test assesses the degree to which individuals can escape a state-oriented mode when necessary. This is done by retrieving easily accessible phenomenal consequences of state orientation that are postulated by the theory of action control. The ACS has three subscales that measure the three major dimensions of state orientation described by Kuhl (1994b): (1) failure-related state orientation (SOF), (2) decision-related state orientation (SOD), and (3) performance-related state-orientation (SOP). The internal consistency coefficients of this instrument range from .71 to .82 (Cronbach's α) and discriminant validity coefficients range between 0.01 and 0.36 (Diefendorff et al., 2000; Kuhl, 1994a, 1985). Twelve items are used to assess state orientation in each domain, leading to 36 items total. For each item two answer alternatives are given. Table 1 lists three items for the SOF and the SOD subscales of the ACS.[1] In the course of this thesis, scores are scaled so that high values represent state orientation and low values represent action orientation, with a possible range from 0 (action orientation) to 12 (state orientation); standardized scores are 5.30 for SOF and 5.45 for SOD, respectively. Internal consistency reliabilities in the current sample were SOF: α = .69, SOD: α = .79, and SOP: α = .52.

[1]It is important to note that in this thesis all experiments were carried out in German.

Participants were additionally asked to fill in the short version of the Volitional Components Inventory (VCI; Kuhl & Fuhrmann, 1998). The VCI comprises 52 propositions. The interviewee has to rate his agreement with each proposition according to the following scale: “The statement applies to me: (0): *not at all*, (1): *some*, (2): *much*, (3): *completely*”. The VCI assesses five main dimensions of action control, with according subscales. Each subscale is measured by four items (cf. Table 2). In the present research, VCI scores were scaled so that high values represented a state-oriented cognitive style, with a possible range from 0 (action orientation) to 16 (state orientation). For the purpose of the current study, the subscales *Coping versus Rumination* (RUM) and *Enactment versus Passivity* (PAS) were of particular interest, because they are designed to correspond with SOF, or SOD respectively. RUM measures how an individual deals with failures and setbacks. Individuals scoring low on this score are characterized by a constructive approach to failure (cf. “learning from mistakes”). A high score on RUM points to a tendency to ruminate. In contrast to SOF, RUM is designed to measure failure-related state-orientation in situations in which no particular threat is present. Items assessing RUM are “After unpleasant experiences I often cannot stop thinking about them.”, “If something bad happens, it takes a long time before I can concentrate on other things again.”, “If I get in a bad mood, it is hard for me to get out of it again.”, and “It is hard for me to get rid of sorrowful thoughts, once they are on my mind.” PAS was designed to assess an individual’s ability to generate the energy necessary to realize his or her intentions. If an individual scores high on PAS, he or she will have difficulties achieving goals deliberately chosen by him- or herself. In contrast to SOD, PAS is supposed to measure decision-related state orientation in situations in which no particular burden is present. The four items assessing PAS are as follows: “I often postpone unpleasant things.”, “I often plan on doing things that in the end I do not get around to doing.”, “I put things off for as long as possible.”, and “I often start different things all at once without finishing them.” External validity of the VCI has been shown to be sufficient for routine application in experimental and/or clinical settings (Forstmeier & Rüddel, 2008). Internal consistency reliabilities in the current sample were RUM: $\alpha = .77$ and PAS: $\alpha = .80$.

Depressiveness. To determine participants’ depressiveness, participants filled in the German version of the Beck Depression Inventory (Kühner et al., 2007). The BDI assesses affective, behavioral, cognitive, and somatic symptoms of depression and aims to measure the severity of depressive symptomatology. It is composed of 21 items for which participants rate a variety of symptoms of depression on a 4-point scale from 0 (*no change/not at all*) to 3 (*substantial change/severely*). Total depression scores are labeled: 0 – 13: minimal; 14 – 19: mild; 20 – 28: moderate; and 29 – 63 severe depression (BDI-II manual; Beck et al., 1996). The BDI has been shown to have good internal

Table 1

Sample Action Control Scale (ACS) Items for the SOF and the SOD Subscales

ACS item
ACF
When I have lost something that is very valuable to me and I can't find it anywhere: a. I have a hard time concentrating on something else. b. I put it out of my mind after a little while.
If I've worked for weeks on one project and then everything goes completely wrong with the project: a. It takes me a long time to get over it. b. It bothers me for a while, but then I don't think about it anymore.
When I am in a competitive setting and I keep losing: a. I can quickly put losing out of my mind. b. The thought that I lost keeps running in my mind.
ACD
When I know I must finish something soon: a. I have to push myself to get started. b. I find it easy to get it done and over with.
When I don't have anything in particular to do and I am getting bored: a. I have trouble building up enough energy to do anything at all. b. I quickly find something to do.
When I get ready to tackle a difficult problem: a. It feels like I am facing a big mountain that I don't think I can climb. b. I look for a way that the problem can be approached in a suitable manner.

consistency (α = 0.84) and good retest reliability (r = .75) in nonclinical samples. Internal consistency reliability in the current sample was α = .74.

Research design and data analysis. To determine the relationship between state orientation and depressiveness and in particular to decide which kind of state orientation is most strongly related to depressive symptoms in nonclinically depressed individuals, a standard multiple regression between BDI score as the dependent variable and the scores for the different types of state orientation as independent variables were performed. Through this analysis is was possible to determine the degree of the relationship between the dependent variable and the independent variables, or in other words, the proportion of variance in the BDI score predicted by regression, and the relative importance of the various independent variables to the solution of the multiple regression analysis (cf. Tabachnick & Fidell, 2007).

Table 2

Overview of the Main Dimensions of the Volitional Component Inventory (Short Version) and its Subscales (Including Sample Items)

Volitional competencies	Cronbach's Alpha
Self-Regulation	
Self-Determination	
"I feel congruent with what I am doing."	
Self-Motivation	
"I know how to motivate myself if necessary."	
Self-Relaxation	
"I can purposefully reduce my nervousness."	
Self-Control	
Cognitive Self-Control	
"If I have to get things done, I make a plan."	
Affective Self-Control (cf. goal orientation without anxiety)	
"I often imagine what will happen, if I don't get things done."	
Volitional Facilitation	
Initiative versus Hesitation	
"If there is something to be done, I start right away."	
Enactment versus Passivity (PAS)	.86
"I often postpone unpleasant things."	
Concentration versus Intrusions	
"My thoughts often wander."	
Self-Access	
Coping versus Rumination (RUM)	.77
"After unpleasant experiences I often cannot stop ruminating about them."	
Self-Access versus Alienation	
"When I am sad, I often lose the feeling of what I really want."	
Integration versus Fragmentation	
"In my behavior different sides keep becoming apparent."	
Life Stress	
Burden	
"Right now, my job is rather burdensome."	
Threat	
"I have to cope with many things that recently changed in my life."	

Note. Each subscale is based on four items.

Results

As the current cases-to-IVs ratio was very small, initially the smallest reliable, uncorrelated set of independent variables with respect to the dependent variable was created to reduce the number of independent variables entered in the multiple regression. Pearson correlations indicated that only SOF (r = .35, p = .04), SOD (r = .33, p = .05), and RUM (r = .43, p = .009) were significantly associated with depressive symptoms as assessed with the BDI. Furthermore, SOF was not significantly associated with SOD ($p > .12$) but significantly correlated to RUM ($r = .49$, $p = .003$), and RUM was not associated with SOD ($p > .10$). Therefore, a standard multiple regression was performed with BDI score as the dependent variable and SOD and RUM as independent variables.

Evaluation of statistical assumptions. Neither SOD, nor RUM showed significant skewness. Searching for outliers in the dependent variable and in the independent variables by examining the standardized values of the variables found one univariate outlier with respect to BDI score ($z > 3.0$). Multivariate outliers were searched using the independent variables as part of a regression run in which Mahalanobis distance of each case to the centroid of all cases was computed. Mahalanobis distance is distributed as the χ^2 variable, with degrees of freedom equal to the number of independent variables. To determine which cases are multivariate outliers, the critical χ^2 at the desired alpha level is determined. Here, critical χ^2 at $\alpha = 0.001$ for 2 *df* was 13.82. Thus, any case with a value larger than 13.82 was considered a multivariate outlier among the independent variables. No case was found meeting this criterion. None of the tolerances approached zero (> .93) and collinearity diagnostics detected no problems (all *VIF*s < 1.5)

Table 3

Standard Multiple Regression of SOD and RUM on BDI Scores in Nondepressed Individuals

Variables	BDI (DV)	SOD	RUM	*B*	β
SOD	.31*			.26	.22
RUM	.42**	.26		.53	.36*
M	5.40	7.60	8.69		
SD	3.59	3.00	2.45		

Note. BDI = Score on the Beck Depression Inventory; SOD = decision-related state orientation as assessed by the ACS; RUM = Score on the “Coping versus Rumination” subscale of the VCI. $R^2 = .22$; adjusted $R^2 = .17$; $R = .47^*$.
$^*p < .05$. $^{**}p < .01$.

Multiple regression. A standard multiple regression was performed wiht BDI score as the dependent variable and SOD and RUM as independent variables. Table 3 displays the correlations between the variables, the unstandardized regression coefficients (*B*s) and the standardized regression coefficients (βs). *R* for regression was significantly different from zero, $F(2, 32) = 4.54$, $p = .02$, with R^2 at .22. The adjusted R^2 value of .17 indicated that about a fifth of the variability in BDI score was predicted by SOD and RUM. Only the regression coefficient of RUM, however, differed significantly from zero indicating that only this variable contributed significantly to regression. This was confirmed by its 95% confidence interval which did not include zero as a possible value (confidence limits were

0.50 to 1.016). Altogether, 22% (17% adjusted) of the variability in BDI score was predicted by the SOD and RUM scores. The direction of the relationships suggested that more depressive symptoms are observed among individuals with a tendency for failure-oriented state orientation.

Discussion

The results of this first, preliminary study provide a description of individual differences in cognitive style related to symptoms of depression in subclinically depressed individuals. Of decision-related state orientation, determined by the Action Control Scale, and failure-oriented state orientation, assessed by the Volitional Component Inventory (cf. RUM), only RUM score was found to be significantly associated with an individual's level of depression. These findings are in line with the functional helplessness model of depression (Kuhl, 1981) as well as with the degenerated intentions hypothesis (Kuhl & Helle, 1986), and they replicate previous studies that demonstrate a strong relation between state orientation and depression (Hautzinger, 1994; Kammer, 1994; Kuhl & Helle, 1986; Rholes et al., 1989). The major contribution of the present study was to add further evidence that, in particular failure-oriented state orientation is associated with depressive symptoms and that failure-related state orientation measured by the RUM subscale of the VCI, rather than the SOF dimension of the ACS, is related to symptoms of depression.

In the present study, the effect of SOF on BDI was completely mediated by RUM score: the significant total effect of SOF on BDI (c_1 = –0.57, p = .04) was accompanied by a non-significant direct effect of SOF on BDI (c'_1 = –0.31, p = .31) and a significant indirect effect of SOF on BDI through RUM ($a_1 b_1$ = –0.27; confidence interval: –0.7488 to –0.0310). Apparently, the RUM subscale of the VCI is more precise in determining individuals' failure-related state orientation. This is probably due to the more differentiated 4-point scale answer options.

The multiple regression analysis of severity of depressive symptoms showed that higher levels of failure-related state orientation were significantly related to higher scores of depressive symptoms. This relationship suggests that a state-oriented personality style may be associated with enhanced depressiveness through its relation with an individual's ruminative thought patterns, rather than through its relation to an individual's hesitation and procrastination. This finding, although correlational, is consistent with the hypothesis that failure-oriented state orientation may be a risk factor for both the depressive reaction per se and for the thought patterns that help maintain it.

It might be argued that the current results are artifacts, insofar as the RUM scale may simply be an alternative measure of depression. There are two main reasons, however, against this argument.

First, the items comprising the RUM scale do not resemble those in the BDI. Items in the BDI largely assess symptoms of the depressive syndrome, namely feeling sad or blue, weight loss, lack of appetite, insomnia, feelings of guilt and disappointment, and self-criticism. The items in the RUM scale, by contrast, particularly aim to determine the difficulty to disengage from thoughts centering around past failure experiences such as "After unpleasant experiences I often cannot stop ruminating about them." (cf. Method section). Only two items of the BDI capture the phenomenologically accessible consequences of maladaptive thought processes, namely indecisiveness and lack of motivation/drive. Crucially, these two items are associated with decision-related state orientation and not with failure-related state orientation. Second, although the RUM score was significantly related to the BDI score, the RUM score was significantly correlated only to four of the BDI items, especially to lack of self-esteem. Such relations would not be expected if the RUM score and BDI score were assessing very similar constructs.

In contrast to failure-related state orientation, performance-related, and in particular decision-related state orientation, had a less marked or even no direct association with the level of depressive symptoms. That is, SOP was neither correlated to BDI, nor did SOD have significant power to predict BDI. Even the interaction between SOD and RUM was not significant ($p > .60$), suggesting that with respect to the level of depressiveness, for example action-oriented thoughts related to decisions did not compensate for failure-related, ruminative thought patterns. A separate regression of depressive symptoms onto SOD and PAS, however, showed evidence that SOD is also related to the level of depressive symptoms ($\beta = .64$, $p = .05$). The strong relationship between depressive symptomatology and failure-related state orientation, but not decision-related or performance-related state orientation, is in particular in favor of a functional process postulated earlier by which failure-related state orientation may work to bring about symptoms of depression: the inability of affected individuals to leave behind especially negative experiences and the resulting engagement of cognitive resources in capacity-reducing and change-preventing thought processes. The concept of failure-related state orientation introduced earlier emphasizes its ruminative character and its preoccupation with aversive experiences. Although it can only be speculated here, it seems plausible that specific altered patterns of brain function my underlie state-oriented individuals' inability to disengage from negative life events. Thus, failure-related state orientation may also be manifest in dysfunctional patterns of brain activity. Research on this issue would go a long way in advancing our understanding of individual differences in personality traits.

From the outset it was suggested that capacity-reducing effects of state-oriented cognitions may result in executive cognitive impairment often found to be associated with a depressive state. The current results lend support for the hypothesis that especially persistent thinking about past aversive experiences might be characteristic of the depressive state and that failure-related, state-oriented cognitions in particular might interfere with ongoing cognitive functioning. However, the current correlational design does not permit to decide whether state-oriented cognitions are indeed associated with impaired executive cognitive functioning and whether such impairments are related to depressiveness. Furthermore, the RUM scale does not allow to determine whether only failure-related, state-oriented cognitions are characteristic of a depressive state, or whether – although unlikely, given the evidence of negative information biases in depression – also success-related, state-oriented cognitions impair executive cognitive functioning in depression.

In summary, this study has identified a large contribution of a singe personality factor, namely failure-related state orientation, for predicting severity of depressive symptoms in subclinically depressed individuals. This result may have implications for cognitive theories of depression and for the study of depression vulnerability in general. With regards to the former, failure-related state orientation appears to be a promising factor for unraveling why some individuals develop depressive symptomatology when confronted with aversive life events, whereas others do not. Of course, other personality factors should also be investigated. Nevertheless, as proposed by Kuhl & Helle (1986), failure-related, state-oriented cognitions – by producing degenerated intentions – may be a "final common pathway" to various forms of depression. Regarding the study of vulnerability to depression in general, the findings reported here suggest that, on top of factors like optimism, explanatory style, social support, and exercise which are considered to be personal resources buffering the impact of aversive life events, specifically cognitive style in terms of failure-related action orientation should be added to the common list of resilience factors which can be used to determine an individual's risk of developing a major depressive disorder.

State Orientation and Depressiveness in Subclinically and Clinically Depressed Individuals (Study 1b)

The findings of Study 1a suggested that in subclinically depressed individuals depressiveness is associated with a state-oriented cognitive style, in particular with failure-related state orientation. Study 1b had two major objectives. First, the aim of this research was to replicate the findings of Study 1a in a sufficiently large sample of subclinically depressed individuals. Second, the current study aimed at examining whether state orientation is also related to depressiveness in clinically depressed individuals. In particular, based on the findings from Study 1a, it was expected that scales that capture an individual's failure-related state orientation, such as SOF and RUM, rather than scales capturing decision-related state orientation, i.e., SOD and PAS, would be related to depressiveness in MDD. The study samples analyzed in this section were provided by the Institute for Motivation and Personality Development Assessment Research and Training (IMPART) at the University of Osnabrück. Study individuals were (i) nondepressed individuals without any current DSM-IV Axis-I disorder and (ii) individuals diagnosed with dysthymia or MDD (according to DSM-IV). Again, the participants' personality styles were assessed using the ACS and the VCI subscales RUM and PAS. Depressiveness was assessed using the according subscale of the Personality Style and Disorder Inventory (Kuhl & Kazén, 2009).

Method

Participant characteristics and sampling procedure. The two study samples used in the current analyses were drawn from a larger data base provided by the IMPART. Participants in the present study were either clients of the IMPART who were being given personality coachings and who were not diagnosed with any psychological illness, or patients of psychotherapists in private practice diagnosed with dysthymia or depression. Individuals were included in the study if they had complete data on all relevant measures.This resulted in two samples of (a) 691 nondepressed individuals (372 men and 319 women) ranging from 17 to 64 years of age (M = 39, SD = 12) and 47 depressed individuals (18 men and 29 women) between the ages of 17 to 71 years of age (M = 40, SD = 12).

Measures, research design, and statistical analysis. The measure of individual differences in state orientation was identical to Study 1a. In the present study, however, depressiveness was assessed by the relevant scale of the Personality Style and Disorder Inventory (PSDI; Kuhl & Kazén, 2009). The PSDI is a self-scoring instrument that evaluates dispositional personality styles. The inventory consists of 140 items that are assigned to 14 scales. The 14 scales are designed to measure the non-pathological equivalents of those personality disorders defined by the DSM-IV and the International Statistical Classification of Diseases and Related Health Problems 10th Revision (World Health Organisation, 2004). Each item is rated on a 4-point scale, with "0" meaning the corresponding item does not fit the respondent at all, "1" somewhat, "2" largely, and "3" markedly. Scores are scaled so that low values represent a low markedness of the corresponding personality style. The 10-item scale *Passive (quiet) style and depressive personality disorder* (DPS) of the PSDI captures a rather passive basic attitude and a deepened experience of own and others' moods, a dampened experience of positive incentives, and a more contemplative than pragmatic attitude. The pathological equivalent of the passive personality style is the depressive personality disorder. This disorder is characterized by frequent attenuated positive affect, feelings of worthlessness and personal deficiencies, and a pessimistic perspective on life. People with this personality style are rather self-critical, often suffer from feelings of guilt, and have problems experiencing positive affect. In the present study, scores ranged from zero (passive personality style) to 12 (depressive personality disorder). The PSDI shows good accordance with a number of clinical and subclinical personality characteristics (e.g., suicidality, depressiveness, psychosomatic symptoms, Big 5, narcism). The reliability of the PSDI (Cronbach's α) varies between .73 and .85. Test-retest coefficients vary between .68 and .83.

Research design and statistical analysis were identical to those described in Study 1a, except for the fact that performance-related state orientation (cf. SOP) got left out in the current analysis, as the results of Study 1a indicated that this dimension of state orientation was neither connected to depressiveness nor to the other dimensions of state orientation.

Results

Subclinically depressed individuals. A standard multiple regression was performed between depressiveness (cf. DPS) as dependent variable and SOF, SOD, RUM, and PAS as independent variables. With 678 respondents and four independent variables, the number of cases was well above the minimum requirement for testing individual predictors in standard multiple regression. Preliminary screening was conducted through residuals. The results of the evaluation of statistical assumptions revealed negative skewness for SOF, SOD, and PAS, apparently due to a ceiling effect; relatively more individuals were state-oriented according to these scales. Considering the large sample size, however, no means were undertaken to transform the variables. The overall shape of the scatterplot for standardized residuals and standardized predicted values indicated no violation of the assumptions of regression and no strong outliers. Tolerance values were feasible (all > .40) and there were no problems with multicollinearity (all *VIP*s < 2.5).

Table 4 summarizes the correlations between the variables, the unstandardized regression coefficients (*B*s), and the standardized regression coefficients (βs) for the standard regression analysis conducted in the sample of subclinically depressed individuals. In this sample, *R* for regression was significantly different from zero, $F(4, 686) = 237.49$, $p < .001$, with R^2 at .58. The adjusted R^2 value of .58 indicated that more than half of the variability in DPS score was predicted by SOF, SOD, RUM and PAS. Of the four independent variables, SOF (β = .09), RUM (β = .59), and PAS

(β = .14) contributed significantly to regression. Again, the relationships suggested that more depressive symptoms are especially found among individuals with a tendency for failure-oriented state orientation, in particular measured by the RUM-scale.

Table 4

Standard Multiple Regression of SOF, SOD, RUM, and PAS on DPS Scores in Nondepressed Individuals

Variables	DPS (DV)	SOF	SOD	RUM	PAS	*B*	β
SOF	.55***					.09	.09*
SOD	.49***	.57***				.04	.04
RUM	.74***	.64***	.50***			.57	.59***
PAS	.50***	.37***	.70***	.50***		.14	.14***
M	4.79	7.87	7.11	6.46	5.55		
SD	3.20	3.36	3.53	3.32	3.12		

Note. DPS = Score on the depression scale of the PSDI; SOF = failure-related state orientation (cf. ACS); SOD = decision-related state orientation (cf. ACS); RUM = failure-related state orientation (cf. VCI); PAS = decision-related state orientation (cf. VCI).
R^2 = .57; adjusted R^2 = .57; R = .76***.
*p < .05. **p < .01. ***p < .001.

Individuals diagnosed with dysthymia or depression. A second standard multiple regression was performed between depressiveness (cf. DPS) as the dependent variable and SOF, SOD, RUM, and PAS as independent variables in individuals diagnosed with dysthymia or depression. With 47 respondents and four independent variables, the number of cases was too small for testing all individual predictors in standard multiple regression. Therefore, following the procedure applied in Study 1a, the smallest reliable, uncorrelated set of independent variables with respect to the dependent variable was created. Again, the correlational structure of dependent and independent variables revealed that this set consisted of SOD and RUM. The evaluation of statistical assumptions revealed no skewed independent variable. There were no univariate outliers (all zs < 3.0) and one multivariate outlier (critical χ^2 > 13.82). Tolerance values were feasible (all > .50) and there were no problems with multicollinearity (all *VIP*s < 2.0).

Table 5 depicts the correlations between the variables, the unstandardized regression coefficients (*B*s), and the standardized regression coefficients (βs) for the standard regression analysis in the sample of depressed individuals. *R* for regression was significantly different from zero, $F(2, 44) = 11.75$, $p < .001$, with R^2 at .35. The adjusted R^2 value of .32 indicated that a third of the variability in DPS score was predicted by SOD and RUM. Of the two independent variables, only RUM (β = .50, p = .001) contributed significantly to the prediction of depressiveness, and also in depressed individuals, more depressive symptoms were related to higher scores of failure-related state orientation.

Table 5

Standard Multiple Regression of SOD and RUM on DPS Scores in Depressed Individuals

Variables	DPS (DV)	SOD	RUM	*B*	β
SOD	.38**			.24	.18
RUM	.57***	.40**		.60	.50**
M	6.13	7.17	7.55		
SD	3.36	2.42	2.79		

Note. DPS = Score on the depression scale of the PSDI; SOD = decision-related state orientation (cf. ACS); RUM = failure-related state orientation (cf. VCI). R^2 = .35; adjusted R^2 = .32; R = .59***.
$^{*}p$ < .05. $^{**}p$ < .01. $^{***}p$ < .001.

Ancillary analyses. To test whether the impact of life stress, measured in terms of burden and threat (cf. VCI), on depressiveness may be moderated by failure-oriented state orientation, depressiveness was first regressed on scores for burden and threat, separately in the subclinically and clinically depressed sample. These analyses revealed that in both samples only the level of perceived burden significantly predicted level of depressiveness (subclinically depressed: β = .52, p < .001; clinically depressed: β = .50, p = .004). Next, separate moderation analyses were conducted for both samples, testing for an interaction between burden and RUM in predicting depressiveness (Hayes, 2012). Analyses revealed a marginally significant interaction in the large sample of subclinically depressed individuals (c_3 = 0.01, t(691) = 1.66, p = .10). Simple slopes revealed that in this sample high levels of burden resulted in higher levels of depression in particular when a failure-related cognitive style was present (cf. Figure 1).

In an additional regression model, all measures for the different types of state orientation together explained an additional 58% of the variance in DPS score after having controlled for age and gender. SOF (β = .09, p = .01), PAS (β = .15, p < .001), and RUM (β = .58, p < .001) emerged as significant correlates in explaining depression. Slightly different from the results in the subclinically depressed population, in the clinically depressed sample, the additional regression analysis showed that after taking into account variance due to age and gender, measures for state orientation explained an additional 28% of the variance in DPS score. Here, RUM emerged as the only significant predictor of depressive personality style (β = .43, p = .01).

To further characterize individuals, who respond with state-oriented cognitions specifically to aversive life experiences (“Brooders”), the sample of subclinically depressed individuals was divided into Brooders and “Copers” based on a median split with respect to RUM score. Afterwards, a forward stepwise binary logistic regression was computed. This procedure includes the predictor variables one at a time in the model according to a χ^2 statistic and an acceptable significance value. It is possible that predictors priorly chosen are discarded in a subsequent step, if they do not sufficiently contribute to group classification. Thus, the procedure finds the (a-theoretical) best solution for the classification problem. For the purpose of the current study, the scores of the subscales of the VCI were used as predictors in the model. Of all subscale scores only (a) “Concentration versus Intrusions”, (b)“Self-access versus Alienation”, and (c) “Self-Relaxation” were included in the final model. All other variables were dropped by the algorithm due to their poor contribution. The final model was significant and correctly classified 82% of the individuals, $\chi^2(3, N = 691) = 396.88$, $p < .001$, Nagelkerke $R^2 = .58$; Concentration: $B = 0.26$; Self-Access: $B = 0.36$; Self-Relaxation: $B = –0.28$.

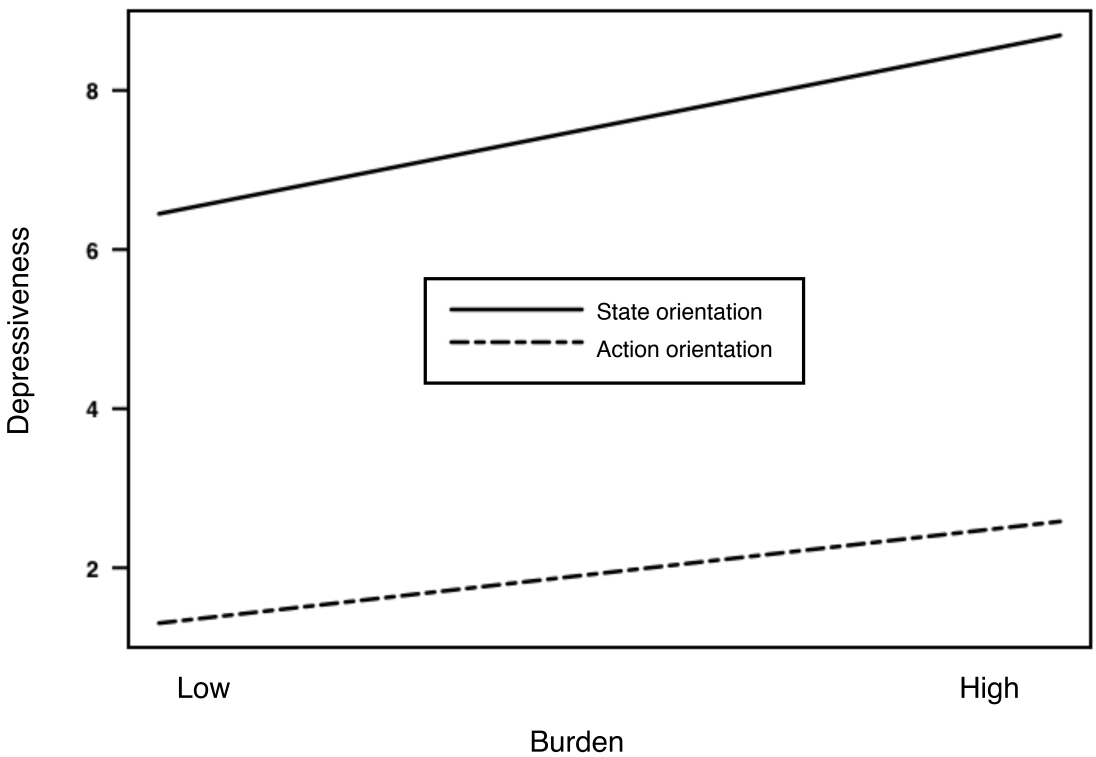

Figure 1. Failure-related state orientation (cf. RUM) moderates the relationship between life stress (cf. burden) and depressiveness (cf. DPS score). Visualization is implemented using the Johnson-Neyman technique for probing interactions. Data for visualizing the conditional effect of burden on depressiveness are based on the mean centered metric of burden and the model-based predicted values of depressiveness.

Discussion

In accordance with expectations, the results of Study 1b confirmed the strong relationship between a state-oriented cognitive style and level of depressiveness in a large sample of subclinically depressed individuals. Again, in particular failure-related state orientation as assessed by the RUM subscale of the VCI significantly predicted level of depressiveness above all other measures of state orientation. Furthermore, the findings of the present study demonstrate that also in clinically depressed individuals ruminative, failure-related state orientation (cf. RUM) is strongly associated with severity of depression. The findings from this study therefore further underline the potential importance of personality factors in adult MDD.

Previous research suggested that state orientation is more related to depressive symptoms than to symptoms of anxiety or to self-consciousness in general (Kammer, 1994). Several studies reported a significant correlation between state orientation and depression (Kammer, 1983; Kuhl, 1985; Rholes et al., 1989; Watkins & Brown, 2002) which is confirmed in the current study and in Study 1a. In the present study, the strongest association between state orientation and depressiveness was found for the failure-related manifestation of this cognitive style, which is also in line with previous findings (Kammer, 1994; Kuhl & Helle, 1986). The observation that failure-related state orientation may function as a marker for vulnerability to depression, whereas decision-related state orientation does not, or not as much, may be at least partly explained by the fact that decision-related state orientation may capture, in general, all thought processes that prevent an effective action control – including cognitions related to previous failure – whereas failure-related state orientation specifically records coping with negative life events, which must be considered a hallmark of the depressive disorder (Lazarus, 1993). A mediation analysis (cf. Hayes, 2012) indeed confirmed the mediating role of failure-related state orientation for the relationship between decision-related state orientation and depression. In this analysis, the total effect of PAS on DPS was statistically different from zero ($c_1 = 0.51$, $p < .001$). Importantly, in addition to a significant direct effect of PAS on DPS ($c'_1 = 0.18$, $p < .001$), there was also a significant indirect effect of PAS on DPS through RUM, $a_1 b_1 = 0.34$ (confidence interval: 0.2880 to 0.3950).

In general, state-oriented individuals have been previously described as having a focus on past, current, or future mental states, whereas low scores on state orientation are associated with a cognitive style that focuses on action alternatives and solutions to problems (Kammer, 1983; Kuhl, 1985; Rholes et al., 1989; Watkins & Brown, 2002). Cognitions typical of state orientation include causal attributional activities, cognitions related to self-evaluation, cognitions closely tied to the emotions associated with the current situation, or, in some cases, a static, “nonelaborative ‘reharshing’ of the situation” (Rholes et al., 1989, p. 264). State-oriented individuals may go through alternative actions plans again and again producing difficulties in initiating new actions. Or, particularly for “Brooders”, there is a preoccupation with the analysis and evaluation of past successes and failures. They tend to think analytically and to reflect on the causes and consequences of a preceding event. Brooding becomes an end in itself, rather than a means to effective action. Attention gets stuck on the analysis of one's current situation: new goals are no longer defined, alternative strategies are no longer developed. Thus, an individual prone to failure-related state orientation is most likely best characterized by his or her inability to let go of past aversive experiences, or in other words: his or her ability in coping with aversive experiences is impaired.

The present study was conducted among both a large sample of subclinically depressed individuals and a smaller sample of clinically depressed individuals which may allow to draw more general conclusions from the current results. The results from the subclinically depressed sample reflect adults with non-elevated depressive symptoms. These adults are individuals, who apparently are not strongly state-oriented after failure. At first glance, these individuals may simply display a strong reflective capacity, which may not inevitably make them more vulnerable to depression. However, the present findings again demonstrate that a strong relation between failure-related state orientation and depressiveness also holds for subclinical manifest depressive symptoms.

Determining the specific characteristics of Brooders deserves further investigation. In the current study, results from an ancillary binary logistic regression analysis concerning the differences in volitional functioning between Brooders and Copers, revealed that the only volitional processes that discriminated between the two groups were Concentration, Self-Access, and Self-Relaxation. The indication that scores on Concentration discriminate between Brooders and Copers is expected, insofar as Concentration measures the ability to hide distractions, from outside or from within (here, especially irrelevant thoughts), which is characteristic of action orientation in general. Self-Access and Self-Relaxation, however, are not readily interpretable. The significance of Self-Access has been implicated in a study that demonstrated that chronic attempts to force oneself into performing falsely self-referred intentions and the resulting tremendous self-regulatory efforts to overcome self-congruent emotions not compatible with those intentions can exhaust an individual so much that a depressive episode may result (Kuhl & Kazen, 1994). Thus, an impaired access to authentic needs and goals may result in Brooders constantly replaying aversive experiences, because they lack the standard by which they could integrate those experiences in the wider context of their entire wealth of experience. Self-Relaxation also emerged as a strong predictor discriminating Brooders and Copers indicating that the ability to calm oneself down in the face of nervousness, excitement, or tension is essential to prevent a state-oriented response to stressful life events. An obvious, possible explanation for this domain being a significant predictor for a brooding cognitive style, may be that individuals who have available strategies to reduce the impact of acute stressful situations may also be able to calm the flood of thoughts and thereby stop the debilitating impact of the “spinning mind”. Individuals’ self-relaxation capacity may therefore function as the resilience factor behind Coper’s failure-related action orientation and may increase Brooders’ vulnerability to depression. The possible significance of additional action control processes for the link between state orientation and depression as reflected in these latter findings, together with the observation that, in the current study, the different kinds of state orientation pooled together still left a large proportion of variance in depressiveness unexplained indicate that there may be other important personality factors that need to be considered to be able to better predict depressiveness. In sum, the assessment of the characteristics of Brooders, that is, of individuals who show a state-oriented cognitive mind set when confronted with negative experiences, is an intriguing opportunity to study the vulnerability to depression in a different light, and needs further investigation.

In conclusion, by considering correlational findings concerning the link between state-oriented cognitions and depressiveness, the present study found additional support for the functional significance of the spinning mind as a factor affecting the severity of a depressive illness. The theoretical framework alluded to in the introduction focuses on depression and its link to state-oriented cognitions. This is only one psychological process that may be relevant for the depressive disorder, but as a common psychological mechanism underlying a variety of other psychological determinants of depression, state orientation may nevertheless be closely related to other relevant psychological processes (e.g. self-esteem, motivation, attachment styles, guilt and shame) and as such may also even be associated with a common neurobiological process of the depressive illness. The delineated characteristics of Brooders may aid in furthering the research on vulnerability factors for depression. Importantly, the impact of several different volitional processes on an individual’s level of state orientation as demonstrated in the current study, emphasizes that with respect to predicting depressiveness from psychological variables related to action control, definite conclusions cannot be drawn and therefore the results of the present study must be regarded as preliminary.

State Orientation as Major Factor in Distinguishing Depressed Individuals From Nondepressed and Anxious Individuals (Study 1c)

A number of studies have suggested that a state-oriented cognitive style may make an individual susceptible to developing a depressive disorder (see, e.g., Kammer, 1994; Nolen-Hoeksema, 1998). This study considers the importance of state orientation as an illness-provoking conditioner of

MDD. Therefore, the proposition of this study is that individuals suffering from a depressive disorder have a cognitive style differentiating them from people who are not depressed. Specifically, based on the findings of previous research and based on the results of Studies 1a and 1b, this difference in cognitive style was predicted to be best characterized by *failure-related state orientation*. However, although previous results indicate that depression is strongly associated with a state-oriented cognitive style, it is possible that state orientation is only a valid discriminator with respect to affective disorders in general and is not specifically able to characterize the depressive disorder. In Study 1c, the predictive power of state orientation was tested in a study sample including clinically depressed individuals, patients suffering from anxiety disorder, patients suffering from anxiety and depression and nondepressed patients. In this way, the predictive power of state orientation to distinguish depressed patients from nondepressed patients, as well as the predictive power of state orientation to distinguish between depressed patients and patients suffering from anxiety disorder, could be tested. Again, existing data were reanalyzed. This time, data were provided by the Institute of Psychology at the University of Osnabrück and by Prof Soledad Cordero. It is important to note that although state orientation was the primary concern of the study reported here, other variables may well differentiate depressed and nondepressed individuals, or depressed and anxious individuals. These could include a variety of social, physiological, environmental, and other psychological mediators.

Method

Participant characteristics and sampling procedure. The sample was part of an existing database at the Institute of Psychology at the University of Osnabrück used in the dissertation project of S. C. The sample consisted of 56 men and 69 women between the ages of 17 and 71 (M = 40.5, SD = 12.1). An overview of diagnoses is provided in Figure 2. Participants were diagnosed with a current depressive symptomatology (n = 15), with current anxiety disorder (n = 13), or comorbid depressive and anxiety symptomatology (n = 47). Fifty participants had neither depressive nor anxiety symptoms. Participants were recruited from three clinics and two psychotherapeutic practices. Two of the clinics were specialized in dermatology (n = 55) and one in alcohol dependency (n = 16). From the two psychotherapeutic practices participants, with different affective and personality disorders were recruited (n = 54).

Measures, research design and data analysis. As in Study 1b, state orientation was assessed by the ACS, and the RUM and PAS subscales of the VCI and depressiveness was measured by the DPS scale of the PSDI. Anxiety was assessed according to the subscale of the Symptom-Checklist (SCL;

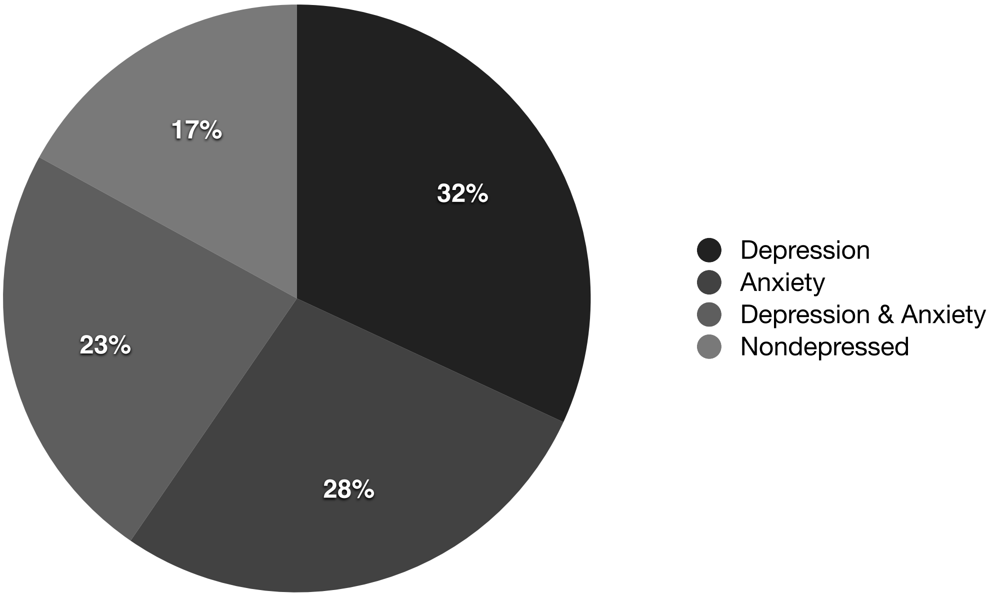

Figure 2. Proportions of diagnoses in the study sample of Study 1c.

Derogatis, 1983; Franke & Stäcker, 1995), a frequently used inventory to assess psychological distress. The SCL is a self-report questionnaire that was designed to assess psychological symptoms of psychiatric and medical patients. Respondents are asked to report the extent to which they have experienced various psychological symptoms within the past seven days using a 5-point Likert scale ranging from 0 (“not at all”) to 4 (“extremely”) (Bruce & Arnett, 2008). The inventory consists of 90 items, ten of which constitute the subscale “Anxiety” (ANX). The ANX score measures the level of nervousness, tension, worry, and panic. The SCL subscales have demonstrated good internal consistency (.77 to .90) and sufficient test-retest reliability (.78 to .90) (Payne, 1985). All measures were collected as part of the anamnesis. A quasi-experimental research design was used: individuals were assigned to either depression, anxiety, comorbid depression and anxiety, or nondepressed group based on the available diagnoses. To determine the relation between different types of state orientation and depression, group differences in mean scores on measures for state orientation were compared using a one-way multivariate analysis of variance (MANOVA) with SOD and RUM as dependent variables. These two measures for decision-related, or failure-related state orientation respectively, were chosen according to the results of Studies 1a and 1b. Subsequently, separate discriminant function analyses were performed to determine how well SOD and RUM scores discriminated (a) depressed and nondepressed patients and (b) depressed and anxious patients.

Results

In total, 125 participants were analyzed for this study. Participants were recruited during a period of ten months from June 2001 to April 2002. Participants' demographics and personality characteristics are presented in Table 6. The groups did not differ in age or gender (*p*s > .50). Except for the comparison between nondepressed and anxious individuals, however, all post hoc pairwise comparisons were significant with regards to DPS score (all *p*s < .01). Specifically, depressed individuals demonstrated higher depressiveness than nondepressed or anxious individuals and individuals suffering from comorbid depression and anxiety displayed the highest depressiveness of all groups. In the whole sample, both SOD and RUM showed a highly significant positive relationship to DPS score (*p*s < .001) and also a strong positive association to one another ($r = .55$, $p < .001$).

Evaluation of statistical assumptions. Two cases had missing values. Thus, the full data set included 123 cases. The group assignment resulted in four groups with different numbers of cases (48, 13, 15, an 47). Therefore, type III of sum of squares were chosen in the MANOVA. Only in the nondepressed group did RUM show positive skewness, as its skewness fell within the range of minus twice the standard error of skewness to plus twice the standard error of skewness. Transformation of this variable was not considered necessary. The inspection of the bivariate scatterplots of SOD and RUM for each group revealed a positive linear relationship between variables. One case was a univariate outlier on the RUM scale ($z > 3.0$). Multivariate outliers were identified as cases with too large Mahalanobis D^2 for their own group, evaluated as χ^2 with degrees of freedom equal to the number of predictors. Applying a critical χ^2 of 13.82 (2 *df* at $\alpha = .001$) found no multivariate outliers in any of the groups. In no group were problems with multicollinearity detected (both *VIF*s < 1.2).

Table 6

Demographics and Personality Characteristics for Participants in Study 1c, by Group

	Nondepressed (n = 48)	Depressed (n = 15)	Anxious (n = 13)	Comorbid (n = 47)	F/χ^2	p
Demographic characteristics						
Age, M (SD)	41 (11)	40 (12)	38 (17)	41 (12)	.18	.91
Female, n (%)	50	48	62	62	2.00	.57
Personality characteristics						
DPS, M (SD)	47.8 (4.52)^{a}	54.4 (4.63)^{bc}	45.1 (1.98)^{ad}	61.0 (8.95)^{ef}	76.45	$<$..001

Note. DPS = standard scores of the depressive personality style scale as assessed by the PSDI. Groups with different superscript letters are significantly different in post hoc pairwise tests.

Group differences in state orientation. To examine group differences in mean scores on measures of state orientation, a one-way MANOVA was conducted. The full model of the MANOVA was significant (Λ = .46, $F(6, 234) = 18.84$, $p < .001$, cf. Table 7). Tests of between-subjects effects indicated that the groups differed significantly on both measures of state orientation (SOD: $F(3, 118) = 19.17$, $p < .001$, $\eta_p^2 = .33$; RUM: $F(3, 118) = 38.90$, $p < .001$, $\eta_p^2 = .50$). Bonferroni-corrected post hoc pairwise comparisons revealed that nondepressed patients were less state-oriented than all other groups on both dependent variables (all *p*s < .05). Anxious individuals and depressed individuals did not differ on SOD or RUM (*p*s > .80).

Predicting group membership. Discriminant function analyses were performed to determine how well SOD and RUM discriminated (a) depressed individuals from nondepressed individuals, (b) depressed individuals from individuals suffering from anxiety disorder, and (c) anxious individuals from patients suffering from comorbid anxiety and depressive disorder. The discriminant function that distinguished depressed from nondepressed individuals had a canonical correlation of .62, Wilks' $\lambda = .61$, $\chi^2(2, N = 63) = 28.64$, $p < .001$. Table 8 shows the correlations between the discriminating variables and the canonical discriminant function with the variables ranked according to the magnitude of their loading on the function. The function was especially defined by the positive loading of RUM. The discriminant function correctly classified 79% of the nondepressed individuals and 80% of the depressed individuals. The overall correct classification rate was 79%. The classification results are shown in Table 9. Analyses further revealed that RUM and SOD could not predict group membership for depressed and anxious individuals better than chance (54% of cases correctly classified). The corresponding discriminant function had a canonical correlation of .17, Wilks' $\lambda = .97$, $\chi^2(2, N = 28) = 0.75$, $p > .60$. However, the discriminant function that distinguished depressed from comorbid individuals was significant: canonical correlation of .39, Wilks' $\lambda = .85$, $\chi^2(2, N = 59) = 8.99$, $p = .01$. This discriminant function was also especially defined by the strong loading of RUM ($c = .76$) and a weaker loading of SOD ($c = .45$). The function correctly classified 69% of individuals.

Table 7

Means, Standard Deviations, and MANOVA for Effects of Group on SOD and RUM

	Nondepressed group (NDP; n = 48)		Depressed group (DP; n = 15)		Anxiety group (ANX; n = 13)		Comorbid group (COM; n = 46)			
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	$F(3, 118)$	Contrasts[a]
SOD	11.5	11.5	23.0	9.7	20.9	10.6	27.0	8.4	19.17***	NDP < DP, ANX, COM
RUM	14.3	6.9	27.3	10.3	24.6	7.8	32.1	8.6	38.90***	NDP < DP, ANX, COM; ANX < COM

Note. SOD = decisions-related state orientation (cf. ACS); RUM = failure-related state orientation (cf. VCI). MANOVA: $\Lambda = .46$, $p < .001$.
[a]Using Bonferroni-corrected post hoc pairwise comparisons.

Table 8

Discriminant Analysis of Study Groups in Study 1c (Nondepressed versus Depressed)

Predictor variable	Correlations of predictor variables with discriminant function	Univariate *F*(1, 61)	Pooled within-group correlation among predictors
RUM	.92	31.59	.39
SOD	.57	12.31	

Note. RUM = failure-related state orientation (cf. VCI); SOD = decision-related state orientation (cf. ACS).

Table 9

Classification Table for Study Groups in Study 1c (Nondepressed versus Depressed)

		Predicted group			
		Nondepressed		Depressed	
Actual group	*n*	*n*	%	*n*	%
Nondepressed	48	38	79	10	21
Depressed	15	3	20	12	80

Ancillary analyses. To further determine the specificity of failure-related state orientation in predicting depressiveness, a hierarchical multiple linear regression analysis was conducted between failure-related state orientation and depressiveness (cf. DPS score), controlling for the level of anxiety. First, ANX scores were entered as a predictor in a first block. Next, RUM scores were entered into the regression analysis in a second block. It is important to note that ANX scores were available only for part of the study sample (N= 55: nondepressed (n = 24); anxiety disorder (n = 7); depressive disorder (n = 5); comorbid anxiety and depressive disorder (n = 19)). The resulting regression analysis revealed that the two predictors explained 58% of the variance in depressiveness (R^2 = .59, $F(1, 52)$ = 60.90, p < .001). It was found that both predictors independently predicted depressiveness (ANX: β = .19, p = .05; RUM: β = .71, p < .001). A follow-up moderation analysis found no significant interaction effect between both predictors (p > .80). Crucially, RUM predicted depressiveness even after controlling for the predictive power of ANX (ΔR^2 = .48, $F(1, 52)$ = 60.90, p < .001).

To further examine personality dispositions specific to depressed in comparison to nondepressed patients, two groups were formed; nondepressed and anxious patients constituted the new "nondepressed" group (*n* = 61), and depressed and comorbid patients formed the new "depressed" group (*n* = 61). Afterwards, a forward stepwise binary logistic regression was computed (cf. Study 1b). In this analysis, the scores of all subscales of the Personality Style and Disorder Inventory (PSDI; Kuhl & Kazén, 2009) were used as predictors in the model. When DPS score was kept as predictor in the model, this score alone classified all individuals correctly as belonging to the nondepressed or depressed group respectively ($\chi^2(1, N = 122) = 169.13$, $p < .001$, Nagelkerke $R^2 = 1.00$). When DPS score was excluded from the list of possible predictors, the algorithms determined two personality factors that together correctly classified 82% of cases. The first predictor captured the dimension "Spontaneous personality style versus emotionally unstable personality disorder" (ICD-10: F60.3), $B = 0.13$, $Wald(1) = 13.61$, $p < .001$, whereas the second predictor assessed the dimension "Self-critical personality style versus anxious (avoidant) personality disorder" (ICD-10: F60.6), $B = 16$, $Wald(1) = 14.68$, $p < .001$; final model: $\chi^2(2, N = 122) = 69.99$, $p < .001$, Nagelkerke $R^2 = .58$. In both groups, these two predictors showed a highly significant positive relation to failure-related state orientation (cf. RUM): emotionally unstable personality: nondepressed: $r = .55$, $p < .001$; depressed: $r = .46$, $p < .001$; self-critical personality: nondepressed: $r = .50$, $p < .001$; depressed: $r = .36$, $p = .005$. Computing analog partial correlations, controlling for variance due to depressiveness, found a significant relationship between RUM and emotionally unstable and self-critical personality respectively only in nondepressed individuals.

Discussion

In the present study, individuals diagnosed with depressive disorder or with comorbid anxiety and depressive disorder had elevated levels of depressive symptomatology compared to nondepressed patients and patients suffering from anxiety disorder. Of all groups, patients suffering from comorbid anxiety and depressive disorder showed the most pronounced level of depression. Interestingly, anxious patients and nondepressed patients did not differ in their level of depressiveness. The results of the current study confirmed that with growing depressiveness from nondepressed via anxious and depressed patients, trough to patients suffering from comorbid anxiety and depressive disorder, levels of state orientation were constantly increasing. Overall, depressed patients displayed a greater degree of failure-related, as well as a greater degree of decision-related, state orientation compared to nondepressed individuals. Likewise, comorbid patients showed a greater disposition toward both kinds of state orientation compared to patients suffering from anxiety disorder alone. The hypothesis that depressed patients should be distinguishable from patients suffering from anxiety disorder based on their levels of state orientation was only partially supported, despite significant differences in depressive severity between these groups. Most probably, the according non-significant discriminant function was the result of the small group sizes. As results demonstrated that comorbid patients and anxiety patients could be discriminated by their respective RUM score, and since RUM score was found to predict the level of depressiveness independently of the level of anxiety, the current study suggests that failure-related state orientation is indeed specifically related to depressive disorders and not to affective disorders in general. Thus, the current results suggest that patients suffering from a depressive disorder share distinct personality characteristics relative to nondepressed or anxious patients, in particular a tendency toward a state-oriented cognitive style after failure experiences.

To date, only very few studies investigated state orientation in major depressive disorder and even less studies are available that examined state orientation in depression over time. For state orientation in general, Rholes et al. (1989) found that this cognitive style is associated with higher BDI scores. In addition, and in good accordance to the current results, findings of Keller et al. (1994) suggested that depressed individuals' level of depressiveness may be most strongly linked to failure-related state orientation. And indeed, until now most studies which have analyzed depressed populations with respect to their level of state orientation, have reported a similar personality disposition towards failure-related state orientation in depressed individuals (cf., e.g., Kammer, 1994; Kuhl & Helle, 1986). In one of the few longitudinal studies on the topic, Hautzinger (1994) reported a decrease in state orientation in depressive patients when in remission. However, despite their improvement, formerly depressed individuals were still more state-oriented than healthy control participants. In line with this, Spasojević & Alloy (2001) demonstrated that ruminative thinking may act as a general proximal mechanism through which other vulnerability factors affect depression.

Previous findings in patients with depressive illness suggested that the depth of depression may be affected by a number of personality measures. For instance, neuroticism, extraversion, emotional stability, self-confidence, and sociability were observed to be significantly associated to the depressed state (cf. Enns & Cox, 1997). Enns & Cox (1997) emphasized the role of neuroticism, at the core of which is a high sensitivity to negative stimuli combined with emotional instability, to be a powerful predictor of depression. Ingram (1990) reported that depression is strongly associated with an increased level of self-focused attention, and Zaretsky et al. (1997) and Freudenstein et al. (2012) demonstrated that self-criticism, perfectionism and narcissism are also strongly related to depressiveness. These observations are consistent with findings of the current study. On scales which reflected self-criticism and emotional instability, patients with a diagnosed depressive disorder scored higher than patients without diagnosed depression. Both of these personality dispositions were strongly associated with failure-related state orientation, specifically suggesting a distinct path both from concerns about negative external assessment (cf. self-criticism) as well as from unstable self-perception and mood (cf. emotional instability) to symptoms of depression through a state-oriented cognitive mind set after aversive life experiences. This link could indeed be confirmed in two mediation models that demonstrated that the impact of self-criticism ($a_1 b_1 = 0.30$; confidence interval: 0.1861 to 0.4499) as well as the impact of emotional instability ($a_1 b_1 = 0.28$; confidence interval: 0.1735 to 0.4370) on depressiveness was mediated by failure-related state orientation (cf. RUM). Interestingly, in the current study, depressiveness was not significantly related to a narcissistic personality style, ($r = .09$, $p = .35$), whereas failure-related state orientation showed a strong relation to narcism, ($r = .09$, $p = .35$). However, here again, RUM mediated the relationship between personality disposition and depressiveness; the indirect effect of narcism on depressiveness via RUM of $a_1 b_1 = 0.23$ was significant (confidence interval: 0.0951 to 0.4265). Thus, the results of the current study provide good support for the notion that a disposition for a state-oriented cognitive style together with a tendency for self-critical, emotionally unstable responses to day to day life challenges may be a stable pattern of personality attributes in patients suffering from MDD. If this assumption is valid, then a state-oriented cognitive style in response to negative life events may indeed be considered a risk factor for depression. Ultimately, the specific kind of state-orientation present could even be expected to influence the type of depressive disorder by facilitating specific maladaptive, change-preventing thought processes.

In summary, this study reports personality dimensions in clinical patients suffering from a depressive disorder. Depressed patients differed from nondepressed patients and from anxious patients principally by displaying a greater degree of failure-related state orientation, in being more self-critical, and in being emotionally unstable. Two important limitations need to be taken into account when interpreting the results. First, the study could not control for the effects of a past illness on the personality, and second, the study represents a cross-sectional rather than a longitudinal assessment. Nevertheless, the findings are consistent with the literature and support the hypothesis that state-oriented cognitions associated with critical self-evaluations and emotional instability may be risk factors for developing a major depressive episode. It is important to note, however, that these personality characteristics may not be enough to explain the variety of core psychopathological phenomena involved in MDD, such as sad mood, anhedonia, insomnia, reduced libido, loss of weight, fatigue, feelings of guilt and worthlessness. They ought to be viewed instead as personality characteristics which may facilitate the development, and sustain the process, of a major depressive disorder.

Chapter 3: Impaired Executive Cognitive Functioning in Depression and its Link to Sustained Information Processing and State Orientation (Study 2)

State orientation, as previously defined, consists of sustained, recurring thoughts that revolve around a common theme. In line with the results of several previous studies (Joormann, 2006; Kammer, 1994; Kuhl & Helle, 1986; Nolen-Hoeksema, 1998; Watkins & Baracaia, 2002), the results of Studies 1a – 1c suggest a close relationship between a state-oriented cognitive mind set and depressiveness. A study reviewed by Stiensmeier-Pelster & Schürmann (1994) exemplarily demonstrated a reduction of manifest depressive mood during a six-month psychiatric treatment. Crucially, therapy was increasingly more successful the more the patients showed a decrease in state orientation. Thus, it seems plausible to assume that state orientation is an important vulnerability factor for MDD.

It is a well replicated finding that MDD is characterized by state-oriented, ruminative thoughts that involve negative, self-deprecating content and pessimistic ideas about the self, the world, and the future. Importantly, state-oriented cognitions are persistent, recurring thoughts that revolve around a common theme. These thoughts unintentionally enter consciousness, thereby shifting attention away from relevant themes and current goals. Depressed individuals' cognitive resources may therefore be strained by competing ruminative thoughts from which they have difficulty disengaging. In line with this, findings cited by Kammer (1994) suggested that inefficiency of emotion control may be a central part of the link between state orientation and depression. Kammer (1994) demonstrated that depressed individuals have more cognitions related to expressions of negative emotions and non-evaluative descriptions of subjective state, than task-relevant cognitions related to correcting action or expression of positive emotions during ongoing failure. Moreover, in a series of studies, Kuhl (1985) provided evidence for a link between state orientation and processes of executive control. In a test in which subjects were asked to memorize words on cards that were in a square and to disregard words on a circle simultaneously presented on the cards, action-oriented individuals recognized fewer "irrelevant" words than state-oriented individuals, suggesting impaired selective attention in state-oriented individuals. In another study, subjects had to decide on a set of dices that would maximize their pay-off. While action-oriented individuals focused on information relevant only to their needs, state-oriented individuals took all available information under consideration. Findings suggested that action orientation is more associated with parsimonious processing of decision-related information than state orientation. With regards to motivation control, in a different study, action-oriented individuals increased their subjective value of a tentatively chosen alternative in an experiment in which house seekers had to decide on an apartment from a list of alternatives. The results of this study indicated that state-oriented individuals attend relatively less to incentive-related information. Also with respect to emotion control, findings demonstrated a link to state orientation: in a sample of hospitalized patients who underwent a hernia operation, state-oriented individuals reported higher pain levels and engaged less often in change-oriented activities than did action-oriented individuals. At the same time, state-oriented patients requested significantly more analgesics and tended to be more passive and contemplative than action-oriented patients.

This line of research provided insights into the effects of state orientation on cognitive functioning, and further emphasized a possible role of state orientation as a cognitive vulnerability factor in depression. However, some important questions remained unanswered. In particular, very few studies so far have investigated which underlying processes might be responsible for the stable individual differences in state orientation that have been reported. Given the observation that state orientation predicts depressive symptoms in clinically and subclinically depressed individuals, it seems particularly important to ask what mediates the debilitating effects of state-oriented, ruminative thought on cognitive performance. Overall, it remains unclear why state-oriented individuals are likely to show depressive symptomatology and the associated impaired executive cognitive functioning.

In an early study, Kuhl & Helle (1986) demonstrated that currently depressed people have an impaired working memory capacity after a "degenerated intention" is induced. Furthermore, Kuhl & Helle (1986) found that depressed individuals also less often remember a current intention after a degenerated intention is induced, independently of current depressive symptoms. These findings were similiar when BDI score as the grouping variable was replaced by the patients' SOF score. In good accordance with these findings, Watkins & Brown (2002) demonstrated that, when ruminations are induced, depressed people indeed show impairment of executive cognitive functioning. However, if depressed patients were distracted from ruminative thinking, they did not display impairments in executive functioning. Watkins & Brown (2002) instructed subjects either to write about causes, reasons, and meanings for their performance and their feelings in a preceding, failure-inducing task, or to write about their direct experience. The former instruction resulted in a greater number of manipulation-related intrusions during the subsequent cognitive task. Importantly, however, in this study, a state-oriented cognitive style increased manipulation-related intrusions independently of writing condition; moreover, both effects occurred after controlling for levels of depression, indicating that state-oriented cognitions, as well as dispositional state orientation are predictors of failure-related intrusions independently of depressiveness. In the same vein, Kuhl (1985) had previously demonstrated that the role of state orientation as a factor moderating the inhibiting effect of exposure to failure occurs over and above the effect of anxiety. Similarly, the results of Watkins & Brown (2002) again demonstrated that ruminations reduce the capacity of executive cognitive functioning, presumably because they compete for processing capacity. However, their results also suggested that ruminative thinking may be at least temporarily reversible. Lyubomirsky & Nolen-Hoeksema (1995) and Lyubomirsky et al. (1999) obtained results supporting the latter conclusion. They found that dysphoric individuals who were distracted from their ruminative thought were as effective in problem solving as non-dysphoric individuals. Therefore, it was suggested that central executive functioning may actually be essentially normal in depressed patients and does not function less efficiently or show reduced capacity, but rather that rumination once triggered "draws resources from the executive interfering with concurrent capacity demanding cognitive tasks" (Watkins & Brown, 2002, p. 400). Importantly, Watkins & Brown (2002) also found that the capacity-reducing effects of task-irrelevant intrusions lasted for the first twelve hours after the failure experience. Similarly, another experimental study was able to demonstrate that capacity-reducing effects of state-oriented ruminations may continue to impair executive cognitive functioning in patients recovered from depression (Watkins & Baracaia, 2002).

Overall, the research reviewed above has significantly increased the understanding of the short-term (and possibly long-term) consequences of state orientation. These data suggest that state orientation has debilitating effects on executive cognitive functioning. State-oriented cognitions may weaken cognitive performance by capturing attention and cognitive resources, thereby preventing these resources from being allocated to demanding tasks. In other words, difficulty in depressed individuals to allocate their cognitive resources in a controlled fashion might be the reason for impaired cognitive performance. This idea has already previously been formulated by Kuhl (1981) in terms of "functional helplessness", that is to say the idea of capacity-reducing effects of uncontrollable, task-irrelevant thoughts that interfere with ongoing executive cognitive functioning. Consequently, when circumstances allow the intrusion of task-irrelevant thoughts, depressed and nondepressed individuals may show comparable executive cognitive performance when depressed individuals are provided with specific goals and strategies to help them concentrate and direct their attention. Levens et al. (2009), using a dual task paradigm, was able to demonstrate that depressed individuals who showed the strongest tendency for a state-oriented cognitive style exhibited the greatest impairment in the controlled allocation of cognitive resources under high-interference conditions. The authors concluded that impaired cognitive performance in depressed individuals may result from, or be exacerbated by, interference from other ongoing cognitive activity, namely state-oriented cognitions (cf. Watkins & Baracaia, 2002). In short: without the ability to effectively disengage from state-oriented, ruminative thought it seems difficult for affected individuals to focus on more adaptive cognitive processes that have the potential to improve executive cognitive performance. Thus, at least in some forms of depression, sustained processing of no-longer relevant information could be regarded a key process underlying maladaptive behavioral patterns, supposedly mediated by a state-oriented cognitive style. Furthermore, since a state-oriented cognitive style – which involves self-focused attention and repetitive, passive focussing on a current theme – may be regarded as a method of coping with negative, aversive life events, it is reasonable to believe that especially cognitive manipulation of emotional, specifically negative material would be in some way compromised in depressed, or state-oriented individuals. Although only very few studies have looked at the the debilitating effect of sustained processing of negative information on executive cognitive functioning, there is empirical research indicating that depression is specifically associated with difficulties in inhibiting negative but not positive material Joormann (2006).

As an initial test of the hypothesis that differences in state orientation between depressed and nondepressed individuals will be reflected in differential effects of sustained information processing on executive cognitive functioning, in Study 2, normal, subclinically depressed participants were presented with what in the context of this thesis will be called the "Affective-Cognitive-Interaction" (ACI) task (Kazén & Kuhl, 2005; Kuhl & Kazen, 1999).

Research on individual differences in state orientation conducted to date have relied on a self-report measure of state orientation, namely the ACS. Unfortunately, however, studies investigating behavioral and information processing measures of state orientation, in particular as they relate to depression, are still missing. As a starting point, Keller et al. (1994), trying to explain the high level of arousal among depressed patients, reported that depressed patients scoring high on failure-related state orientation (SOF) showed a decrease in executive cognitive performance from admission to discharge. No parallel finding was obtained for SOD scores. Kazén & Kuhl (2005) also looked at cognitive processes that might underlie state orientation as conceptualized by Kuhl (1994b). For this purpose, they designed the ACI task. They investigated the role of affect for volitional efficiency by manipulating the valence of word primes that were given before a sequence of two tasks, a Stroop Color Naming Task (Stroop, 1935) and a second cognitive task. The Stroop Color Naming Task is a classic test of cognitive psychology. Its experimental design allows quantification of the strength of executive cognitive functioning. Participants are instructed to name the color in which the current Stroop stimulus is printed in. Incongruent Stroop stimuli consist of color words printed in colors that do not match the color denoted by the color word. Congruent Stroop stimuli are color words printed in their respective color. Control Stroop stimuli may be non-color words or symbols printed in color. The according *Stroop effect* is defined as the delayed reaction time (RT) for incongruent compared to congruent or control stimuli respectively, which has been consistently found in a wealth of studies (cf. W. Johnson et al., 2003; MacLeod, 1991). A stronger Stroop effect is assumed to indicate impaired executive cognitive functioning. In contrast to standard Stroop task designs, the ACI design consists of a series of three different kinds of stimuli, (1) a prime stimulus, (2) a Stroop stimulus, and (3) a stimulus related to a second cognitive task. Crucially, in each trial of the ACI task, initially, an affective word is presented; sometimes participants are told to ignore the word, sometimes they are instructed to consider it a preparatory signal, and sometimes the word is presented along with the instruction to read the word and to try to relive the feeling associated with it (Kazén & Kuhl, 2005; Kuhl & Kazen, 1999). Among other things, the ACI task was used to investigate the hypothesis that individual differences in state orientation will moderate volitional inhibition. Specifically, it was assumed that unemployed individuals, who – due to their repeated failure at obtaining a job – were believed to be in particularly state-oriented at the time of testing, would show an increased Stroop effect after being reminded of negative situations in comparison to being reminded of neutral or positive situations. In two independent studies, Kazén & Kuhl (2005) found that the Stroop effect nearly disappeared when participants were primed with positive words. In contrast, in both studies unemployed individuals showed a significantly higher Stroop effect after presentation of negative word primes compared with neutral word primes. Both effects were due to faster or slower RTs in the incongruent Stroop condition respectively. Additionally, participants in the first study showed an overall impaired performance reflected in increased RTs and higher error rates in response to incongruent Stroop stimuli.

Whereas the results of Kazén & Kuhl (2005) suggested that state orientation is associated with sustained information processing of emotional words that in turn interferes with subsequent executive cognitive functioning, it remains unclear whether this relationship exists particularly in depressed individuals. Thus, in the present study, the ACI task was used to investigate whether depressed and nondepressed individuals show differences in interference levels and whether such differences are related to differences in state orientation. The ACI task was particularly chosen because it allows the observation of the modulation of the Stroop effect specific to both negative and positive affective stimuli, thus making it possible to find valence-related discrepancies between depressed and nondepressed individuals in sustained information processing. As mentioned above, previous research suggested that depressed individuals are characterized by a processing bias for negative information over positive information (Joormann, 2006, 2004; MacLeod et al., 1986; Williams & Oaksford, 1992). Consequently, in addition to the previously shown volitional facilitation effect after positive and a volitional inhibition effect after negative primes, it was predicted that depressed individuals would exhibit increased interference levels after negative word primes compared to positive word primes and that depressed individuals would show higher interference levels after negative primes compared to nondepressed individuals. To the extent that state orientation reflects a general enhanced facility to maintain emotionally evocative thoughts, it was further expected that interfering sustained emotional processing would be related to levels of state orientation in depressed individuals. In short, the present study investigated the underlying cognitive processes by which state orientation, in particular in depression, may interfere with executive cognitive performance. It was expected to observe negative priming-induced modulations in behavioral measures of executive cognitive functioning in depressed individuals which were predicted to be related to levels of state orientation.

The current study involved university students, whose depressiveness was assessed by the BDI. Participants were then grouped by their depressive symptoms into nondepressed and depressed individuals. Although the overall project ultimately aimed at investigating interfering sustained information processing in MDD, prior research has shown that investigations of information processing biases using otherwise healthy samples with depressive characteristics is a feasible starting point and can yield effects similar to those observed in patients (cf. Joormann, 2006; Krompinger & Simons, 2011, 2009).

Method

Participant Characteristics and Sampling Procedure

The sample included 21 women and four men between the ages of 20 and 38 years (M = 26.0, SD = 3.9). Participants were recruited via several mailing lists of the University of Osnabrück and volunteered to participate. All participants reported normal or corrected to normal vision and normal color vision. Participants gave informed written consent to the study and were paid 10,- Euros or participated for partial course credit.

Measures, Research Design, and Data Analysis

In line with the results of Studies 1a – 1c , in the present study, *state orientation* was assessed by the RUM scale of the VCI. To determine participants' *depressiveness*, participants completed the BDI (cf. Study 1a). Internal consistency reliabilities in the current sample were: RUM: α = .88; BDI: α = .90. The extent to which sustained processing of emotional information interfered with executive cognitive functioning was operationalized in terms of the Stroop effect in the ACI task (Kazén & Kuhl, 2005; Kuhl & Kazen, 1999). In the present study, the Stroop effect, as a measure of executive cognitive functioning, was manipulated by affective priming. The experimental design included the following factors: Prime Type (neutral, positive, negative-burden, negative-threat) and Stroop Condition (incongruent, congruent). Both experimental factors were varied within participants and were fully crossed. Employing an additional quasi-experimental design, individuals were post hoc assigned to either a depressed or a nondepressed group based on their BDI score (median split). Afterwards, RT and error data of the Stroop task were analyzed with a 4 (Prime Type: neutral, positive, negative-threat, negative-burden) $\times$ 2 (Stroop Condition: incongruent, congruent) $\times$ 2 (Group: nondepressed, depressed), Greenhouse-Geisser-adjusted, mixed within-within-between design ANOVA with Bonferroni-corrected pairwise post hoc comparisons where applicable. Raw data for the analyses were correct RTs and number of errors in the first Stroop task (cf. below).

Experimental manipulations

Content of the manipulation. To investigate the effects of sustained processing of emotional information on a subsequent cognitive task, affective prime words were used to trigger emotional processing right before a Stroop task (cf. ACI task). Participants were told that the experiment dealt with interindividual differences in self-regulation and how motivation might influence different cognitive processes. The Stroop task included incongruent and congruent stimuli. The incongruent condition included twelve different word-color pairings ["BLAU" (blue) printed in yellow, green or red ink, "ROT" (red) printed in yellow, green or blue ink, "GRÜN" (green) printed in blue, yellow or red ink, and "GELB" (yellow) printed in blue, red or green ink. For the congruent Stroop stimuli, the color of the word matched the color word. To generate individual prime words a modified version of the Critical Life Events Questionnaire (CLEQ) was applied (cf. Kazén & Kuhl, 2005). In the CLEQ, participants were asked to generate six single words for three different affective categories. The categories were (i) positive achievement-related, (ii) achievement, threat, and (iii) achievement burden. These categories were chosen in accordance with the findings of Kazén & Kuhl (2005), which demonstrated that in particular achievement-related affective stimuli led to interference in the ACI task. In the first category, participants were asked to generate words that reminded them of concrete situations in which they experienced pleasure of achievement. Examples of positive achievement-related words were the German words for “bonanza”, “volleyball”, and “internship”. In the second category, participants were asked to fill in words that reminded them of situations in which they experienced performance pressure. Sample items of this category were “interview”, “tax law”, and “exam”. In the last category, participants generated words that reminded them of difficult achievement goals they had ahead of them at the time. Here, participants choose words like “application”, “presentation”, or “homework”. Finally, from a list of 60 words, participants were asked to choose ten “neutral” words, which did not elicit any emotional reaction in them. Six of these “neutral” items were included in the study, while care was taken to minimize the overlap between neutral and affective primes. Thus, there were six primes for each affective category (positive, negative-burden, negative-threat) plus six neutral words.

Method of manipulation and data acquisition. Presentation software (Neurobehavioral Systems, Inc.) was used to control the presentation and timing of all stimuli. Stimuli were presented on a 21.5-in TFT monitor. Participants’ viewing distance to the monitor was approximately 60 cm. The primes and Stroop stimuli were 1 cm high. The Stroop task used button press response instead of vocalization. This design enabled a better control of performance in comparison with a vocal answer and minimized movement-related artifacts associated with speaking (cf. Study 3). RT in color naming was recorded via the participant pushing “d” and “f” with their left index and middle finger and “j” and “k” buttons with their right index and middle finger on a keyboard. Each participants was assigned one of 24 different key-color assignments.

Procedure. The experiment was carried out individually in a quiet room. Participants were welcomed and informed about the experiment and its general scope. Afterwards, participants gave written consent to the procedure and started filling out the questionnaires. After finishing the questionnaires, participants got written instructions for the computer task. The ACI paradigm used two consecutive Stroop tasks after the affective word priming. The second task in the ACI design is introduced to ensure that participants had to from a strong intention to successfully perform the task (cf. Kazén & Kuhl, 2005). Thus, an experimental trial consisted of an initial fixation cross (500 ms), word prime stimulus (1500 ms), blank screen (500 ms), first Stroop stimulus (until button press; maximal 3000 ms), blank screen (500 ms), and a second Stroop stimulus (until button press; maximal 3000ms) (cf. Figure 3). The intertrial interval was randomly chosen between 500 ms and 1000 ms. The

Stroop condition was the same in the first and the second Stroop task within a single trial. In total 48 trials per cell were generated, yielding a total count of trials of 384. Trials were pseudo-randomized such that the same prime category never appeared twice in a row and that the same Stroop condition appeared maximally twice in a row. The pseudo-randomized order of the trials was the same for every participant. The task of the participants was to react as fast and as accurately as possible to the color of each word presented. Participants were instructed to regard the initial prime word as a preparation signal which would be more effective the more one would remember the associated event. Participants ran through three training phases of twelve trials each using a separate set of neutral prime words. If they felt confident with the task, they proceeded to the testing phase. In the testing phase, participants completed three blocks of 128 trials each and were given the opportunity for self-paced breaks between blocks. After finishing the computer task, participants were thanked and informed about the current research question in detail, if they were interested. The average duration of the whole procedure was about two hours.

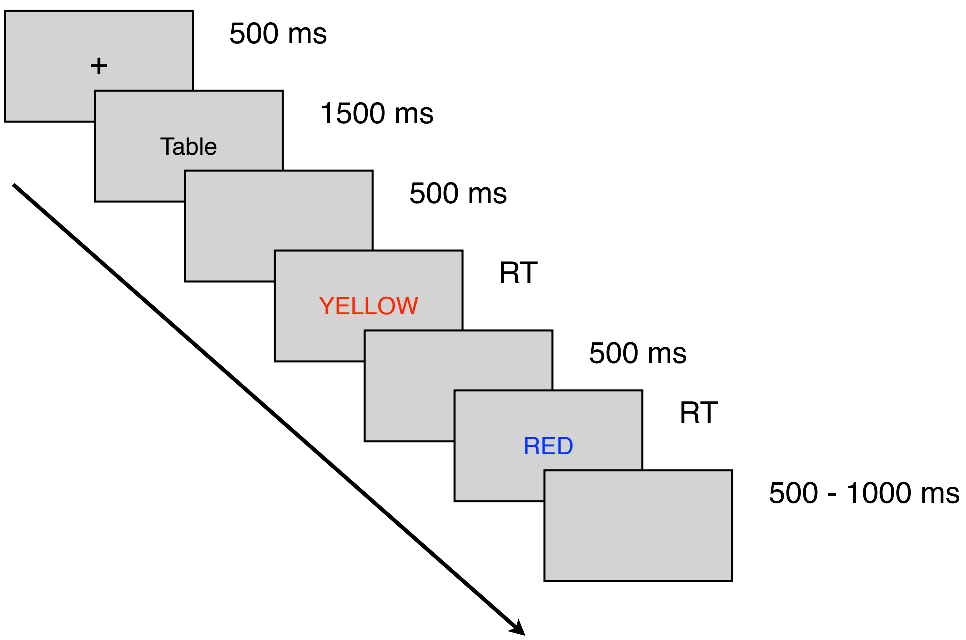

Figure 3. Schematic of the Affective-Cognitive-Interaction (ACI) task. Numbers depict the presentation duration of each stimulus. RT = Reaction time; A Stroop stimulus was presented until button press, but maximally for 3000 ms. At study, the prime word was a self-chosen, affectively neutral word or a self-generated word reminding the participant of a positive, a threatening, or a burdening event in the achievement domain. A congruent Stroop stimulus in the first task was always followed by a congruent Stroop stimulus in the second task and analogous for incongruent Stroop stimuli.

Results

In total, 25 individuals participated in the study. Participants were recruited from June 13 until June 23, 2010, primarily from the students community of the University of Osnabrück. Demographic, personality and clinical characteristics of high and low depressed subgroups are presented in Table 10. Groups did not differ in age or gender distribution. However, depressed individuals were significantly more state-oriented than nondepressed individuals.

Affective Interference in Depressed and Nondepressed Individuals

Evaluation of statistical assumptions. Raw data for the analyses were correct RTs and number of errors in the first Stroop task. Mean RTs and accuracy were calculated for each trial type for each group. There were no missing values among mean RT or mean error rate. Thus, for the mixed design ANOVA, the full data set included 24 cases, with the exclusion of one case with missing BDI score. The median-split according to BDI score created two groups with the same sample size of $n = 12$. RTs in each cell of the design were normally distributed and no univariate outlier were detected. Likewise, error data were sufficiently normally distributed in each cell and showed no univariate outliers. Multivariate outliers were identified as cases with too large Mahalanobis D^2 for their own group, evaluated as χ^2 with degrees of freedom equal to the number of dependent variables. Applying a critical χ^2 of 26.13 (8 *df* at $\alpha = .001$) found no multivariate outliers in either group, neither for RT, nor for error data.

Mixed design ANOVA. To investigate the influence of sustained processing of the affective word prime on performance in the Stroop task in depressed and nondepressed individuals, RT and error data were initially analyzed with a Prime Type $\times$ Stroop Condition $\times$ Group Greenhouse-Geisser adjusted, mixed design ANOVA with repeated measures on the first two factors. Some participants most probably mixed up the key-color assignment during the experiment such that in some cases error rates > 40% ($n = 6$) were found. Excluding these cases, the mean error rate was 11.3% ($SD = 11.2$). In terms of accuracy, the analysis revealed neither a significant main effect, nor a significant interaction effect, either with or without individuals with an error rate > .40% (all *p*s > .15).

Preliminary analyses of RT data revealed that for both groups RTs did not differ for negative-burden and negative-threat primes within each Stroop condition (all *p*s > .60). Therefore, the RT data were collapsed across these two prime levels. In a Prime Type $\times$ Stroop Condition $\times$ Group ANOVA subsequently conduced a main effect of Stroop Condition, $F(1, 22) = 38.12$, $p < .001$, $\eta_p^2 = .63$, was obtained, showing that it took participants longer to react to incongruent Stroop stimuli (estimated marginal mean (*EMM*) = 1050 ms, *SD* = 54) than to congruent Stroop stimuli (*EMM* = 888 ms, *SD* = 40; cf. Table 11). In addition, the Prime Type × Stroop Condition interaction showed a trend for a significant difference, $F(2, 44) = 2.85$, $p = .07$, $\eta_p^2 = .12$. Post hoc comparisons revealed that in the congruent Stroop condition participants reacted faster if they previously saw a positive affective word prime (*EMM* = 863 ms, *SD* = 41) compared to a neutral word prime (*EMM* = 910 ms, *SD* = 37), multivariate test: $F(2, 21) = 6.50$, $p = .006$, $\eta_p^2 = .38$. Additional exploratory analyses further revealed, that this effect was especially prominent in depressed individuals ($p = .02$) and absent in nondepressed individuals ($p > .15$); all other *p*s > .19 (cf. Figure 4). Testing the differential response hypothesized for depressed individuals in response to negative compared to positive word stimuli in a 2 (Prime Type: positive, negative) × 2 (Stroop Condition: incongruent, congruent) × 2 (Group: depressed, nondepressed), again revealed a main effect of Stroop Condition, $F(1, 22) = 63.01$, $p < .001$, $\eta_p^2 = .74$, and a significant Prime Type × Stroop Condition interaction $F(1, 22) = 6.80$, $p = .02$, $\eta_p^2 = .24$. Post hoc pairwise comparisons revealed that the interaction effect was especially due to nondepressed individuals reacting faster after negatively primed (*EMM* = 993 ms, *SD* = 73) compared to positively primed, incongruent Stroop stimuli (*EMM* = 1051 ms, *SD* = 78), whereas depressed individuals showed faster reaction times after positively (*EMM* = 865 ms, *SD* = 57) compared to negatively primed, congruent Stroop stimuli (*EMM* = 899 ms, *SD* = 61).

Table 10

Demographic, Personality, and Clinical Characteristics for Participants in Study 2

	Nondepressed (n = 12)		Depressed (n = 12)					95% CI		
	M	*SD*	*M*	*SD*	*t*	*df*	*p*	LL	UL	Cohen's *d* [a]
Demographic variables										
Age (years)	26	4.4	26	3.8	−.05	22	.96	−3.55	3.38	−0.21
Sex (% female)	83		83							
Personality variables										
RUM	8.08	1.73	11.58	3.53	−3.09	22	.007	−5.85	−1.15	−1.32
Clinical variables										
BDI	2.50	2.24	13.75	7.15	−5.20	22	<.001	−15.92	−6.58	−2.22

Note. RUM = failure-related state orientation (cf. VCI); BDI = Beck Depression Inventory.
[a]Cohen's *d*: 0.20 = small effect; 0.50 = medium effect; 0.80 = large effect.

Table 11

Estimated Mean Reaction Times in the ACI Task as a Function of Group, Stroop Condition, and Prime Type (Study 2)

	Nondepressed			Depressed		
Variable	Neutral	Positive	Negative	Neutral	Positive	Negative
Incongruent Stroop						
Mean RT	1040	1051	993	1075	1067	1071
SD	87	78	73	87	78	73
Congruent Stroop						
Mean RT	899	860	885	921	885	899
SD	53	57	61	53	57	61

Note. All RTs are in milliseconds.

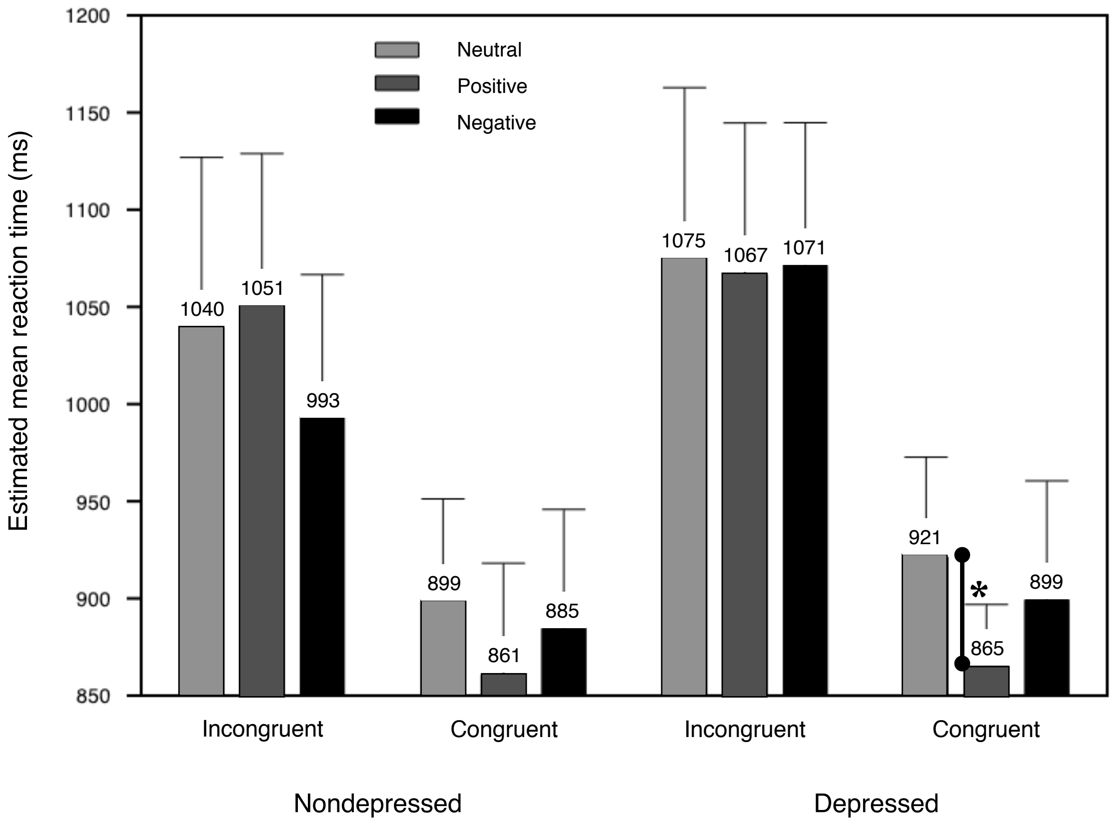

Figure 4. Estimated mean reaction times in the ACI task as a function of the Prime Type, Stroop Condition, and Group in Study 2. Relatively more depressed individuals showed significantly faster reaction times after positively primed, control Stroop stimuli compared to neutrally primed, control Stroop stimuli. Asterisk indicates significant differences at the .05 level. In both groups, the Stroop effect was found in each condition (all *p*s < .001, except for the neutral priming condition: depressed: $p = .01$; nondepressed:$p = .02$).

Affective Interference and its Relation to Cognitive Style

To examine the relation among state orientation, in particular RUM, depressiveness, and cognitive impairment in the ACI task, a multiple linear regression analysis of RUM scores across groups was conducted. Specifically, a multiple linear regression analysis was conducted in which the difference in RTs after neutral and positive primes in the congruent Stroop condition was entered as the dependent variable, and RUM and group, as well as the two-way interaction were entered as predictors. This analysis yielded no significant main or interaction effect (all $p > .50$). Moreover, explorative correlational analyses revealed that RUM was not correlated to reaction times in any experimental condition, neither in the whole sample (all *p*s > .28), nor in one of the subgroups (all *p*s > .18)

Ancillary Analyses

Controlling for anxiety, measured by the Beck Anxiety Inventory (Beck et al., 1988), in the mixed-design ANOVA, revealed that, although no longer significant, the "facilitation" effect after positive word primes compared to neutral word primes in the congruent Stroop condition, independently of the current anxiety level, was by far the strongest effect in both depressed and nondepressed individuals and overall the strongest effect in depressed individuals.

Discussion

The current data show an important effect of depressiveness on task performance in terms of an interference effect presumably resulting from sustained processing of affective information; but the nature of this effect is somewhat unclear. On the Stroop Color Naming Task, depressiveness interacted with reaction times for positively primed, congruent Stroop stimuli. In addition, qualitative differences in performance between relatively less depressed individuals and relatively more depressed individuals were apparent for negatively primed, incongruent Stroop stimuli. After positively primed, congruent Stroop stimuli, depressed individuals responded faster compared to neutrally primed, congruent Stroop stimuli, whereas nondepressed individuals showed faster reaction times after negatively primed, incongruent Stroop stimuli compared to positively primed Stroop stimuli. These data suggest distinct facilitating effects of tonic activation of affective information in depressed and nondepressed individuals. Both depressed and nondepressed individuals showed a priming effect after positive valenced words in the congruent Stroop condition though, whereas only the nondepressed group showed a significant interaction between negative affective prime words and responses in the incongruent Stroop condition.

Studies reviewed earlier have tended to support the idea that individuals susceptible to depression fail to disengage from self-focused thought. The apparent difficulty disengaging from processing self-relevant information seems to be grounded in a lack of inhibition of negative information, or an over-elaboration of negative information, respectively. Depressive cognition seems to favor negative stimuli over neutral or positive stimuli. Likewise, depressed individuals seem to be less likely to spontaneously generate positive thoughts and more likely to spontaneously generate negative thoughts. Problems inhibiting negative information may be a result of, at least in part, a tendency to initially give negative stimuli excessive attention. Surprisingly, the effect of depression on affective interference found in the present study was inconsistent with this reasoning and with the study hypotheses. In relatively more depressed individuals, in the incongruent Stroop condition, reaction times were not affected by whether or not the prime word was affectively valenced. In the congruent Stroop condition, however, valence of the prime word mattered. This pattern of affective interference was contrary to expectations generated from previous findings on “volitional facilitation” and “volitional inhibition” effects in the ACI task (Kazén & Kuhl, 2005; Kuhl & Kazen, 1999). These previous findings would have predicted a different outcome, namely increased reaction times after negative prime words and/or decreased reaction times after positive prime words compared to affectively neutral prime words in the incongruent Stroop condition and reaction times in the congruent Stroop condition would have been unchanged by affective priming. The experiment failed to show this “classical” volitional facilitation effect on reaction times for incongruent Stroop stimuli after positive primes. It is not easy to identify possible reasons for this failure to find a volitional facilitation effect. The sample size may have been too small or the stimuli may have been insufficiently self-relevant. Instead of the expected volitional facilitation effect, (behavioral) facilitation was observed in the congruent Stroop condition after positively valenced prime words. In relatively less depressed individuals though, priming had an influence on performance during the high interference condition (cf. incongruent Stroop condition). However, here again, results were contrary to expectations, since facilitation was observed in the negative priming condition. Thus, depression appeared to be associated with different effects on different kinds of processing. Depression was neither simply related to impaired overall performance, nor was it characterized by a general bias towards negative information. There are three depression effects to consider in more detail: the speedup of response to positively primed, congruent Stroop stimuli, the unchanged reaction time after negatively primed Stroop stimuli, and the observation that none of these two effects – and in general reaction times in none of the experimental conditions – were significantly related to individuals’ levels of (failure-related) state orientation.

First of all, the faster response of depressed – and to a lesser extent also of nondepressed individuals – to positively primed, congruent Stroop stimuli is broadly consistent with the observation that the congruent Stroop condition reflects more reduced interference than true facilitation in comparison to a “XXXX” control or an unrelated-word control (Dalrymple-Alford, 1972). However, facilitation was observed only after positive words in the congruent Stroop condition, and primarily in depressed individuals. This result may be regarded comparable to findings on semantic/affective priming, which demonstrate that affective primes do not have generalized facilitating effects. Rossell & Nobre (2004), for example, found substantial differences in the degree of semantic priming produced by different affective categories. However, in their research, no differences in the degree of priming were found using neutral or positive prime-target pairs. Moreover, no priming facilitation was found using fear-inducing stimuli and inhibition was found using sad prime-target pairs. Importantly, researchers found no mood induction or general arousal effects from affective primes, if targets were neutral. Hence, this line of research seems unable to provide an explanation for the current findings. Research on the so-called behavioral inhibition/behavioral facilitation systems (BIS/BAS) suggests that depressed individuals may exhibit deficient BAS and overactive BIS functioning (Kasch et al., 2002). Each of these motivational systems is assumed to be related to broad affective quality, BAS to positive affect, BIS to negative affect. The BIS is supposed to be sensitive to signals of punishment, non-reward, and novelty, whereas the BAS is said to be sensitive to signals of reward, non-punishment, and escape from punishment (Carver & White, 1994). Thus, BIS activation is believed to cause inhibition of goal-directed behavior, whereas activation of the BAS is assumed to cause an individual to initiate or increase movement goal-directed behavior. Greater BAS sensitivity should therefore be reflected in greater proneness to engage in goal-directed efforts and to experience positive feeling when an individual is exposed to cues of reward. This reasoning suggests that positive mood induction by positive words may result in behavioral facilitation. The difference between controls and depressed individuals may then be regarded as a matter of small sample sizes. However, this reasoning does not provide a strong argument to explain why facilitation should be especially found in the low-interference condition. Notably, the argumentation may suggest that the facilitating effect found in the current study would not have been observed in a control Stroop condition.

In terms of the results of faster reaction times in nondepressed individuals for negatively primed, incongruent Stroop stimuli compared to positively primed, incongruent Stroop stimuli, the interpretation is also highly speculative, in particular because these findings are based on qualitative, descriptive observations. The findings may suggest that relatively less depressed individuals increase their efforts in a task, especially when they are reminded of previous failure, whereas depressed individuals are not able to exploit previous failure experiences to enhance current task performance. Indicative for this interpretation may be the finding that in the current study, in relatively less depressed individuals, reaction times for negatively primed, incongruent Stroop stimuli showed a positive relationship to self-motivation ($r = .54$, $p = .07$), whereas in relatively more depressed individuals the opposite pattern was found ($r = -.11$, $p = .74$). The two subgroup correlations were significantly different from each other ($z = 2.32$, $p = .01$). Thus, the initially counterintuitive finding suggests that the ACI task does not appeal to individuals who are able to motivate themselves, but rather accommodates and activates individuals who are less able to motivate themselves and therefore may rather be drawn to automatic stimulus processing (cf. congruent Stroop condition). And indeed, relatively less depressed individuals also showed higher levels of self-motivation (M = 6.9, SD = 1.78) than relatively more depressed individuals (M = 6.0, SD = 2.26); t = 1.11, p = .28.

Also somewhat counterintuitively, in the present study, depressed individuals were insensitive to negative affective primes. At this point, there seems to be no plausible explanation for this lack of affective interference. However, a possibility is that both task difficulty and level of current depressive symptomatology in the current sample of young, subclinically depressed individuals were insufficient to produce affective interference effects in overt behavior in the expected manner. Alternatively, in the current study, depressed individuals may have been successful at the (effortful) suppression of negative cognitions, since they did not show a drop in performance for negatively primed, incongruent Stroop stimuli in comparison to nondepressed individuals. As already mentioned, this result may be due to the fact that only subclinically depressed individuals were tested. Nevertheless, it may be speculated that already relatively more depressed individuals, who may be characterized by elevated levels of achievement motivation[2] concentrate all their efforts on performing well in the high interference condition, such that they are not distracted in the incongruent condition by task-irrelevant thoughts that would otherwise interfere with cognitive performance. In the low interference, congruent Stroop condition, however, perhaps the concentration drops, and the affective prime words may be able to modulate task performance. This reasoning suggests that depressed individuals may be able to use specific cognitive strategies within the two seconds between the onset of the prime word and the Stroop stimulus, to alter the relative activation levels of affective stimuli, in particular of negative stimuli. Thus, depressed individuals may be able to suppress sustained information processing for a short time period when highly motivated to perform a task and may then no longer attend to off-task cognitions otherwise induced by negative priming (cf., e.g., Watkins & Brown, 2002). However, the ACI paradigm may not be ideally suited to demonstrate higher active suppression of negative cognitions in depressed individuals compared with nondepressed individuals; longer periods of continuous performance may be more suitable. Moreover, these considerations raise the question of whether affective interference, if observed, is caused by mental efforts to suppress negative information, or rather by cognitive capacities centering around these negative information. To find an answer to this question remains a challenge for future research. It is important to note, however, that in the current

[2]In the current study, relatively more depressed individuals had a less marked affiliation motive in comparison to relatively less depressed individuals ($t(22) = 3.10$, p = .005). Achievement motive was not assessed.

study, effects of sustained processing of negative information in depressed individuals seem not to have affected ongoing executive cognitive functioning observable in behavioral performance. Measures able to assess more subtle (temporal) effects, such as for example event-related potentials, may have been able to demonstrate decisive impact of persistent, ruminative thought on cognitive performance in depression. In other words, the present findings should be regarded as preliminary. They may indicate that depressed individuals, when provided with external positive, affective stimulation, may well show enhanced performance in rather automatic tasks. Alternatively, the present findings may suggest that depressed individuals, if they are challenged but not over-challenged, and in particular if they are highly motivated (state- or trait-wise) may very well be able – in a laboratory setting – to draw up specific strategies that prevent them from being distracted from the task at hand. In either case, the present findings and the ACI task may serve as a starting point for identifying processes related to state-oriented cognitions and their role in the cognitive pathology of depression.

In this study, no support was found for the idea that sustained information processing of affective, in particular negative information, interferes with ongoing executive cognitive functioning (cf. "affective interference"). Therefore, it could not been tested whether such an interfering effect could be related to a state-oriented cognitive style. Depressed individuals' levels of state orientation were not related to the facilitating effects found in the current study. This is not surprising, since the tendency for state-oriented thoughts is postulated to occur after negative priming; positive prime words are not supposed to induce sustained information processing. However, reaction times after negative priming were also not related to RUM scores, although ruminative thought has been identified as one of the most robust factors associated with (recurrent) depression. In line with the reasoning above, the most likely explanation for the absence of a correlation between state orientation and reaction times after negative priming in the current study is that negative primes only insufficiently induced state-oriented cognitions and/or participants adopted strategies that prevented sustained information processing to interfere with ongoing executive cognitive functioning

Taken together, the pattern of results in the current study may point to an important difference between depressed and nondepressed individuals, namely their distinct dealing with affective information. Based on the current findings, it seems as if, whereas relatively less depressed individuals are motivated being reminded of prior failure, relatively more depressed individuals are instead motivated by being reminded of prior success, but only if task difficulty is low, otherwise, the facilitating effect of positive mood induction seems not to be able to facilitate performance. Depressed individuals confronted with negative information may spend much effort on inhibiting this negative stimulus, whereas they may permit themselves to get involved with positive stimulation similarly to nondepressed individuals (Gotlib et al., 2005). This dealing with negative information may therefore be the reason for affective interference, or at least for a lack of facilitation, as found for relatively more depressed individuals in the current study. Crucially, however, the sustained processing of negative information may also result in improved performance, as long as the current executive cognitive task is “mood-congruent”, that is, if the current cognitive challenge is also related to the processing of negative information (Goeleven et al., 2006). In sum, it still seems plausible that both depressed and nondepressed individuals may persistently process affective information, which might lead to interference with ongoing executive cognitive functioning. However, depressed and nondepressed individuals seem to utilize affective information in a (qualitatively) completely different way. Against this background, future research should also assess individuals' basic motivational structure to investigate whether in particular achievement motivation may be related to facilitating effects of negative priming.

Overall, the data show that the ACI task may be a useful tool for investigating some but not all of the underlying processes associated with affect-related processing biases in depression. The effect of depression on priming was firstly to sharpen the response to congruent Stroop stimuli after positive primes. This result was not predicted by the functional helplessness model of depression and may indicate that the influence of depression on sustained information processing and resulting affective interference is rather counterintuitive. Secondly, effects of depression on performance after negative primes are consistent with the idea that depressed individuals may be able to perform equally well, compared to nondepressed individuals, if certain situational factors are met. Speculatively, this latter effect may be especially related to a distinct motivational structure in depressed individuals. The bottom line is that the relationship between sustained information processing and executive cognitive functioning in depression may be more complex than initially supposed. The current results await replication, especially with a clinically depressed sample. Moreover, further research is necessary to establish whether comparable effects of sustained information processing on executive cognitive functioning are found for other tasks.

In conclusion, the current results warn against attributing all effects of depression on cognition to a general bias in sustained processing of negative information. Studies combining tests of sustained information processing in depression with measures of brain function may be of great help in clarifying the relation between depression, sustained information processing, and affective interference. Such a combined approach may be able to shed more light on specific processes underlying sustained information processing in MDD, its interfering effects with ongoing executive cognitive functioning, and its relation to specific personality styles. Such studies are especially important since, to date – as illustrated in the present research – relevant studies have produced somewhat conflicting results.

Chapter 4: Neurophysiological Indicators of Sustained Information Processing and Affective Interference in Depressed Individuals and its Relationship to State Orientation (Study 3)

As argued in the previous chapters, prolonged involuntary information processing, especially of negative information, is a robust cognitive finding associated with major depression (cf. also, e.g., MacLeod & Matthews, 1991; Siegle, Steinhauer, et al., 2002). As such, sustained information processing may be a possible etiological factor in the development and maintenance of depression. Potentially, the clinical relevance of sustained processing in response to affective stimuli would be enhanced if it interfered with subsequent tasks. For example, if an individual is criticized, elaboration on the criticism rather than working could result in poor job performance. To examine such interference effects, in the present study, depressed and nondepressed individuals completed a task in which trials alternately required emotional processing and nonemotional processing, namely the ACI task (cf. Study 2).

An adequate understanding of the processes leading to impaired executive cognitive functioning caused by sustained information processing may help therapists more effectively identify and modify dysfunctional thought processes in depression. In contrast to Siegle, Steinhauer, et al. (2002), who introduced the notion of "affective interference" as denoting involuntary, dominant processing of negative information in depressed individuals, in the context of this thesis, affective interference refers to the inability of depressed individuals to properly disengage from negative information, or sustained processing of information in depression respectively, particularly of affective information. Sustained information processing in depression has been inferred from a variety of behavioral and brain imaging measures (Eugène et al., 2010; Joormann, 2006, 2004; Kuhl & Helle, 1986; MacLeod et al., 1986; Nolen-Hoeksema, 1998). Crucially, experimental studies have suggested that while depression may not be characterized by a rapid negative attentional bias, which is characteristic of threat detection in anxiety, it may instead be associated with a subsequent over-elaboration of negative information and the inability to disengage from the emotion evoked by the negative stimulus, once it has been appraised (Gotlib et al., 2004). However, although a number studies suggest that depressed individuals are characterized by sustained information processing, studies that combine combine measures for executive cognitive functioning, personality style, and brain function are rare. In particular, there are only very few studies that investigated the functional brain correlates of sustained information processing interfering with ongoing executive cognitive functioning in depression and the possible link to individual cognitive style. The lack of studies combining behavioral, cognitive, and brain measures limits the understanding of sustained information processing and its impact on executive cognitive functioning in depression insofar as behavioral approaches cannot examine differential recruitment of specific psychological processes that may be revealed by patterns of neural activation. Moreover, it is possible that depressed individuals are actually showing increased sustained processing of negative information, but the effect is not evident in a behavioral response given that it is an end-result of many processes that lead to its production (cf. also Study 2). Furthermore, functional impairments in depressed individuals may be subtle and diffuse and therefore the validity of behavioral measures assessing cognitive functioning and their relation to personality may be limited. Similarly, measures of brain function and state orientation alone are of limited usefulness in examining the nature and extent of cognitive deficits in depression and their relation to state orientation. Also, cognitive deficits in depression and their relation to state orientation may be secondary to impaired mood rather than being a primary aspect of the disorder. Likewise, depressed individuals may use different strategies in their performance of the cognitive task relative to healthy controls. Therefore, combining tests of executive cognitive functioning with both measures for brain function and measures for state orientation may allow for direct comparison not only between depressed and nondepressed individuals, but also within groups, and make it possible to determine whether the brain responds with sustained information processing to specific information, whether this processing interferes with subsequent cognitive functioning, and how interference effects may be modulated by personality style. Thus, in the present study, together with measures for individual levels of state orientation, brain function was measured during the ACI task, an experimental paradigm which allows to test to what extent processing of affective information interferes with subsequent executive cognitive functioning. In this way, it was attempted to assess whether individuals suffering from major depression display patterns of brain activity consistent with impaired executive cognitive functioning which results from sustained information processing. Notably, because of the lack of corresponding studies, the specific deficits in executive cognitive functioning that may be related to involuntary sustained information processing, and the role of state orientation in these deficits, are not well understood. Thus, the present experiment was a first attempt to address this issue by comparing brain activity of individuals experiencing a major depressive episode and control participants, as they engage in a task of executive cognitive functioning after being previously induced with task-irrelevant affective information processing.

While a wide range of cognitive tasks have been administered to depressed individuals with and without concomitant assessment of brain function, while both depression and state orientation have been investigated with respect to their underlying cognitive and brain processes, and while attempts have been made to clarify the moderating role of state orientation on the relationship between depression and brain function, the number of studies co-administering measures for brain function, executive functioning, and state orientation in depression is very limited. Little is known about the brain processes underlying impaired executive cognitive functioning associated with sustained information processing in depression and its relationship to a state-oriented cognitive style. Recently, the work of Berman et al. (2011) adopted the idea described earlier (cf. Chapter 1) of increased default-mode network connectivity with the subgenual ACC in major depression. They hypothesized that default-mode network connectivity, particularly in the subgenual cingulate cortex, would be related to state orientation, or rumination respectively, because “mind-wandering” had been shown to engage regions of the default-mode network. To address their two main research questions of whether the default-mode network connectivity for depressed individuals and nondepressed controls varies between off-task and on-task periods, and whether measures of rumination predict connectivity of the default-mode network especially in the subgenual ACC for depressed and nondepressed individuals, Berman et al. (2011) conducted a functional connectivity analysis in according fMRI data. In this analysis, depressed individuals showed stronger connectivity of the default-mode network with the subgenual ACC than nondepressed controls. Moreover, state orientation – in terms of the tendency to ruminate – showed a significant positive relationship to connectivity in the subgenual ACC, suggesting that default-mode network connectivity with the subgenual cingulate is related to ruminative tendencies. An especially noteworthy finding was that compared with rest, the MDD group demonstrated significantly reduced connectivity while engaged in a cognitive task, whereas the control group showed no reliable changes in connectivity for task versus rest, suggesting – in line with research previously mentioned – that being engaged in a task may disrupt the ability to ruminate in depressed individuals by distracting them and thereby interrupting the neural circuit that may mediate rumination. Although these results provided evidence of a link between sustained information processing in terms of ruminative thought and activity in the default-mode network in depression, the interference effect of sustained information processing on a different cognitive task was not investigated. In contrast, Siegle, Steinhauer, et al. (2002) using event-related fMRI, explicitly examined the interfering impact of sustained processing of affective information on the performance during a subsequent task of cognitive functioning. Their research questions were whether depression is characterized by sustained processing of (emotional) information, whether such sustained processing would interfere with a current cognitive demand, and what the relation is between state orientation, measured as rumination, and brain processes underlying a possible interference effect of sustained information processing. Analyses revealed that depressed individuals displayed sustained amygdala processing in response to negative information in a valence identification task in comparison with nondepressed controls. Crucially, although no statistically significant differences in cognitive functioning were found, a number of participants reported that they made errors on nonemotional processing trials (here: Sternberg task) particularly following previously presented negative, personally relevant words, because they were still thinking about these words. In accordance with these phenomenological reports, the difference in sustained amygdala activity induced by negative versus positive words was moderately related to self-reported rumination.

There are several neural models of depression that point to candidate brain processes that may be responsible for sustained processing of affective information in depression. In particular, in line with the findings of Berman et al. (2011), the model of depression put forward by Pizzagalli (2011) assumes that disruption of the coupling between the default-mode network and the task positive network, specifically the inability to reduce activity in the default-mode network and/or dominance of the default-mode network over the task-positive network, possibly coupled with impairments in modulating amygdalar activity, will result in excessive information processing and a maladaptive state-oriented cognitive style. Pizzagalli (2011) further proposed that the tendency to engage in maladaptive, state-oriented information processing, in turn, will interfere with or deplete cognitive resources needed to perform other primary cognitive tasks. Similarly, Bar (2009) suggests that involuntary sustained information processing may stem from excessive inhibition of the medial temporal lobe by the medial prefrontal cortex through hyper-connectivity between these two brain regions. Thus, in this view, excessive inhibition of the medial temporal lobe by an abnormally activated medial prefrontal cortex would explain the inability of depressed patients to disengage from debilitating rumination. In addition, Mayberg (2009) puts forward the hypothesis that the reciprocal interaction between ventral limbic brain regions and dorsal cortical brain regions determines brain dysfunction associated with major depression. Specifically, in her model, the function of the prefrontal cortex coupled with the activity of the subgenual anterior cingulate cortex, is assumed to be at the core of brain dysfunction found in depressed individuals. Taken together, these theoretical models of depression provide a neurobiological basis for the difficulty in inhibiting negative information, or involuntary sustained information processing respectively, in depressed individuals. It is suggested that especially the dorsolateral prefrontal cortex and the anterior cingulate cortex are involved in involuntary sustained processing of affective information in depressed individuals. The current research therefore focused on identifying sustained information processing as it relates to activity in the anterior cingulate cortex and the dorsolateral prefrontal cortex in depression. The following section outlines the method used for assessing sustained information processing interfering with ongoing cognitive functioning and predictions for depressed individuals.

Due to the nature of fMRI data, which exhibits relatively poor temporal resolution, from the results of brain imaging studies it cannot be said for certain at what stages in stimulus processing specific difficulties emerge. Thus, to overcome the limitations of behavioral, as well as brain imaging, methodology, and to be able to reveal subtle changes that take place at various stages in the information processing stream, the use of event-related brain potentials (ERPs) may be an appropriate means of examining the extent to which sustained information processing interferes with executive cognitive functioning. The ERP is an electrophysiological measures which is sensitive to temporally defined stages of information processing. ERP research is therefore able to identify different temporal stages of information processing and enables researchers to describe the processing of information within the brain with millisecond resolution by averaging stimulus time-locked electroencephalographic voltage changes (Luck, 2005). Thus, differences in ERPs among different conditions or between groups can be used to index processing biases. Furthermore, because specific ERP components have previously been associated with specific aspects of cognitive functioning in normal cognition, ERPs provide a tool with which to further investigate sustained involuntary information processing in depression. However, so far, no study has specifically examined brain processes associated with sustained information processing interfering with ongoing cognitive functioning using ERPs. To this end, the present study was designed to identify the effect of sustained information processing on ongoing cognitive functioning and the corresponding time-course as a function of valence of the persistently processed information among major depressive individuals.

As in Study 2, in the present study, the “Affective-Cognitive-Interaction” (ACI) paradigm was used (Kazén & Kuhl, 2005; Kuhl & Kazen, 1999). By combining a Stroop Color Naming Task (Stroop, 1935) with an affective priming procedure, this experimental task was originally designed to operationalize “volitional facilitation”, or “volitional inhibition” respectively. In this paradigm, the common Stroop task was chosen as an established task taxing executive cognitive functioning. The Stroop task induces cognitive interference and thereby evaluates and individual’s ability to inhibit overlearned responses (Ottowitz et al., 2002, cf. Chapter 3). Using the ACI design, volitional facilitation and volitional inhibition can be measured in terms of the degree to which the content of an affective stimulus presented right before a Stroop task predicts the corresponding Stroop interference. Specifically, volitional facilitation is indicated when the Stroop effect decreases due to faster reaction times in the incongruent Stroop condition. Analogously, an increased Stroop effect due to slower reaction times in the incongruent Stroop condition is indicative of volitional inhibition. For the purposes of the present research, the ACI task is conceptualized slightly differently. Here, the ACI task is assumed to provoke sustained information processing by instructing individuals to remember situations which they previously rated to be associated with neutral, positive, or negative feelings immediately before they perform a Stroop Color Naming Task. The interfering effect of sustained processing of affective information on executive cognitive functioning is then measured as the modulation of reaction times in the Stroop task as a function of the valence of the word primes. In addition, in the present study, the interfering effect of sustained information processing on executive cognitive functioning is determined in terms of the modulation of Stroop task-related ERP components by the affective priming. Put differently, in the ACI task "affective interference" was operationalized as the degree to which the affective content of a word prime predicted behavior and brain activity on a subsequent task of executive cognitive functioning.

Changes of several ERP components for the ACI task were assumed to reflect (i) sustained processing of affective information and (ii) affective interference of sustained information processing on executive cognitive functioning. With respect to initial and sustained information processing, the P1 and N1 ERP components were of interest. The P1 ERP component is a positive-direction component detected at the parieto-occipital electrodes around 70–130 ms after stimuli onset. This component is thought to reflect the processing of the low-level features of stimuli and the initial encoding of sensory information (Yang et al., 2011). The N1 ERP component (140–200 ms) appears to be modulated by task-related features and is assumed to be related to voluntary discrimination processes. Specifically, this component appears to be larger in tasks requiring target discrimination than in tasks requiring simple detection (Hopf et al., 2002). With regards to brain correlates associated with affective interference, there were also ERP components that were of particular interest. Certain ERP components are thought to indicate the amount of executive cognitive effort being allocated to performing a task. Moreover, certain ERP components are assumed to be sensitive to the effects of affective stimuli at various stages of information processing. For example, Hanslmayr et al. (2008) investigated the temporal dynamics of interference elicited in the Stroop task and the different brain process that may underlie conflict detection and conflict resolution in this task by means of an analysis of ERPs. Similar to the results of prior brain imaging studies (Ottowitz et al., 2002), they found a stronger negativity at fronto-central electrodes for incongruent compared to neutral stimuli and stronger positivity for incongruent compared to neutral stimuli in fronto-polar scalp regions. These researchers concluded that the time window around 400 ms may be sensitive to interference in the Stroop task. Furthermore, based on a source localization and a time frequency analysis additionally conducted, Hanslmayr et al. (2008) concluded that (a) the enhanced fronto-central negativity for incongruent items most likely stems from activation of the anterior cingulate cortex and (b) sustained phase coupling between anterior cingulate cortex and lateral prefrontal cortex may reflect the recruitment and engagement of higher-order control mechanisms which are needed in order to solve interference and to select the proper response. In short, N400-like effects in the Stroop task may reflect monitoring functions and interference detection in the anterior cingulate cortex and the elicitation of central executive processes in the prefrontal cortex. In this way, the anterior cingulate cortex and the lateral prefrontal cortex may interact with one another in order to overcome interference. In the same vein, Krompinger & Simons (2011) argued that N400-like effects during the Stroop task are modulated by conflict induced by the task and that this ERP component indexes the initial conflict detection stage. Moreover, Krompinger & Simons (2009) hypothesized that in addition to the N400-like effect representing conflict monitoring, a P3 ERP component may additionally represent executive cognitive control exerted during the Stroop task.

There has been a wealth of research examining the relationship between ERP components – used as cortical indices of altered information processing – and processing of (affective) stimuli. Researchers have tried to determine the processes important for the genesis of specific ERP components and then in turn use these components to investigate how they are modulated by certain types of information processing. In particular, experimenters have targeted components emerging in the late stages of the P3 "family" (Luck, 2005), i.e., the so-called P3b and late positive potential (LPP), as being especially sensitive to motivationally relevant stimuli (Bradley et al., 2007; Delplanque et al., 2006; Schupp et al., 2000, 2004). Studies have consistently shown that these late components are in particular enhanced for emotional versus neutral stimuli.

The P3 is an ERP component thought to reflect the amount of attention devoted towards processing a stimulus (Krompinger & Simons, 2011) . This ERP component, a positive potential elicited around 300 ms after the occurrence of a stimulus, seems to be differentially affected by valence and arousal dimensions of affective stimuli (Delplanque et al., 2006). Especially the parietally distributed P3 is assumed to index a late evaluation stage of processing and the updating of working memory (Delplanque et al., 2006). The P3 is therefore regarded as a useful tool to measure the enactment of conflict resolution processes. Many experiments examining the P3 in depressed versus nondepressed populations found reduced amplitudes associated with depression (Cavanagh & Geisler, 2006; Kayser et al., 2000; lv et al., 2010). However, findings are inconsistent; for example, Krompinger & Simons (2009) demonstrated that depressed individuals exhibited larger P3s in response to negative compared to positive stimuli with a parietal distribution, which was consistent with a “classic” context-updating processing P3b interpretation.

The modulation of the late positive potential by affectively valenced stimuli is most pronounced around 400 – 600 ms following a stimulus, but in some cases continues for up to a second after the offset of a stimulus (Brown et al., 2012). When viewing emotional, compared to neutral stimuli, modulation of the LPP has proved to be a replicable finding (Pastor et al., 2008). It was therefore suggested that the LPP reflects processing essential for initial semantic categorization. For example, Yen et al. (2010) demonstrated that affective stimuli, independent of their valence, induce greater LPP amplitudes than neutral stimuli and those stimuli with the strongest affective content elicit the highest LPP amplitudes. Authors argued that LPP amplitude reflects the level of arousal created by a stimulus. Crucially, other research concluded that LPP indexes attentional engagement with current stimuli which in turn may be associated with interference in subsequent cognitive processing (Weinberg & Hajcak, 2011). Brown et al. (2012) speculated that the LPP reflects a global inhibition of activity in the visual cortex, focusing brain activation on the processing of emotional stimuli. Recent investigations of the LPP in depression suggest that in depressed individuals the increase in LPP amplitude typically seen in nondepressed individuals in response to aversive stimuli may be attenuated (Foti et al., 2010).

Besides late positive ERP components, a negative-going deflection, the stimulus-locked N2, maximal at frontal scalp locations and occurring between 200 and 400 ms after stimulus onset, is the component most often linked to executive cognitive function (Folstein & Van Petten, 2008). In tasks involving suppression or inhibition of distracting stimuli, such as in a Flanker, Stroop, or Go/Nogo paradigm, the N2 amplitude is enhanced when an individual must exert control in order to perform the task correctly (cf. Krompinger & Simons, 2009). It has therefore been suggested that the N2 ERP component reflects evaluation of targets and possibly response selection, as well as some aspects of visual attention or visual classification processing. The N2 with an anterior scalp distribution is also thought to reflect cognitive control, mismatch detection and affective experiences. In short, the N2 amplitude seems to be a reliable indicator of conflict monitoring. Moreover, the amplitude of the N2 ERP component has been directly linked to the activity of the anterior cingulate cortex, a structure that is thought to play a prominent role in executive cognitive functioning (Hanslmayr et al., 2008). Thus, observing the cognitive-control related N2 component while depressed individuals perform a cognitive task after they have been induced with affective information processing may allow for more insights into interfering effects of persistent information processing during ongoing executive cognitive functioning in depression suggested in the reasoning employed above.

In the present study, an attempt was made to replicate the specific interference effect of sustained information processing found in Study 2 in individuals suffering from MDD. Secondly, the aim was to investigate brain processes that may be impaired in executive cognitive functioning due to sustained information processing. As explained above, ERPs provide a noninvasive central measure of brain activity on a trial-by-trial basis and were therefore chosen as an appropriate dependent measure for the current study. Thus, in the present study, electroencephalographic recordings were obtained from participants while they were performing the ACI task. The current study involved inpatients of a psychiatric clinic suffering from clinically manifest depression and nondepressed controls matched for age, gender, and intelligence. Care was taken to rule out a number of confounding variables that may impact the effect of sustained information processing on behavioral and brain processes in depressed groups.

Since, as mentioned above, studies have very rarely specifically examined the interfering effect of sustained processing of affective information using ERPs, the current study sought to use ERPs in order to better understand the temporal dynamics of sustained information processing interfering with ongoing cognitive functioning in depression, or put differently, the current study aimed at using ERPs to investigate affective interference during executive cognitive functioning in depression. Furthermore, the present study aimed at investigating the way in which individual differences in state orientation influence a possible interference effect associated with sustained information processing. It was also sought to determine whether individual differences in state orientation modulate affective interference with regards to corresponding brain activity. That is to say, it was explored whether specific EEG parameters for depressed and nondepressed individuals varied between conditions of the ACI task, and whether measures for state orientation predicted those EEG parameters for depressed individuals and controls.

To do this, ERPs were recorded while participants completed the ACI task. The design of this task was assumed to allow the detection of discrepancies in brain activity associated with affective interference between nondepressed and depressed individuals. Specifically, the task should allow the observation of the modulation of late positive potentials as well as the modulation of the N2 ERP component, specific to both sustained processing of negative and positive stimuli. Thus, to investigate

P3, LPP, and N2 biases associated with interfering sustained information processing, the ACI design described above was used, employing positively and negatively valenced words as well as neutral words to answer the following question: Do individuals with major depression and nondepressed individuals show differential P3, LPP, and N2 activity in an ongoing executive cognitive task depending on the type of affective information they had to process right before the cognitive task? Importantly, however, this experiment allowed to test both brain activity associated with affective interference assumed to be caused by the persistent processing of information previously presented, and brain activity associated with differences in initial and sustained processing of affective information. Therefore, is was also examined whether depressed and nondepressed individuals show differential brain activity in response to affective priming, in particular in the parameters of the N1 and P1 ERP components. To additionally examine whether individual differences in state orientation are related to sustained information processing and/or to the degree of affective interference, self-report measures of state orientation were administered and sustained information processing, in terms of brain activity, and affective interference, in terms of behavioral and electroencephalographic data, were examined in relation to self-reported state orientation. In sum, this study examined brain processes associated with sustained information processing after affective information had been briefly presented, and executive cognitive functioning and corresponding brain processes affected by sustained information processing in depressed and nondepressed individuals by assessing ERPs during the ACI task. Additionally, the study examined the extent to which sustained information processing and affective interference were related to self-report measures for state orientation.

Based on the rationale elaborated on above, the following analytic strategy was adopted: 1) sustained processing of affective information was examined in terms of ERPs following affective priming in the ACI task. 2) Affective interference was investigated in terms of RTs and error data in the Stroop task that followed the affective priming in the ACI task. Moreover, affective interference was examined in terms of ERPs modulated by affective priming. 3) The relationship between individual levels of state orientation and measures for sustained information processing and affective interference was investigated. 4) Finally, the interrelationships between measures for sustained information processing, affective interference, and state orientation were examined.

It was hypothesized that depressed individuals would exhibit increased initial and sustained processing for affective prime stimuli, in particular negative primes, as indicated by an overall increased amplitude for early sensory ERP components (cf. N1 and P1) after affective priming. Next, it was predicted that interference of affective information processing would be reflected in slower responses in the Stroop task in particular in depressed individuals and in particular after negative prime words. Original findings for the ACI task would suggest the detection of decreased reaction times after positively primed, incongruent Stroop stimuli in both groups and increased reaction times after negatively primed, incongruent Stroop stimuli, in particular in depressed patients (cf. Kazén & Kuhl, 2005; Kuhl & Kazen, 1999). However, the results of Study 2 indicated a different pattern of behavioral effects and therefore effects were predicted especially for the control Stroop Condition. Next, it was expected that sustained information processing reflected in early perceptual ERP components would carry over into the subsequent executive cognitive task, resulting in affective interference that, in turn, would be reflected in altered brain function as well. Specifically, hypotheses regarded the detection of decreased late positive potentials and decreased N2 amplitudes in depressed individuals especially after being primed with negative stimuli. As discussed above, the amplitudes of the N2 and P3 ERP components are associated with conflict detection and interference resolution respectively. If depression is associated with increased sustained information processing – which may be related to an overactivity of the default-mode network – and resulting affective interference, these two ERP components should be particularly decreased indicating affective interference on the level of brain function. Or, in other words, decreased N2 and P3 amplitudes would reflect abnormalities in cortico-cingulate function resulting from sustained information processing. Based on the findings of studies mentioned above, it was predicted that affective interference would not only operate at the executive cognitive stages of processing, reflected by abnormal N2 and P3 amplitude parameters, but also at later stages of the processing stream. Thus, it was expected to see prime-induced modulations in the LPP component, too. However, no prediction was made about the direction of this influence. Finally, since research has shown important individual differences in proneness to state-oriented cognitions, it was sought to correlate measures for both sustained information processing and affective interference with measures for dispositional state orientation. It was hypothesized that higher levels of sustained information processing as well as higher levels of affective interference would both be related to higher levels of state orientation. However, because only scarce data is available on this specific topic, these predictions were less clear about the relative strength of this relationship in the control and the MDD group.

Method

Participant Characteristics

In total, 59 patients (31 men and 28 women; mean age = 37.6 years, *SD* = 11.7) and 52 control participants (28 men and 24 women; mean age = 36.0 years, *SD* = 11.1) with on average 10.9 (*SD* = 1.6) and 11.9 (*SD* = 1.4) years of school education participated in the study. Participants were eligible for the study if they were between 18 and 65 years old and had native or native-level knowledge of German. Patients were eligible to participate if they met the Diagnostic and Statistical Manual of Mental Disorders, 4th Ed. (Saß et al., 1998) criteria for unipolar depressive disorder (MDD; DSM-IV 296.2x and 296.3x). The diagnosis of MDD was determined by the patients' treating therapist. Patients had to be capable of consent and had to be in voluntary inpatient treatment. Control participants were eligible for the study if they had no current or past Axis I disorder. A number of exclusion criteria existed for this study. Participants were also not included, if they were left-handed or color blind, if they had eyesight problems, a weakness in writing and reading, diabetes, dementia, multiple sclerosis, epilepsy, or any other neurological or cardiovascular disease, or if they reported substance abuse. Patients were not included in the study if they were taking benzodiazepines or had a comorbid borderline personality disorder. Other comorbid diagnoses were permitted provided that depression was the primary clinical diagnosis. Control participants were excluded from the study if they had a record of psychiatric or psychological treatment for depressive symptoms or if they used centrally acting drugs. The eligibility screening procedure of the present study included the German version of the structured clinical interview for DSM-IV (SCID; Wittchen et al., 1997). In both groups, medical students trained in SCID administration assessed clinical diagnoses and thereby confirmed the diagnoses for patients and the eligibility of controls. In the case of patients, the diagnostic interview was carried out in a separate session lasting up to 2.5 h. Finally, all depressed individuals were required to have a minimum score of 19 on the BDI and all control participants were required to have a maximum score on the BDI of 9. These latter two criteria were designed to ensure inclusion of participants with similar levels of severity of depressive symptoms in both groups.

Sampling Procedure

Depressed individuals were recruited from a psychiatric clinic in a university teaching hospital by personal approach (Department of Psychiatry and Psychotherapy at the Philipps-University Marburg). Control participants were recruited from the urban area of Marburg (Germany) through online advertisements and print advertisements posted in numerous locations within the community (e.g., university, kiosks, supermarkets, taxation office, job center). Data were collected in premises of the Department of Psychiatry and Psychotherapy at the Philipps-University Marburg. The first participants in the study were patients. The treating therapists reported patients to the principal investigator who were preliminary diagnosed with major depressive disorder and willing to participate in the study. In a first meeting, patients who were interested in participating were informed about the procedure of the study and screened for exclusion criteria. Afterwards, the SCID was conducted. If no contra-indications were present, an appointment for the experimental session was made. Approximately 80% of patients initially approached participated in the study. A phone screen served as preliminary test for control participants. In this first telephone interview, people interested in participating in the study were informed about the study and screened for exclusion criteria. Control participants who resembled patients previously tested in age, gender and education were called a second time to make an appointment for the experimental session. About 30% of control participants initially interested in participating were included in the study. In the case of control participants, the SCID was conducted directly after the experimental session, such that they did not have to come to the clinic twice. The study was reviewed and approved by the Ethics Committee of the Faculty of Medicine at the Philipps-University Marburg and all participants gave written informed consent before testing. All participants were paid 50,– Euros for their participation.

Measures and Covariates

State orientation. Based on the findings of Studies 1a – 1c, in the present study, state orientation was assessed by the RUM subscale of the VCI. Internal consistency reliability in the current sample was α = .88.

Depressiveness. In this study, as in Study 2, the level of participants' depressiveness was assessed by the BDI. Internal consistency reliability in the current sample was: α = .94. Additionally, the Hamilton Rating Scale for Depression (HRSD; M. Hamilton, 1960) which is the standard measure of depression severity for clinical trials, was used. In contrast to the BDI, where the participant rates himself, with the HRSD, the participant is rated by a third person. The HRSD consists of ratings made by a third person interviewing the participant on 21 questions. Each rating is graded according to severity from 0 to 2 or from 0 to 4. The maximal score is 66. Scores > 10 indicate mild depression, scores > 20 a moderate depression, and scores > 30 a severe depression. The internal, interrater, and retest reliability estimates for the HRSD are mostly satisfactory. Similarly, established criteria are met for convergent, discriminant, and predictive validity (Bagby et al., 2004). Internal consistency reliability in the current sample was: $\alpha = .90$.

Anxiety. To address the distinctiveness of anxiety and depression, the Beck Anxiety Inventory (BAI; Beck et al., 1988) was used to assess participants' level of anxiety. The BAI is 21-item self-report inventory for measuring the severity of anxiety in psychiatric populations. It consists of descriptive statements of anxiety symptoms which are rated on a 4-point scale with the following correspondence: "Not at all" (0 points); "Mildly; it did not bother me much" (1); "Moderately; it was very unpleasant, but I could stand it" (2); and "Severely; I could barely stand it" (3). Internal consistency (Cronbach's alpha) ranges from .92 to .94 for adults. The test-retest reliability (1-week interval) is around .75. The BAI is significantly correlated with the Trait (.58) and State (.47) subscales of the State-Trait Anxiety Inventory (Laux et al., 1981). Total scores of 0 to 7 reflect "Minimal level of anxiety", scores 8 to 15 indicate "Mild anxiety", scores of 16 to 25 reflect "Moderate anxiety", and scores 26 to 63 indicate "Severe anxiety". Internal consistency reliability in the current sample was: $\alpha = .93$.

Intelligence. General intelligence was assessed by the multiple choice verbal intelligence test (MWTB; Lehrl, 2005). The MWTB consists of a short instruction for the responder to decide in each group of four words presented which of the words really exists. In total there are 37 groups of words ordered by increasing difficulty. The standardized total number of correctly identified words is used to determine general intelligence.

Sustained information processing and affective interference. As in Study 2, sustained information processing and affective interference was assessed by a modified Stroop Color Naming Task, namely the ACI task. In the present study, participants rated all 18 affective prime words used in the ACI task. Ratings were obtained on 7-point scales (1 = "not at all" to 7 = "completely", or 1 = "difficult" to 7 = "easy" respectively) on the following dimensions: (a) how strongly each word could still trigger the associated affective response, (b) how well participants could control whether each word triggered the corresponding affective response, and (c) how much they perceived the word, or thought respectively, to be "self-willed" when it entered consciousness. Sustained information processing and affective interference in terms of brain activity was assessed as the parameters of the N1, P1, N2, P3, and LPP ERP components analyzed as a function of Prime Type, Stroop Condition and Group.

Research Design and Data Analysis

The study used a combined experimental-quasi-experimental design. Individuals performed the ACI task and were assigned to either the patient or control group based on the SCID diagnosis for control participants and based on the SCID in combination with the clinical diagnosis for patients. All researchers involved were aware of the group membership of each participant. Statistical analyses were conducted using SPSS (version 19.0.0.1). Initially, prime stimuli were examined to be sure that stimuli deemed personally relevant and affectively neutral, positive, or negative respectively were indeed perceived that way by participants. Afterwards, data analysis was performed in multiple stages. First, sustained processing of affective information was investigated in terms of “prime-locked” ERPs. Second, to evaluate the impact of persistent information processing on executive cognitive functioning, affective interference was analyzed in terms of RTs and errors in the Stroop task, as well as in terms of the modulation of “stimulus-locked” ERP components related to executive cognitive functioning as a function of affective priming.

For the analysis of behavior, only trials with correct responses were used. RT and error data were analyzed in separate 3 (Prime Type: neutral, positive, negative) $\times$ 2 (Stroop Condition: incongruent, control) $\times$ 2 (Group: patient, control) mixed-design ANOVAs with repeated measures on the first two factors and Greenhouse-Geisser-adjusted p-levels. When indicated, following the omnibus tests, Bonferroni-corrected pairwise post hoc comparisons were used to localize significant effects.

To investigate the brain correlates of sustained information processing and affective interference, EEG data was processed using BrainVision Analyzer (version 2.01.3931). Data was filtered using a Butterworth zero phase filter (low cutoff = 0.5 Hz; high cutoff = 18 Hz). Afterwards, irregular artifacts were excluded by visual inspection. Next, the Cz electrode was disabled and the sampling rate reduced to 128 Hz. Then, an independent component analysis employing an infomax (gradient) restricted algorithm was used to determine components in the data related to eye movement and pulse. After excluding eye and pulse components, the Cz electrode was enabled by topographic interpolation using spherical splines (order of splines = 4). Then, two different segmentations were performed: (i) EEG segments beginning 200 ms before and ending 1000 ms after the prime stimulus (“prime-logged” analysis; cf. sustained information processing) and (ii) EEG segments beginning 2000 ms before and ending 2000 ms after the first Stroop stimulus (“stimulus-logged” analysis; cf. affective interference). For both segmentations, automatic artifact rejection was applied, which tested for gradient steps above 50 μV/ms 200 ms before, to 200 ms after, stimulus onset and for a maximal difference within this interval of 200 μV. For each channel, the current source density was calculated (order of splines: 4) and a baseline correction was applied using the interval from –200 ms to 0 ms, (prime-locked) or –800 ms to –600 ms (stimulus-locked) respectively. For each participant, ERPs were constructed by separately averaging artifact-free, prime-logged and artifact-free stimulus-locked segments with correct responses, in each experimental condition. Data of participants were discarded, if there were less then 20 artifact-free segments in any of the six experimental conditions. Finally, grand averages were calculated for each group in each condition.

Upon visual inspection of prime-locked topographies, a positivity at electrodes Oz and Pz was identified starting around 150 ms after prime onset ("P1"). Moreover, a negativity was identified in the same time interval at sites P7 and P8 ("N1"). Inspection of the corresponding grand-averaged waveforms additionally revealed late positivity (LP) component between 300 to 600 ms. Automatic peak quantification was used in order to quantify the P1 component between 133 – 210 ms post-stimulus onset at sites Pz and Oz. Analogously, peak amplitude and peak latency parameters were measured for the N1 component (133 – 210 ms) at electrodes P7 and P8. The mean amplitude of the LP component was quantified at electrode Pz between 300 and 600 ms. Visual inspection of stimulus-locked topographies revealed (a) a negativity at central and fronto-central electrode sites between 200 and 430 ms ("N2"), (b) a positivity at parietal electrode sites between 300 and 660 ms ("P3"), and (c) a positivity at central electrode sites between 430 and 970 ms ("LPP"). Peak quantification involved automatic identification of the maximum amplitudes within defined latency ranges or the calculation of mean amplitudes, respectively. The defined latency ranges were as follows: N2: 203–430 ms, P3: 305–665 ms, LPP: 430–970 ms. Maximum amplitudes, or mean amplitudes respectively, in the defined latency ranges were determined at electrodes Cz and FCz (N2), Pz, P3, P4, P7, and P8 (P3), and Cz and FCz (LPP).

Amplitude and latency parameters of prime-locked ERP components were analyzed in separate 3 (Prime Type: neutral, positive, negative) $\times$ 2 (Group: patient, control) mixed within-between design ANOVAs and Greenhouse-Geisser-adjusted *p*-levels. When indicated, following the omnibus tests, Bonferroni-corrected pairwise post hoc comparisons were used to localize significant effects. Amplitude and latency parameters of stimulus-locked ERP components were analogously analyzed in separate 3 (Prime Type: neutral, positive, negative) $\times$ 2 (Stroop Condition: incongruent, control) $\times$ 2 (Group: patient, control) mixed-design ANOVAs with repeated measures on the first two factors.

Experimental Manipulations

Content of manipulation. The experimental manipulation followed the procedure described in Study 2 (cf. ACI task). However, to increase the Stroop effect, instead of congruent Stroop stimuli, in this study, control Stroop stimuli were used appearing as rows of four Xs, in each of the four colors. Word primes were generated as described before, only that – based on the results of Study 2 – instead of two different kinds of negative prime word categories only one category was used: the threat category. Again, participants chose six words out of a list providing 60 words, so that those words would not elicit any positive or negative affective reaction (neutral words). Again, the task of the participants was to react as fast and as accurately as possible to the color of each word and again participants were instructed to regard the initial prime word as a preparation signal which would be more effective the more they would remember the associated event.

Methods of manipulation and data acquisition. Stimuli were presented on a 15-in TFT monitor. A computer running Presentation (Neurobehavioral Systems, Inc.) controlled stimulus presentation and response collection. Participants' viewing distance to the monitor was approximately 60 cm. The primes and Stroop stimuli were 1 cm high. Reaction times (RTs) in the Stroop task were recorded via the participant pushing "d" and "f" with their left index and middle finger and "j" and "k" buttons with their right index and middle finger on a keyboard. The first 24 participants in each group were assigned one of 24 different key-color assignments; afterwards the assignment started over with the first key-color assignment, and so forth.

The EEG was acquired using a Neuroscan NuAmps digital amplifier. EEG activity was recorded from 26 Ag/AgCl electrodes (positioned according to the international 10-20 system): Fp1, Fpz, Fp2; F7, F3, Fz, F4, F8; FC5, FC3, FCz, FC4, FC6; C3, Cz, C4; P7, P3, Pz, P4, P8; M1, M2; O1, Oz, O2. The vertical electrooculogram (EOG) was recorded from two electrodes below both eyes, and the horizontal EOG from two electrodes at the outer canthi of the eyes. The forehead was used as ground. The primary reference was Cz. EEG and EOG data were sampled with 500 Hz (Acquire, version 4.3.1, Neuroscan (Inc.) and stored continuously on a PC hard disk, together with stimulus and response markers. Impedances were kept below 15 kΩ.

Procedure. The current procedure was part of a larger study focusing primarily on ERPs associated with executive functioning in depression. These studies are to be reported elsewhere. At least two days before the testing session, participants were given, or sent, a number of questionnaires and were asked to fill in the forms and bring them to the experimental session. On top of the questionnaires, all participants were given an information sheet and a corresponding consent form. The information sheet included information about the background and purpose of the study, about the apparatus used, procedure and expected duration of the study, handling of incidental findings, and data protection regulations. On the day of the experimental session, participants had to bring the signed consent form to be able to participant in the study. On the day of testing, a blood sample was taken from control participants before they were brought to the testing room. In the case of patients, the blood sample was taken during regular clinical routines on the day of testing or one to two days before or after. In the testing room, participants were then welcomed again and informed about the details of the study and the whole procedure. The experiment was carried out individually in a quiet room and started with participants being asked to fill in two short questionnaires assessing their current mood state and their intelligence. Afterwards, the EEG cap was put on. This included lightly abrading the scalp and adding electrode gel until all impedances were sufficiently low.

Initially, participants started with a Flanker task that lasted about 17 minutes. Afterwards, they got the instructions for the ACI task on a sheet of paper. After all open questions were answered, participants began with three practice blocks of the task before the real experiment began. The practice phase allowed participants to acclimate to the task environment, ensured that they understood the overall objective of the task, and ensured that they were sufficiently familiar with the key-color assignment. The following experimental session lasted for about 35 minutes, interrupted only by two self-paced breaks in-between blocks. As described in Study 2, an experimental trial consisted of an initial fixation cross (500 ms), word prime stimulus (1500 ms), blank screen (500 ms), first Stroop stimulus (until button press; maximal 3000 ms), blank screen (500 ms), and a second Stroop stimulus (until button press; maximal 3000ms) (cf. Figure 3). The intertrial interval was randomly chosen between 500 ms and 1000 ms. The Stroop condition was the same in the first and the second Stroop task within a single trial. In total, there were 48 trials per cell, yielding a total count of trials of 288. Trials were pseudo-randomized such that the same prime category never appeared twice in a row and that the same Stroop condition appeared maximally twice in a row. The pseudo-randomized order of the trials was the same for every participant. After finishing the Stroop task, two minutes of resting EEG were recorded, followed by a Bias Competition task (25 minutes, one break) and finally a Go/Nogo task (around 13 minutes). At the end, participants were thanked and informed about the current research question in detail, if they were interested. In sum, each assessment session lasted approximately three hours.

Results

Participant Flow and Recruitment

In total, 111 individuals participated in the study. Recruitment of participants started in January 2011 and ended in February 2012. The flow of participants is depicted in Figure 5. In the MDD group, three participants did not receive the experimental manipulation, due to color blindness (*n* = 1) and due to prior release from the clinic (*n* = 2). In the control group, one participant did not return the questionnaires. Thus, complete data sets were available for 56 depressed individuals and for 51 nondepressed individuals.

Ten patients had to be excluded because their main diagnosis was modified during the course of treatment (bipolar: *n* = 4, alcohol dependence: *n* = 3, obsessive-compulsive disorder: *n* = 1, adaptive disorder: *n* = 1, dysthymia: *n* = 1). Further depressed individuals had to be excluded due to missing data (*n* = 1), due to too many errors in the experimental task (*n* = 2), due to technical problems during EEG acquisition (*n* = 1), due to heavy artifact contamination of the EEG (*n* = 9), due to too few EEG segments per conditions (*n* = 2), due to left-handedness (*n* = 1), and due to too low BDI scores (*n* = 10). In the control group, three individuals had to be excluded because of prior depressive episodes (*n* = 2) and an existing neurological disease (*n* = 1). Furthermore, two control participants had to be excluded due to too many errors. Further nondepressed individuals had to be excluded due to missing data (*n* = 2), technical problems during EEG acquisition (*n* = 1), poor EEG quality (*n* = 7), and due to too few segments per conditions (*n* = 4). To create two groups of the same size matched for age, gender and IQ (cf. Ho et al., 2007), four depressed individuals had to be excluded due to too low IQ scores. Thus, in the end, data on 16 depressed individuals and 16 nondepressed individuals were usable.

The final study sample consisted of 16 nondepressed individuals (5 men and 11 women) and 16 depressed individuals (4 men and 12 women). Table 12 presents the demographic, personality, and clinical characteristics of both groups. Depressed and non depressed individuals did not differ with respect to age, general intelligence, or gender composition (χ^2 = 0.16, *p* = .69). In both self and external assessment, patients showed a depressive symptomatology that was much more pronounced than among control participants. Similarly, depressed individuals had significantly higher levels of state orientation. Associations between study variables are given in Table 13. The self-reported overall duration of depressive illness among patients ranged from nine to 950 weeks (*M* = 312, *SD* = 337).

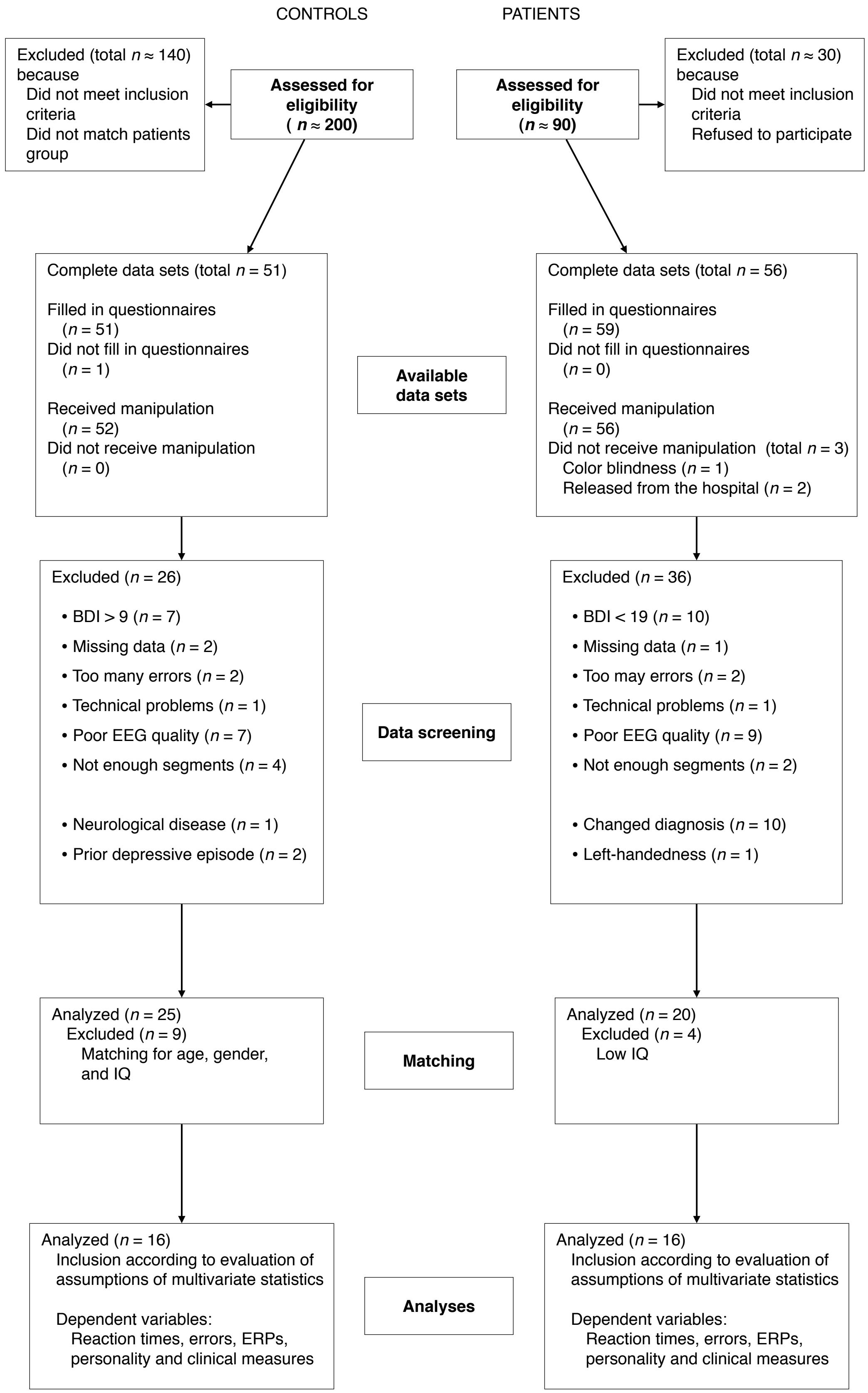

Figure 5. Participant flow chart for Study 3.

Table 12

Demographic, Personality, and Clinical Characteristics for Participants in Study 3

	Controls (n = 16)		Patients (n = 16)					95% CI		
	M	*SD*	*M*	*SD*	*t*	*df*	*p*	LL	UL	Cohen's *d* [a]
Demographic variables										
Age (years)	34	11	34	10	−0.07	30	.95	−8.06	7.56	−0.03
Sex (% female)	69		75							
MWTB	114	6.3	109	8.9	1.79	30	.08	−0.69	10.44	0.65
Personality variables										
RUM	3.12	2.16	9.37	2.42	−7.72	30	$<$.001	−7.90	−4.60	−2.82
Clinical variables										
BDI	2.44	2.97	27.50	6.52	−13.99	30	$<$.001	−28.72	−21.41	−5.11
HRSD	0.38	0.89	18.40	5.04	−14.09	29	$<$.001	−20.64	−15.41	−5.23
BAI	3.90	3.85	20.75	12.47	−5.16	30	$<$.001	−23.70	−9.99	1.88

Note.
Variations in sample size are due to the variation in number of participants who filled in the respective questionnaire. MWTB = verbal intelligence measured by the multiple choice verbal intelligence test; RUM = failure-related state orientation (cf. VCI); BDI = Beck Depression Inventory; HRSD = Hamilton Rating Scale for Depression; BAI = Beck Anxiety Inventory.
[a]Cohen's *d*: 0.20 = small effect; 0.50 = medium effect; 0.80 = large effect.

Table 13

Correlation Matrix for Demographic, Personality, and Clinical Variables in Study 3 (n = 32)

Variable	*1*	*2*	3	4	5
RUM	-				
BDI	$.83^{***}$	-			
HDRS	$.80^{***}$	$.90^{***}$	-		
BAI	$.65^{***}$	$.67^{***}$	$.67^{***}$	-	
MWTB	.26	−.32	−.33	−.18	-

Note. RUM = failure-related state orientation (cf. VCI); BDI = Beck Depression Inventory; HDRS = Hamilton Depression Rating Scale; BAI = Beck Anxiety Inventory; MWTB = general intelligence measured by the multiple choice verbal intelligence test.
$^{***}p < .001$, two-tailed.

All depressed individuals were taking one or more antidepressants from the following classes: selective serotonin reuptake inhibitors (7 individuals), selective serotonin noradrenalin reuptake inhibitors (6 individuals), alpha-2 blocker (4 individuals), mood stabilizer (2 individuals), other medication (5 individuals). Figure 6 gives an overview over main diagnoses in the MDD group. Main diagnoses included (i) recurrent depressive disorder with a moderate current episode (ICD-10: F33.1: $n = 7$), (ii) recurrent depressive disorder with a severe current episode without psychotic symptoms (ICD-10: F33.2: $n = 5$), (iii) severe depressive episode without psychotic symptoms (ICD-10: F32.2; $n = 2$), and (iv) moderate depressive episode (ICD-10: F32.1; $n = 2$). Eight depressed individuals were diagnosed with comorbid dysthymia (ICD-10: F34.1; $n = 8$), and one individual each was diagnosed with comorbid undifferentiated somatoform disorder (ICD-10: F45.1), harmful use of cannabinoids (ICD-10: F12.1), accentuation of personality trait (ICD-10: Z73.1), specific spelling disorder (ICD-10: F81.1), specific (isolated) phobia (ICD-10: F40.2), obesity (ICD-10: E66.0), and specific personality disorder (ICD-10: F60.3).

Manipulation Check

Initially, a 2 (Valence: positive, negative) × 2 (Group: controls, patients) mixed within-between design ANOVA tested whether word length differed between different prime categories and between groups. Analysis revealed that word length differed significantly between prime categories, $F(2, 58) = 6.47$, $p = .003$, $\eta_p^2 = .18$. Positively valenced words (estimated marginal mean *EMM*) = 9.8, *SD* = 0.5) as well as and negatively valenced words (*EMM* = 9.8, *SD* = 0.5) had roughly two letters more than neutral prime words (*EMM* = 8.2, *SD* = 0.3). Importantly, however, there was no difference between positive and negative prime words ($p > .90$), no significant group effect ($p > .80$)

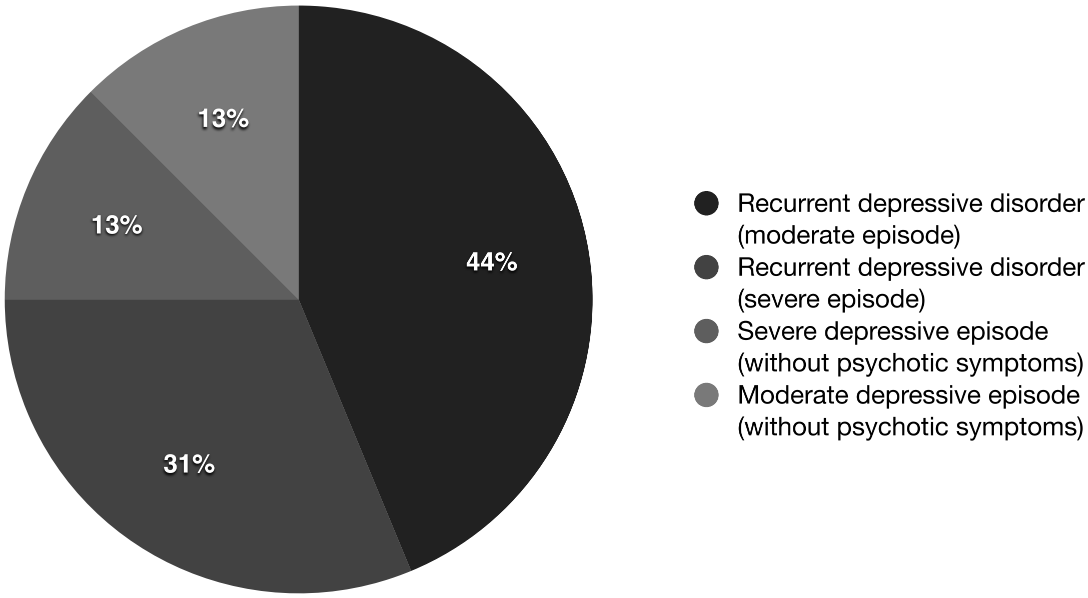

Figure 6. Main diagnoses in MDD group in Study 3.

and no Valence × Group interaction effect ($p > .38$). Next, separate 2 (Valence: positive, negative) × 2 (Group: controls, patients) mixed-design ANOVAs were calculated for the three ratings obtained for the self-generated prime words in the CLEQ. Both positive and negative prime words equally strongly triggered the corresponding affective response ($F(1, 28) = 0.80$, $p = .38$, $\eta_p^2 = .03$). However, participants stated that it was more difficult for them to control whether negatively valenced prime words triggered the corresponding affective response (*EMM* = 4.12, *SD* = 0.27) compared to positively valenced prime words (*EMM* = 5.25, *SD* = 0.26); $F(1, 28) = 10.01$, $p = .004$, η_p^2 = ..26. Similarly, participants experienced negative primes as being less self-willed; they perceived themselves less as being the origin of the thoughts associated with the prime words in the case of negatively valenced words (*EMM* = 3.51, *SD* = 0.32) compared to positively valenced words (*EMM* = 4.50, *SD* = 0.36), $F(1, 28) = 8.72$, $p = .006$, η_p^2 = ..24.) There were no significant interaction effects (all *p*s > .08). Interestingly, an exploratory follow-up MANOVA revealed that nondepressed individuals had less difficulty preventing negative thoughts from entering consciousness (*M* = 4.68, *SD* = 1.50) compared to depressed individuals (*M* = 3.57, *SD* = 1.43), $F(1, 28) = 4.23$, $p = .05$, $\eta_p^2 = .13$.

Sustained Information Processing

N1. Raw data for the analysis of the the prime-locked N1 ERP component were peak amplitude and peak latency parameters for each valence condition and for each group at electrodes P7 and P8. For the mixed-design ANOVA, the full data set included 32 cases, 16 cases in each group. In each group and in each cell, latencies were normally distributed and no univariate outliers were detected. Likewise, peak amplitude data were normally distributed in each cell for each group and showed no univariate outliers. Multivariate outliers were identified as cases with too large Mahalanobi D^2 for their own group, evaluated as χ^2 with degrees of freedom equal to the number of dependent variables. Applying a critical χ^2 of 22.46 (6 *df* at $\alpha = .001$) found no multivariate outliers in either group, neither for peak latency, nor for peak amplitude parameters. To investigate differences in initial information processing as a function of stimulus valence between depressed and nondepressed individuals, peak latency and peak amplitude data of the prime-locked N1 ERP component were analyzed in separate Site × Prime Type × Group Greenhouse-Geisser adjusted, mixed-design ANOVAs with repeated measures on the first two factors. Analyses revealed no significant main or interaction effect for latency data (all *p*s > .10). For peak amplitude data, analysis also revealed no significant main or interaction effect (all *p*s > .15).

P1. Data screening of peak latency and peak amplitude parameters of the prime-locked P1 ERP component at electrodes Oz and Pz revealed positive skewness only for latency data after positive primes in controls at electrode Pz. Otherwise data proved to be sufficiently accurate for statistical analysis. A Site × Prime × Group mixed-design ANOVA on peak latency data revealed a significant main effect of Site ($F(1, 30) = 6.75$, $p = .02$, $\eta_p^2 = .18$). Moreover, the Site × Group interaction approached significance ($F(1, 30) = 3.98$, $p = .06$, $\eta_p^2 = .12$). Bonferroni-corrected post hoc comparisons revealed that the P1 ERP component occurred first at the Pz (*EMM* = 167 ms, *SD* = 2.46) and subsequently at the Oz (*EMM* = 175 ms, *SD* = 3.26). Furthermore, analysis demonstrated that only in nondepressed individuals did P1 latencies differ as a function of site. ANOVA analysis conducted for P1 peak amplitude parameter revealed a marginally significant Site × Group interaction, $F(1, 30) = 3.54$, $p = .07$, $\eta_p^2 = .11$, and a marginally significant Prime Type × Group interaction, $F(1, 30) = 2.86$, $p = .07$, $\eta_p^2 = .09$. Post hoc pairwise comparisons revealed that in nondepressed individuals the amplitude of the prime-locked P1 ERP component was smaller at electrode Pz (*EMM* = 17.43 μV, *SD* = 3.27) compared to electrode Oz (*EMM* = 22.83 μV, *SD* = 3.21; multivariate test: $F(1, 30) = 2.92$, $p = .10$, $\eta_p^2 = .09$). In depressed individuals this effect was absent (multivariate test: $F(1, 30) = 0.91$, $p = .35$, $\eta_p^2 = .03$). Crucially, analyses further revealed that depressed and nondepressed individuals differed considerably in prime-locked P1 amplitude in response to negatively valenced word primes (depressed: *EMM* = 23.70 μV, *SD* = 2.80; nondepressed: *EMM* = 18.96 μV, *SD* = 2.80, cf. Figure 7). At the Pz electrode, where the effect was strongest, this group difference reached significance in a Bonferroni-corrected post hoc comparison; univariate test: $F(1, 30) = 4.21$, $p = .05$, $\eta_p^2 = .12$.

Late positivity. In both groups, mean amplitude data of the LP ERP component at electrode Pz was positively skewed in all conditions due to single cases with substantially deviant values. Accordingly, in the MDD group, one case had to be excluded as univariate outlier. Subsequently, a Prime Type × Group mixed-design ANOVA found a marginally significant main effect of Prime Type, $F(2, 58) = 2.89$, $p = .07$, $\eta_p^2 = .09$. Post hoc pairwise comparisons revealed that after affectively valenced prime words LP mean amplitude was significantly increased compared to affectively neutral words (cf. Figure 7). In other words, in both the negative priming condition (*EMM* = 8.07 μV, *SD* = 0.82) and the positive priming condition (*EMM* = 8.35 μV, *SD* = 0.86) participants showed higher LP amplitudes compared to the neutral priming conditions (*EMM* = 7.01 μV, *SD* = 0.85; neutral versus positive: $p = .05$; neutral versus negative: $p = .25$). Exploratory analysis revealed that this effect was especially driven by depressed individuals (cf. Figure 8).

Affective Interference

Behavioral data. Prior to analysis, RT and error data were examined for accuracy of data entry, missing values, and fit between their distributions and the assumptions of multivariate analysis.

Evaluation of statistical assumptions. The variables were examined separately for depressed and nondepressed individuals. All means and standard deviations were plausible. RT data showed no out of range value in any of the two groups. In the MDD group, positive skewness was found for error data in the control Stroop condition after positive primes. This skewness was due to a univariate outlier ($z > 3.0$) that was excluded from following analyses. There were no missing data. By using Mahalanobis distance with $p < .001$, derived from leverage scores, no cases were identified as multivariate outliers in either of the two groups. Thus, analyses were based on 15 depressed and 16 nondepressed individuals in case of error data, and on 16 depressed and 16 nondepressed individuals in case of RT data.

Mixed design ANOVA. To investigate the impact of sustained information processing on ongoing executive cognitive functioning in depressed and nondepressed individuals, RT and error data

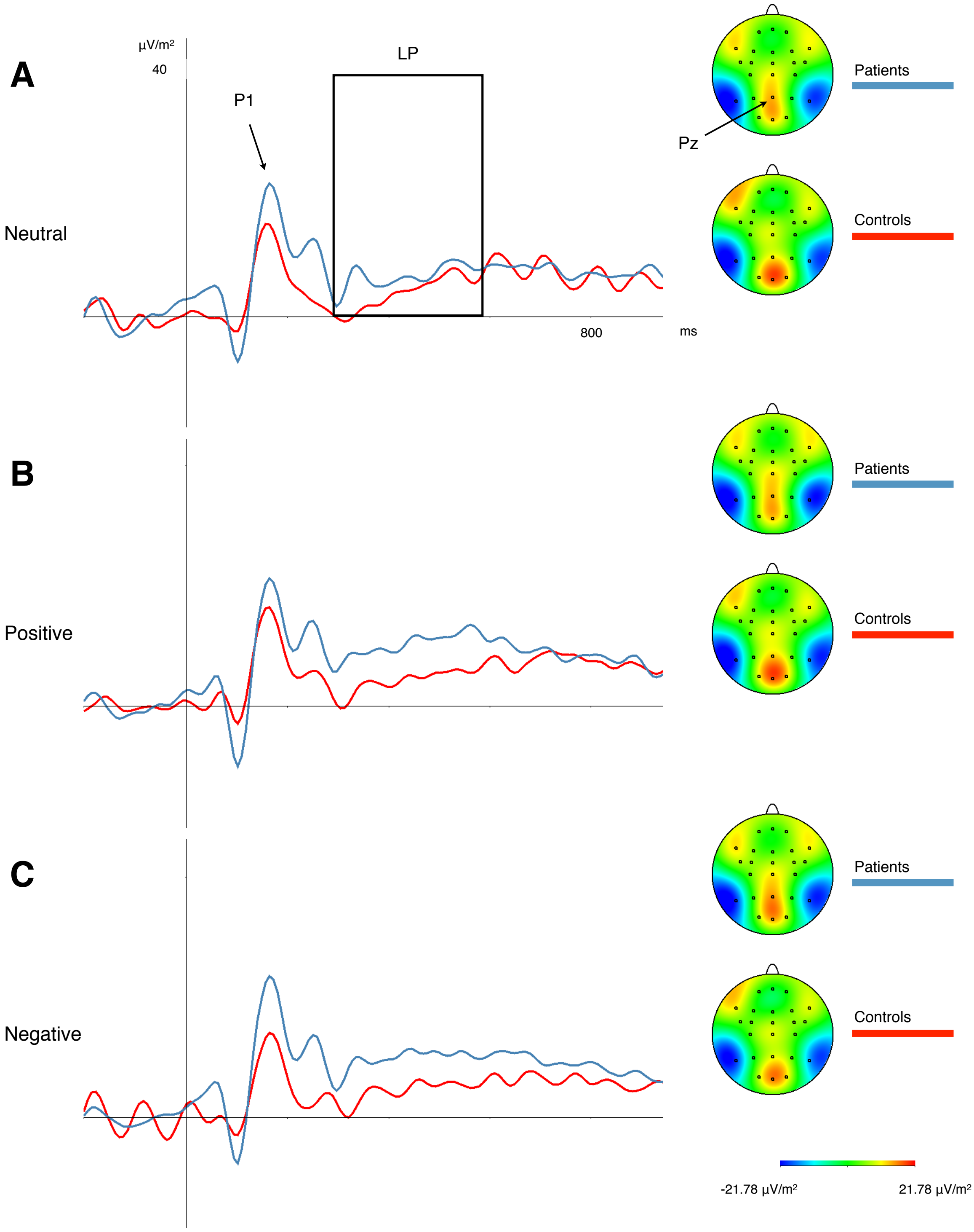

Figure 7. Grand-averaged ERPs elicited by neutral (A), positive (B), and negative prime words (C) at Pz parietal recording site in depressed and nondepressed individuals. Evaluated P1 peak and measurement window used for LP ERP component are indicated at panel A. Topographic two-dimensional maps depict the P1 ERP component at the interval between 156 – 273 ms for depressed and nondepressed individuals during each condition (topographic interpolation by spherical splines (order = 4, maximum degree of Legendre polynomials = 10, $\lambda = 1 \times e^{-5}$.

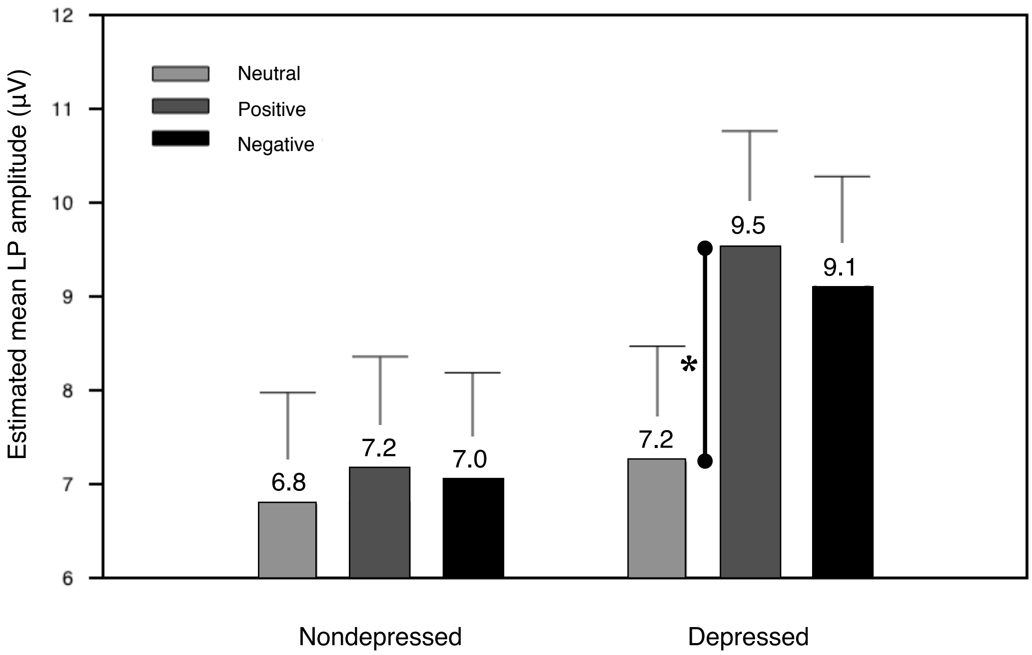

Figure 8. Estimated mean LP amplitude after neutral, positive, and negative prime words at site Pz as a function of Group. Asterisk indicates significant differences at the .05 level.

were analyzed in separate Prime Type × Stroop Condition × Group Greenhouse-Geisser-adjusted, mixed-design ANOVAs with repeated measures on the first two factors. For error data, analysis revealed no significant main or interaction effect (all *p*s > .25). In particular, depressed and nondepressed individuals did not differ in mean number of errors ($p = .26$; mean error rate: depressed: 2.35 % ($SD = 1.68$); nondepressed: 2.61 % ($SD = 1.12$)). For the RT data, analyses revealed a significant main effect of Stroop Condition, $F(1, 30) = 69.02$, $p < .001$, $\eta_p^2 = .70$. Bonferroni-corrected post hoc tests showed that RTs were faster in the control condition ($EMM = 794$ ms, $SD = 24$ ms) compared to the incongruent Stroop condition ($EMM = 882$ ms, $SD = 28$ ms). Furthermore, a Prime Type × Stroop Condition interaction was found, $F(2, 60) = 6.51$, $p = .003$, $\eta_p^2 = .18$. This interaction effect indicated slower responses after negative word primes ($EMM = 818$ ms, $SD = 28$ ms) in comparison to neutral ($EMM = 783$ ms, $SD = 23$ ms) and positive word primes ($EMM = 782$ ms, $SD = 22$ ms), in the control Stroop condition. Exploratory analysis revealed that this effect was especially prominent in depressed individuals, in which Bonferroni-corrected post hoc pairwise comparisons revealed significantly slower RTs after negative primes in the control Stroop condition ($EMM = 842$ ms, $SD = 40$) compared to neutral primes ($EMM = 795$ ms, $SD = 33$; $p = .04$) and positive primes ($EMM = 796$ ms, $SD = 32$; $p = .02$; cf. Figure 9 and Table 14).

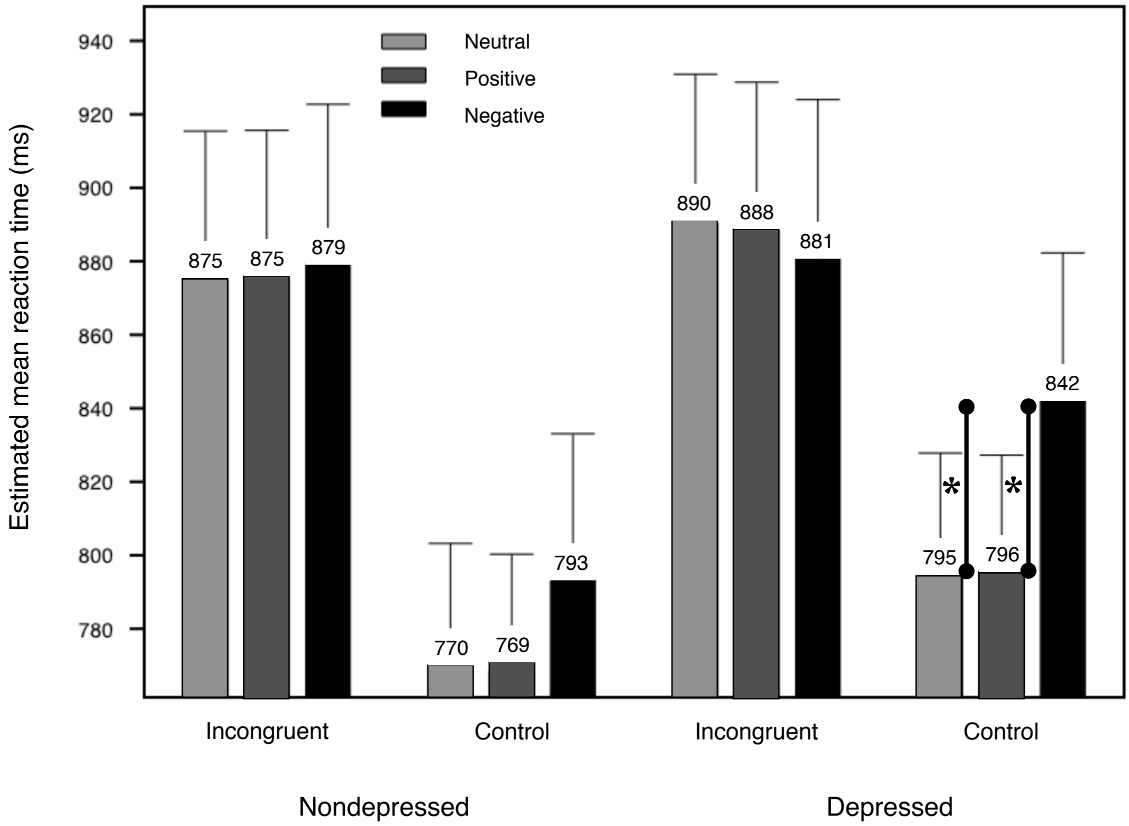

Figure 9. Estimated mean reaction times in the ACI task as a function of the Prime Type, Stroop Condition, and Group in Study 3. Depressed individuals showed significantly slower RTs after negatively primed, control Stroop stimuli compared to neutrally or positively primed, control Stroop stimuli. Asterisk indicates significant differences at the .05 level. In both groups, the Stroop effect was found in each condition (all *p*s < .001, except for depressed individuals in the negative priming condition: $p = .04$).

Table 14

Estimated Mean Reaction Times in the ACI Task as a Function of Group, Stroop Condition, and Prime Type (Study 3)

	Nondepressed			Depressed		
Variable	Neutral	Positive	Negative	Neutral	Positive	Negative
Incongruent Stroop condition						
Mean RT	875	875	879	890	888	881
SD	41	40	43	41	40	43
Control Stroop condition						
Mean RT	770	769	793	795	796	842
SD	33	32	40	33	32	40
Incongruent – Control						
Mean RT	105^{***}	106^{***}	86^{***}	95^{***}	92^{***}	39^{*}

Note. All RTs are in milliseconds.
$^{*}p < .05$. $^{***}p < .001$.

N2. The N2 ERP component was quantified at electrodes FCz and Cz as the most negative peak within the time window of 203 to 430 ms after onset of the first Stroop stimulus. Latency and amplitude parameter of the N2 were examined for accuracy of data entry, missing values, and fit between their distributions and the assumptions of multivariate analysis. The variables were examined separately for depressed and nondepressed individuals. Neither latency nor amplitude data showed out of range values in either group and all means and standard deviations were plausible. There were no missing cases and no univariate outliers with respect to latency data (all zs < 2.3). With respect to amplitude parameters, however, one nondepressed individual was identified as a univariate outlier ($z > 3.0$) and excluded from further analysis. By using Mahalanobis distance with $p < .001$, derived from leverage scores, no multivariate outliers were found. Only amplitude data measured at the FCz for controls after positive primes in the control Stroop condition showed negative skewness. Otherwise, no problems with the statistical assumptions of multivariate statistics were observed. Thus, N2 peak latency and peak amplitude parameter were deemed sufficiently accurate for statistical analysis.

Latency and amplitude parameters of the N2 ERP component were analyzed with separate 2 (Site: FCz, Cz) × 3 (Prime Type: neutral, positive, negative) × 2 (Stroop Condition: incongruent, control) × 2 (Group: patients, controls) within-within-within-between mixed-design ANOVAs. The analysis found a significant main effect of Site for latency data, $F(1, 30) = 4.40$, $p = .05$, $\eta_p^2 = .13$, revealing that the N2 ERP component reached its peak first at the Cz (*EMM* = 305 ms, *SD* = 9.85) and afterwards at the FCz (*EMM* = 326 ms, *SD* = 6.73). Analyzing N2 peak amplitude parameters, revealed that the Prime Type × Group interaction approached significance, $F(2, 58) = 3.13$, $p = .06$, $\eta_p^2 = .10$. Bonferroni-corrected pairwise comparisons demonstrated that whereas in depressed individuals the N2 was more pronounced in the positive priming condition (*EMM* = –17.82 μV, *SD* = 2.02) compared to the negative priming condition (*EMM* = –16.16 μV, *SD* = 2.15), nondepressed individuals showed the exact opposite pattern: here, the N2 was clearly marked after negative primes had been presented (*EMM* = –17.72 μV, *SD* = 2.23) compared to positive primes (*EMM* = –15.91 μV, *SD* = 2.09); multivariate tests: depressed: $F(2, 28) = 2.72$, $p = .08$, $\eta_p^2 = .16$; nondepressed: $F(2, 28) = 1.96$, $p = .16$, $\eta_p^2 = .12$. At electrode Cz, where the effect was strongest, the Prime Type × Group interaction was significant, $F(2, 58) = 5.39$, $p = .009$, $\eta_p^2 = .16$ (cf. Figure 12; cf. also Figures 10 and 11).

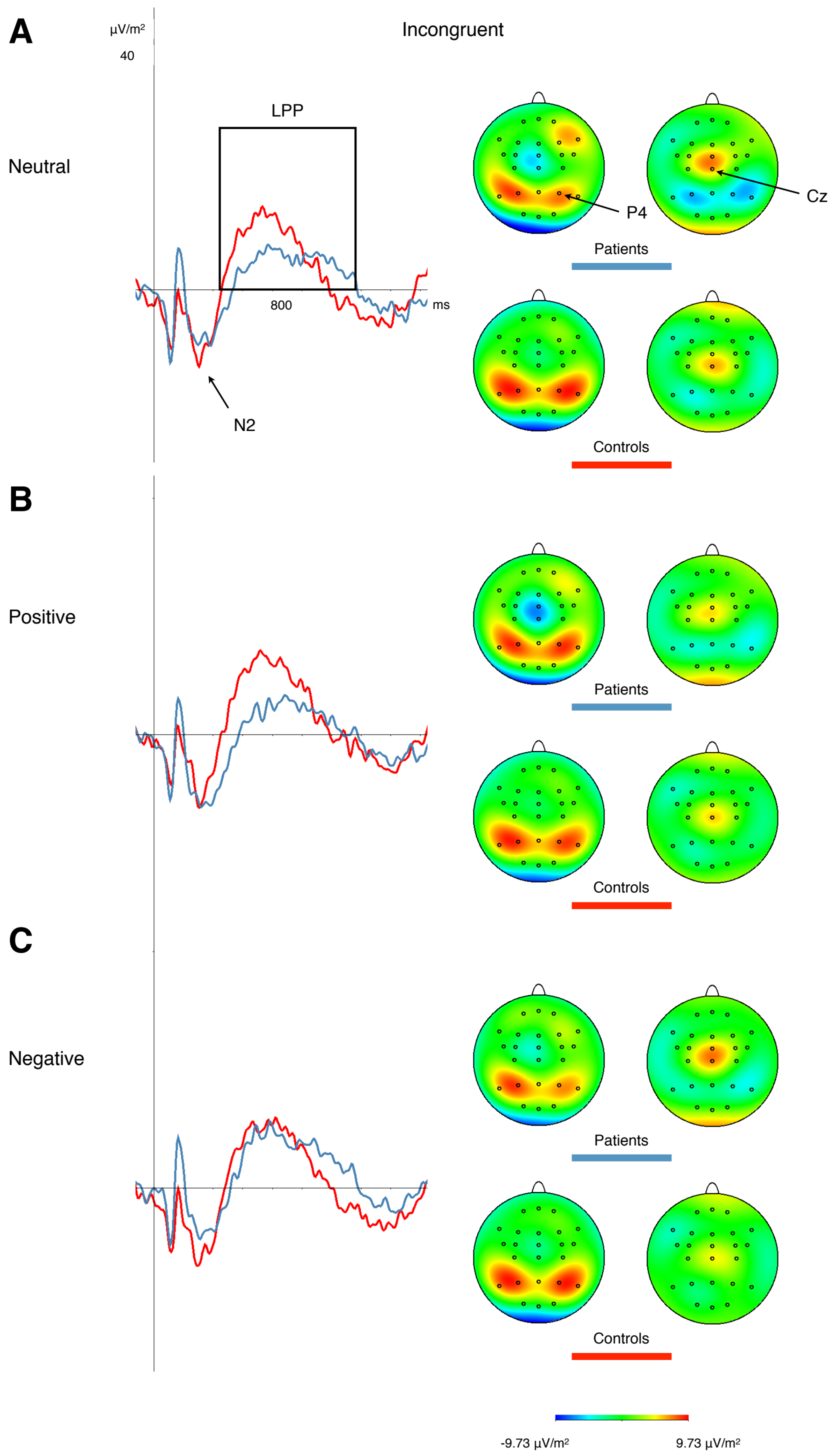

Figure 10. Grand-averaged ERPs elicited at electrode Cz as a function of Prime Type in the incongruent Stroop condition in depressed and nondepressed individuals. Evaluated N2 peak and measurement window used for LPP ERP component are indicated at panel A. Topographic two-dimensional maps depict the N2, P3, and LPP ERP components at the intervals between 219–656 ms (left) and 664–1102 ms (right) for depressed and nondepressed individuals during each condition; topographic interpolation by spherical splines (order = 4, maximum degree of Legendre polynomials = 10, $\lambda = 1 \times e^{-5}$).

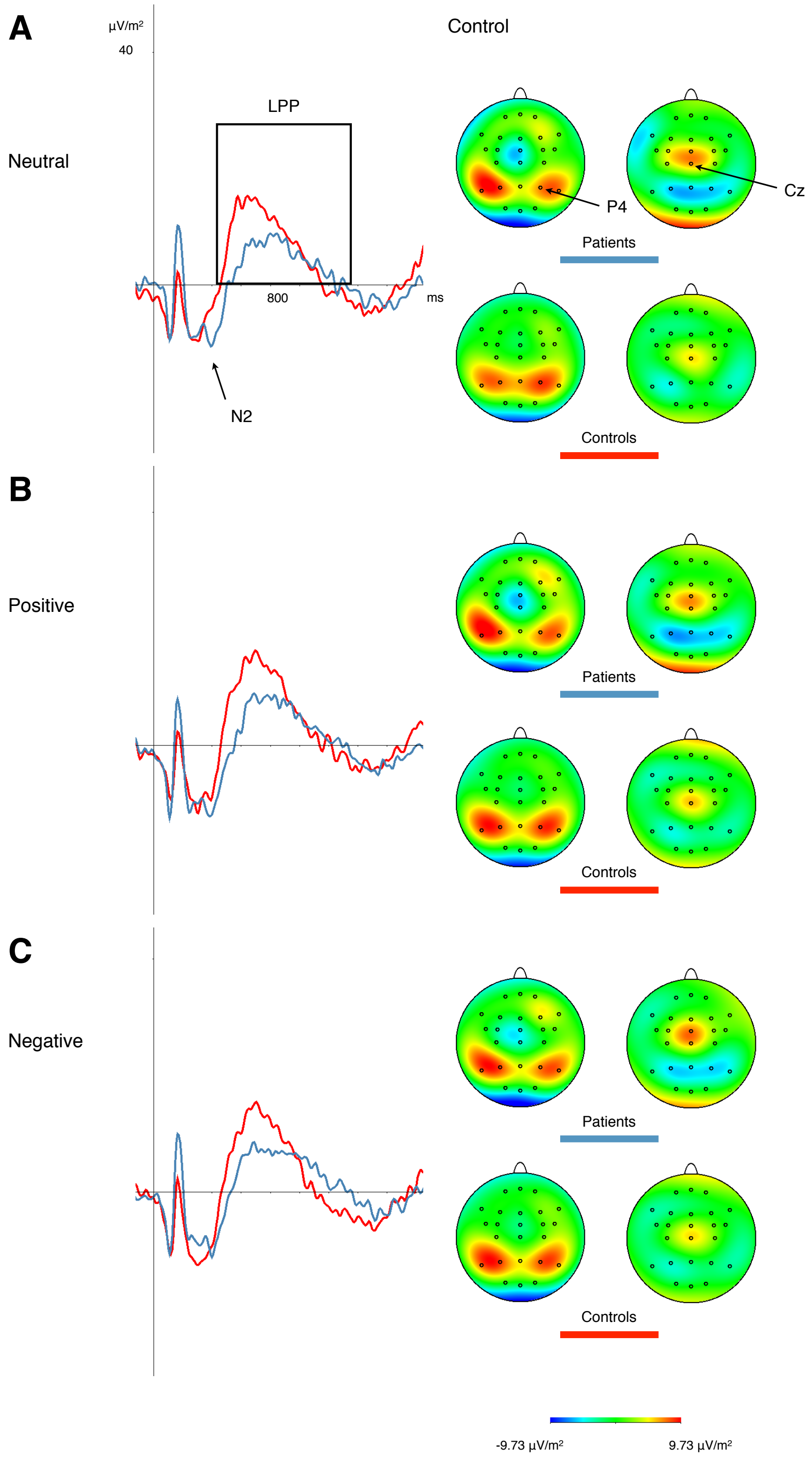

Figure 11. Grand-averaged ERPs elicited at electrode Cz as a function of Prime Type in the control Stroop condition in depressed and nondepressed individuals. Evaluated N2 peak and measurement window used for LPP ERP component are indicated at panel A. Topographic two-dimensional maps depict the N2, P3, and LPP ERP components at the intervals between 219–656 ms (left) and 664–1102 ms (right) for depressed and nondepressed individuals during each condition; topographic interpolation by spherical splines (order = 4, maximum degree of Legendre polynomials = 10, $\lambda = 1 \times e^{-5}$).

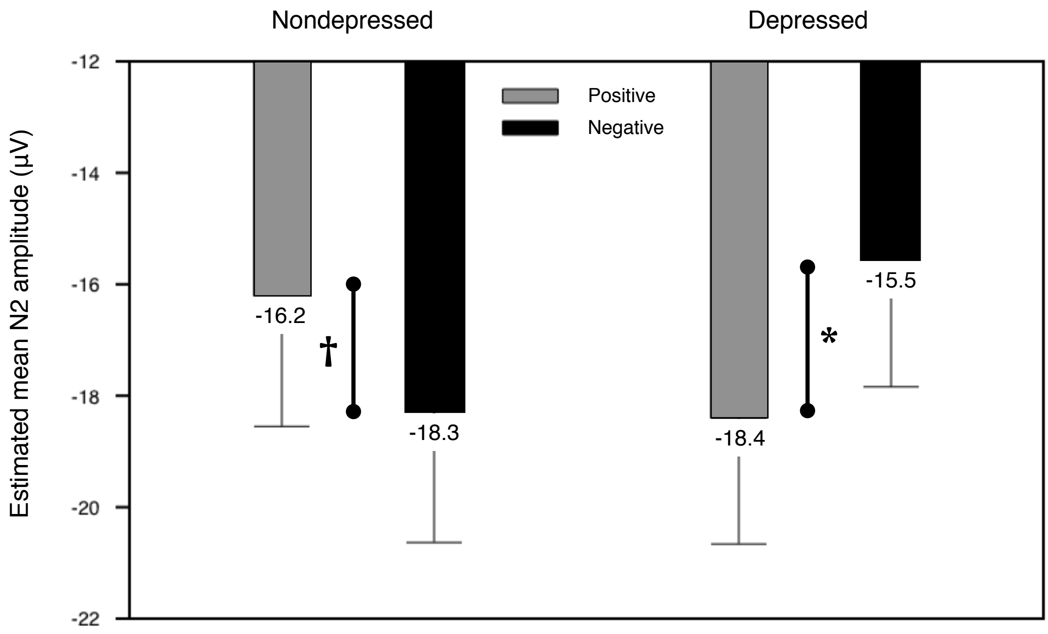

Figure 12. Estimated mean N2 amplitude after positive and negative prime words at site Cz as a function of Group. Dagger indicates significant differences at the .08 level. Asterisk indicates significant differences at the .05 level.

P3. The P3 was quantified at electrodes Pz, P3, P7, P4, and P8 as the mean amplitude within the time window of 305 to 665 ms after Stroop stimulus onset. Data screening revealed positively skewed mean amplitude data in both groups for several conditions and for several electrodes. Skewness was due to a few cases with significantly deviant values. Accordingly, two cases in each group had to be excluded as univariate outliers ($z > 3.0$). Otherwise, no problems with the statistical assumptions of multivariate statistics were observed. Thus, P3 mean amplitude data were deemed sufficiently accurate for statistical analysis. Mean amplitude parameters of the P3 ERP component were analyzed with a 5 (Site: Pz, P3, P7, P4, P8) × 3 (Prime Type: neutral, positive, negative) × 2 (Stroop Condition: incongruent, control) × 2 (Group: depressed, nondepressed) mixed-design ANOVA with repeated measures on the first three factors. As the sole result, analysis revealed a significant Site × Prime Type × Stroop Condition × Group interaction, $F(8, 208) = 3.51$, $p = .006$, $\eta_p^2 = .12$. Follow-up mixed-design ANOVAs for each site separately revealed that the Prime Type × Stroop Condition × Group interaction was significant only at electrode P4, $F(2, 52) = 4.29$, $p = .03$, $\eta_p^2 = .14$. At this site, the main effect of Group also approached significance, $F(1, 26) = 3.75$, $p = .06$, $\eta_p^2 = .13$, indicating that overall, depressed individuals exhibited a smaller amplitude in the P3 ERP component than nondepressed individuals. Bonferroni-corrected pairwise comparisons demonstrated that in all conditions except for positively primed, incongruent Stroop stimuli and negatively primed, control Stroop stimuli, depressed individuals showed significantly smaller P3 mean amplitudes compared to nondepressed individuals (cf. Table 15 and Figures 13). Additionally, nondepressed individuals demonstrated marginally significant larger P3 amplitudes in response to negatively primed, incongruent Stroop stimuli (*EMM* = 19.10 μV, *SD* = 3.38) compared to positively primed, incongruent Stroop stimuli (*EMM* = 15.84 μV, *SD* = 2.53), multivariate test: $F(2, 25) = 2.67$, $p = .09$, $\eta_p^2 = .18$. This effect did not reach significance in depressed individuals (multivariate test: $F(2, 25) = 2.42$, $p = .11$, $\eta_p^2 = .16$).

Late positive potential. With respect to the mean amplitude of the LPP ERP component, data screening revealed no violations of the assumptions of multivariate statistics or any other problems with data accuracy. The LPP was quantified at electrodes FCz and Cz as the mean amplitude within the time window of 430 to 970 ms after Stroop stimulus onset. Mean amplitude data of the LPP component was analyzed with a 2 (Site: FCz, Cz) $\times$ 3 (Prime Type: neutral, positive, negative) $\times$ 2 (Stroop Condition: incongruent, control) $\times$ 2 (Group: nondepressed, depressed) within-within-within-between mixed-design ANOVA. Analysis revealed a significant Site $\times$ Group interaction effect, $F(1, 30) = 8.86$, $p = .006$, $\eta_p^2 = .23$, that was qualified by a marginally significant Site $\times$ Prime Type $\times$ Group interaction, $F(2, 60) = 2.53$, $p = .09$, $\eta_p^2 = .08$. Post hoc pairwise comparisons revealed that whereas nondepressed individuals showed a larger mean amplitude of the LPP at electrode Cz (*EMM* = 11.46 μV, *SD* = 1.29) compared to electrode FCz (*EMM* = 9.65 μV, *SD* = 1.33; multivariate test: $F(1, 30) = 5.37$, $p = .03$, $\eta_p^2 = .15$), depressed individuals showed the opposite pattern, that is, larger LPP mean amplitude at electrode FCz (*EMM* = 9.56 μV, *SD* = 1.33) compared to electrode Cz (*EMM* = 8.08 μV, *SD* = 1.29; multivariate test: $F(1, 30) = 3.59$, $p = .07$, $\eta_p^2 = .11$). Crucially, analysis further revealed that at electrode Cz controls demonstrated larger LPP mean amplitudes (*EMM* = 11.46 μV, *SD* = 1.29) than patients (*EMM* = 8.08 μV, *SD* = 1.29; multivariate test: $F(1, 30) = 3.46$, $p = .07$, $\eta_p^2 = .10$). At electrode FCz the group difference was absent, multivariate test: $F(1, 30) = 0.002$, $p = .97$, $\eta_p^2 < .01$. Finally, post hoc pairwise comparisons revealed that larger LPP mean amplitudes at electrode Cz for nondepressed compared to depressed individuals were especially prominent after neutral ($p = .03$) and positive priming ($p = .06$) and less marked after negative priming (p = ..27; cf. Figures 10 and 11).

Table 15

Estimated Mean Amplitude of the P3 ERP Component at Electrode P4 in the ACI Task as a Function of Group, Stroop Condition, and Prime Type (Study 3)

	Incongruent Stroop condition			Control Stroop condition		
Variable	Neutral prime	Positive prime	Negative prime	Neutral prime	Positive prime	Negative prime
Nondepressed						
Mean amplitude	15.71	15.84	19.10	17.58	17.49	16.16
SD	2.41	2.53	3.38	2.61	2.71	2.50
Depressed						
Mean Amplitude	9.05	10.80	9.23	9.49	9.92	10.75
SD	2.41	2.53	3.38	2.61	2.71	2.50
Mean Difference	6.69†	5.04	9.87*	8.09*	7.57†	5.41

Note. All RTs are in milliseconds.
$^{\dagger}p < .07$. $^{*}p < .05$.

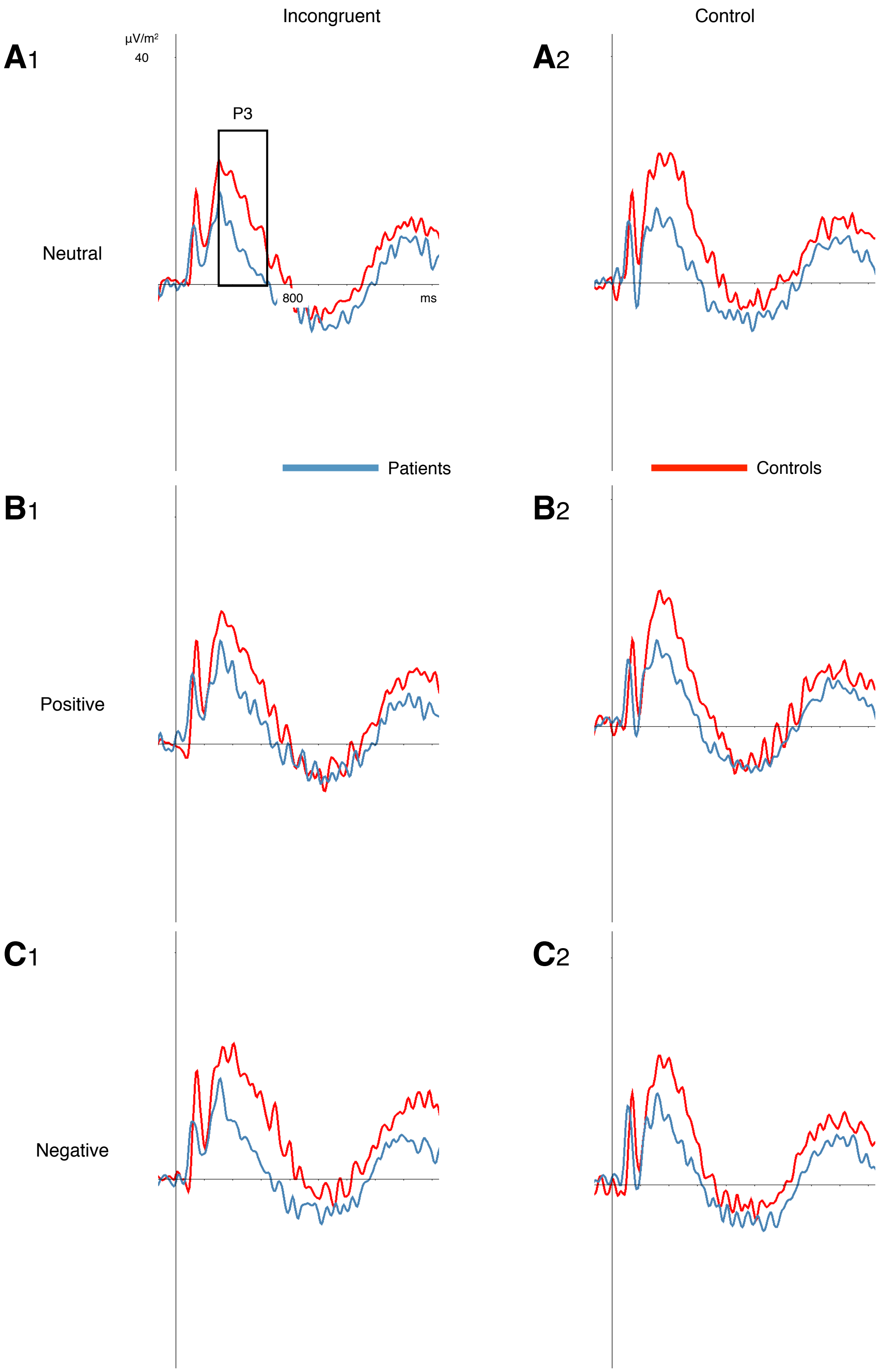

Figure 13. Grand-averaged ERPs elicited at electrode P4 as a function of Prime Type and Stroop Condition in depressed and nondepressed individuals. Measurement window used for P3 ERP component is indicated at panel A1. See Figures 10 and 11 for P3 topographies.

The Impact of State Orientation

To test the hypothesis that measures of sustained information processing would be related to failure-related state orientation, in particular to RUM, P1 and LP amplitude parameters respectively were correlated with RUM scores. These analyses revealed that the relationship between RUM and P1 amplitude approached significance ($r = .34$, $p = .06$), and that RUM was not associated to LP amplitude ($r = .30$, $p = .10$). However, when controlling for variance due to current depressive symptomatology (cf. BDI score), the relationship between P1 amplitude and RUM no longer reached significance ($r = .16$, $p = .39$), whereas the association between LP amplitude and RUM became significant ($r = .38$, $p = .04$). To further investigate the latter effect between failure-related state orientation and mean LP amplitude, partial correlations controlling for variance in BDI score were performed in each group separately; since relatively high RUM scores are characteristic of depression, a single correlation across both groups could have been redundant with the results of the corresponding ANOVA. It was found that, compared to their nondepressed counterparts, who showed no link between failure-related state orientation and LP amplitude ($r = .07$, $p = .81$), depressed individuals demonstrated a strong association between RUM scores and LP amplitude ($r = .61$, $p = .02$).

To examine the relationships between RUM, depression and affective interference, moderation analyses were conducted (Hayes & Matthes, 2009). The goal of these moderation analyses was in particular to examine whether the relationship between depression and affective interference was moderated by RUM. In all analyses, a simple moderation model was used to estimate the moderated path coefficients (Hayes, 2012). Thus, measures for affective interference found to be different between depressed and nondepressed individuals in the previous statistical analyses were subjected to separate moderation analyses with Group as the predictor variable and RUM as the moderator variable, or put differently, measures for affective interference were regressed simultaneously onto Group and RUM and the corresponding interaction term (Hayes, 2012). Measuring affective interference in terms of reaction times, analyses found no significant effects (all ps > .13; overall model: $R^2 = .10$, $F(3, 28) = 1.09$, $p = .39$). With regards to N2 amplitude, analyses also revealed no significant result (all ps > .17; overall model: $R^2 = .10$, $F(3, 27) = 1.00$, $p = .43$). For P3 amplitude parameters, analyses revealed predictive power of Group that approached significance ($c_1 = –11.76$, $t(24) = –1.89$, $p = .07$), while the other two predictors did not add to predictive power (ps > .13; overall model: $R^2 = .22$, $F(3, 24) = 2.31$, $p = .10$). However, in this analysis, a considerable interaction effect was present, $c_3 = 2.49$, $t(24) = 1.56$, $p = .13$). To decompose this interaction, simple slopes were computed. As illustrated in Figure 14, higher levels of state orientation were related to relatively higher P3 amplitudes in nondepressed individuals and to relatively lower P3 amplitudes in depressed individuals. To further determine the interaction, RUM scores and P3 parameters were correlated separately for depressed and nondepressed individuals. This analysis revealed that the interaction of RUM and Group was due to a positive correlation between RUM and P3 amplitude in nondepressed individuals ($r = .38$, $p = .25$) and a negative correlation between RUM and P3 amplitude in depressed individuals ($r = –.46$, $p = .10$). Although neither of these correlations was statistically significant, they were significantly different from each other ($z = 2.10$, $p = .02$). To assess whether these associations were attributable to inter-individual differences in depression or anxiety levels partial correlations were computed. Correlation coefficients stayed significantly different, when the influence of current depressiveness (cf. BDI) was partialled out ($z = 2.27$, $p = .02$) and also when the effect of anxiety (cf. BAI) was partialled out ($z = 2.02$, $p = .02$). In a final moderation analysis, it was found that both Group ($c_1 = –9.46$, $t(28) = –3.23$, $p = .003$) and RUM ($c_2 = 0.97$, $t(28) = 2.54$, $p = .02$) independently predicted LPP amplitude parameter (overall model: $R^2 = .28$, $F(3, 28) = 3.67$, $p = .02$).

Ancillary Analyses

Unique discriminative power of ruminative state orientation. Similarly to the procedure described in Study 1c, in the present study it was also examined how well RUM discriminated depressed individuals from nondepressed individuals and whether RUM predicted group membership better than BAI. Logistic regression analysis was employed to predict the probability that an individual would belong to the MDD group. The predictor variables were participants' RUM and BAI score. A test of the full model versus a model with intercept only was statistically significant, $\chi^2(2, N = 32) = 32.32$, $p < .001$, Nagelkerke $R^2 = .85$. RUM and BAI scores together were able to correctly classify 94% of both depressed and nondepressed individuals, accordingly yielding an overall success rate of 94%. However, employing a .05 criterion of statistical significance, only the partial effect of RUM approached significance ($B = 0.65$, $Wald(1) = 3.48$, $p = .06$), whereas BAI score did not demonstrate predictive power to differentiate between groups ($B = 0.23$, $Wald(1) = 1.80$, $p = .18$). For comparison: using BDI score as sole predictor in the model yielded a perfectly accurate classification between groups ($\chi^2(1, N = 32) = 44.36$, $p < .001$, Nagelkerke $R^2 = 1.00$). This result was excepted given that groups were built according to their levels of depressiveness. Level of state orientation as assessed by RUM as sole predictor yielded an overall percentage of correctly classified cases of 91% ($\chi^2(1, N = 32) = 28.97$, $p < .001$, Nagelkerke $R^2 = .79$).

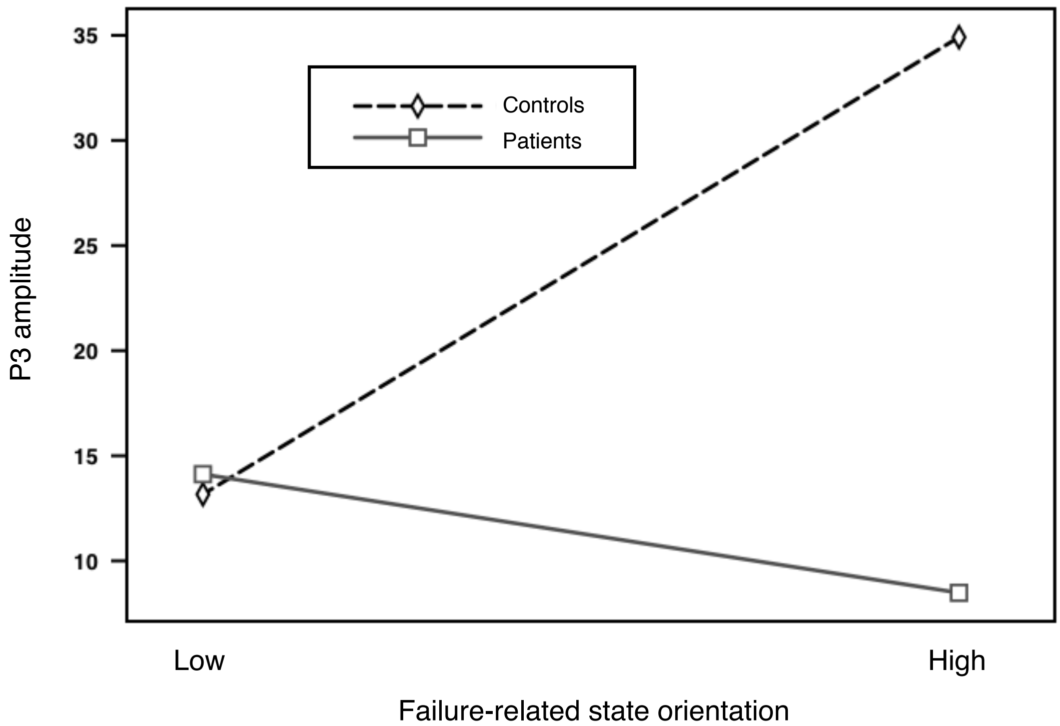

Figure 14. Depression moderates the relationship between state orientation and the amplitude of the P3 ERP component. Visualization is implemented using the Johnson-Neyman technique for probing interactions. Data for visualizing the conditional effect of state orientation on P3 amplitude are based on the mean centered metric of state orientation (cf. RUM) and the model-based predicted values of P3 amplitude.

To further explore the relative influence of different kinds of state orientation on group membership a forward stepwise binary logistic regression was computed. Of SOF, SOD, SOP, RUM, and PAS (cf. Chapter 1, Study 1a), only RUM score was included in the final model, whereas all other variables were dropped by the algorithm due to their poor contribution (the corresponding final model has been characterized in the previous paragraph). In a final, exploratory analysis, the scores on all subscales of the VCI were included as predictors in a forward stepwise binary logistic regression. Here, the algorithm only included level of Burden and Self-Access in the model. The corresponding final model was significant, $\chi^2(2, N = 32) = 40.17$, $p < .001$, Nagelkerke $R^2 = .90$, and correctly classified 100 % of cases (Burden: $B = 9.67$; Self-Access: $B = –6.86$).

Potential confounding variables. To test for the possibility that group differences found in prior analyses were due to some specific confounding variables, a series of MANOVAs was conducted. Initially, a MANOVA was computed on (1) mean reaction time, (2) mean P1 amplitude at electrode Pz, (3) mean LP amplitude at electrode Pz, (4) mean N2 amplitude at Cz, (5) mean P3 amplitude at P4, and

(6) mean LPP amplitude at Cz as a function of Group and Gender. This analysis demonstrated a main effect of Group that approached significance, $F(6, 23) = 2.39$, $p = .06$, $\eta_p^2 = .38$., indicating that depressed and nondepressed individuals differed, in particular, in P3 amplitude ($p = .15$) and in LPP amplitude ($p = .06$). However, the analysis further revealed a main effect of Gender of similar strength, $F(6, 23) = 2.16$, $p = .08$, $\eta_p^2 = .36$, indicating that men and women differed significantly in P1 ($p = .05$), LP ($p = .04$), N2 ($p = .07$), and LPP amplitude ($p = .009$). The Group × Gender interaction was not significant ($p = .41$).

Next, Mann-Whitney U tests were used to determine whether the distribution of RT, P1, LP, N2, P3, and LPP parameters differed (i) between patients who took one medication versus patients who took more than one medication, (ii) between patients with a first time depressive episode and patients with recurrent depressive episodes, and (iii) between patients with comorbid dysthymia versus patients without comorbid dysthymia (cf. “double depression”). The Mann-Whitney test was chosen, because this nonparametric test is appropriate for use with small samples and is more sensitive to between-group differences than are ANOVA statistics. Analyses revealed that for all dependent variables the distribution was the same across groups for all three different groupings (all *p*s > .13).

The path from prime-locked ERPs to stimulus-locked ERPs to reaction times. To examine the relationship between sustained information processing and affective interference in more detail, an attempt was made to establish a link between ERPs associated with sustained information processing, ERPs related to affective interference, and overt behavior. For this purpose, first of all, the association between the two relevant ERP measurers of sustained information processing (cf. P1 and LP amplitude) and the three ERP measures of affective interference (cf. N2, P3, and LPP amplitude) was examined by means of a canonical correlation analysis (cf. Tabachnick & Fidell, 2007). The purpose of a canonical correlation analysis is to investigate the types and number of relationships between two sets of variables, in particular in terms of each variable’s unique contribution to the overall relationship. From two sets of variables, the analysis computes pairs of construct variables (“canonical variates”) and their association (“canonical correlation”). In addition, the analysis determines the correlation of each variable and its corresponding variate ("canonical loading"). The combination of canonical correlation and canonical loading allows to determine which variable of each set contributes the most to the relationship(s) found for the pairs of canonical variates. Thus, for the purpose of the present investigation, the two ERP measures for sustained information processing served as first set and the three ERP measures for affective interference served as the second set in the analysis. The analysis found one significant relationship in the data. The corresponding canonical correlation was $r_c = .63$,

Λ = .58, $\chi^2(6)$ = 15.46, p = .02. P1 amplitude loaded on the first canonical variate (c = –.96), whereas N2 amplitude (c = .83) and LPP amplitude (c = .64) loaded on the second canonical variate. An additional correlational analysis revealed that only P1 amplitude was significantly associated with overall reaction time, r = –.35, p = .05.

Next, multiple regression analysis was used to examine which of the three ERP measures for affective interference significantly predicted overall reaction time. The results of the regression showed that N2, P3, and LPP amplitude explained 32% of the variance in reaction times (R^2 = .38, $F(3, 28)$ = 5.79, p = .003). However, only LPP ERP parameters significantly predicted reaction times (β = –0.62, $t(31)$ = –3.96, p < .001), whereas N2 and P3 parameters did not predict reaction times (N2: β = 0.08, $t(31)$ = 0.47, p = .46; P3: β = 09, $t(31)$ = 0.55, p = .59).

Thus, in a last step, it was tested whether the relationship between P1 amplitude and reaction times was mediated by LPP amplitude parameters. A simple mediation model was used to assess the effect of P1 amplitude parameters on overall reaction times, both directly and indirectly through LPP amplitude parameters (Hayes, 2012). This model computed the total effect in addition to the path coefficients and the direct and indirect effects. The total effect was statistically different from zero (c_1 = –3.71, p = .05; cf. Figure 15). The direct effect of P1 amplitude on reaction times was not significant (c'_1 = –1.19, p = .49), whereas the indirect effect through LPP amplitude was statistically significant as evidenced by a 95% bias-corrected bootstrap confidence interval that did not include zero (a_1b_1 = –2.51; confidence interval: –5.1199 to –0.8010). Considering this model only for negatively primed, control Stroop stimuli (cf. Reaction times effect), analysis revealed that, although neither the total effect nor the direct effect of P1 amplitude on reaction times were significant (ps > .30), the indirect effect of P1 amplitude on reaction times after negatively primed, control Stroop stimuli through LPP amplitude was significant (a_1b_1 = –2.04; confidence interval: –5.4534 to –0.2354). Importantly, however, neither for overall measures for P1, LPP, and reaction times, nor for the specific parameters for negatively primed, control Stroop stimuli was the link between P1 amplitude, LPP amplitude and RTs moderated by RUM or Group.

Processing of negative information in depression. Starting from the observations that (a) after negatively valenced prime words patients exhibited larger prime-locked P1 amplitudes than controls and that (b) patients demonstrated larger N2 amplitudes for positively primed Stroop stimuli compared to negatively primed Stroop stimuli, whereas control participants showed the exact opposite pattern, a correlational analysis for P1 and N2 amplitude parameters revealed a strong negative association, r = –.51, (p = .003) between these two ERP measures. A follow-up subgroup analysis

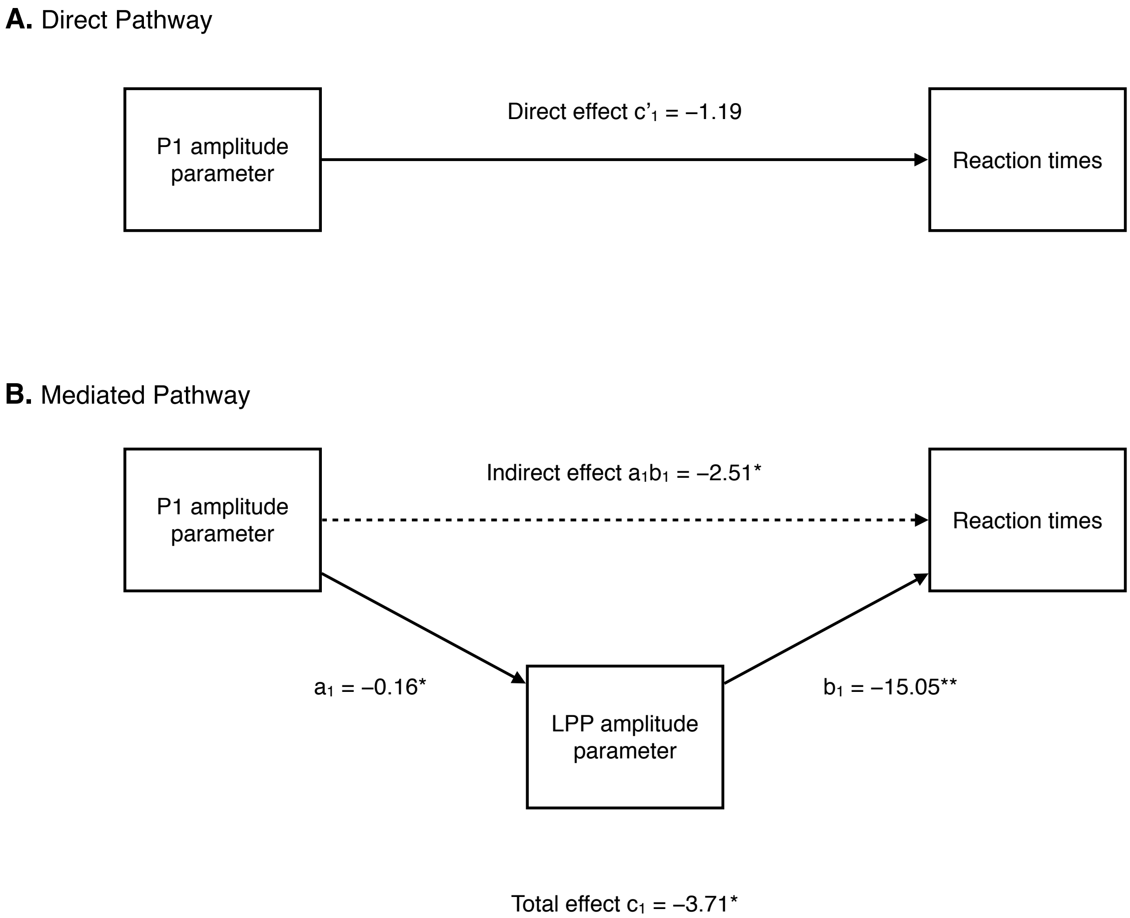

Figure 15. Path coefficients for the relationship between P1 amplitude and overall reaction times as mediated by LPP amplitude.
$^{*}p < .05$. $^{**}p < .01$.

demonstrated that this association was especially prominent in nondepressed individuals (r = –.70, p = .002) and less marked in depressed individuals (r = –.37, p = .16; z = -1.22, p = .11). A corresponding moderation analysis revealed that in addition to significant or marginally significant main effects of P1 amplitude (c_1 = –0.44, p < .001) and Group (c_2 = 5.29, p = .09) the P1 × Group interaction was also significant (c_3 = 0.47, p = .05; cf. Figure 16). Notably, separate subgroup partial correlations revealed that this interaction effect was almost unchanged after variance in depressive symptomatology (cf. BDI) or variance in failure-related state orientation (cf. RUM) had been partialled out (controlling for BDI: z = –1.34, p = .09; controlling for RUM: z = –1.50, p = .07). Finally, as expected based on the findings of prior analyses, testing the power of P1 amplitude in predicting reaction times through N2 found a significant total effect (c_1 = –3.71, p = .05), but no additional direct or indirect effect (ps > .10).

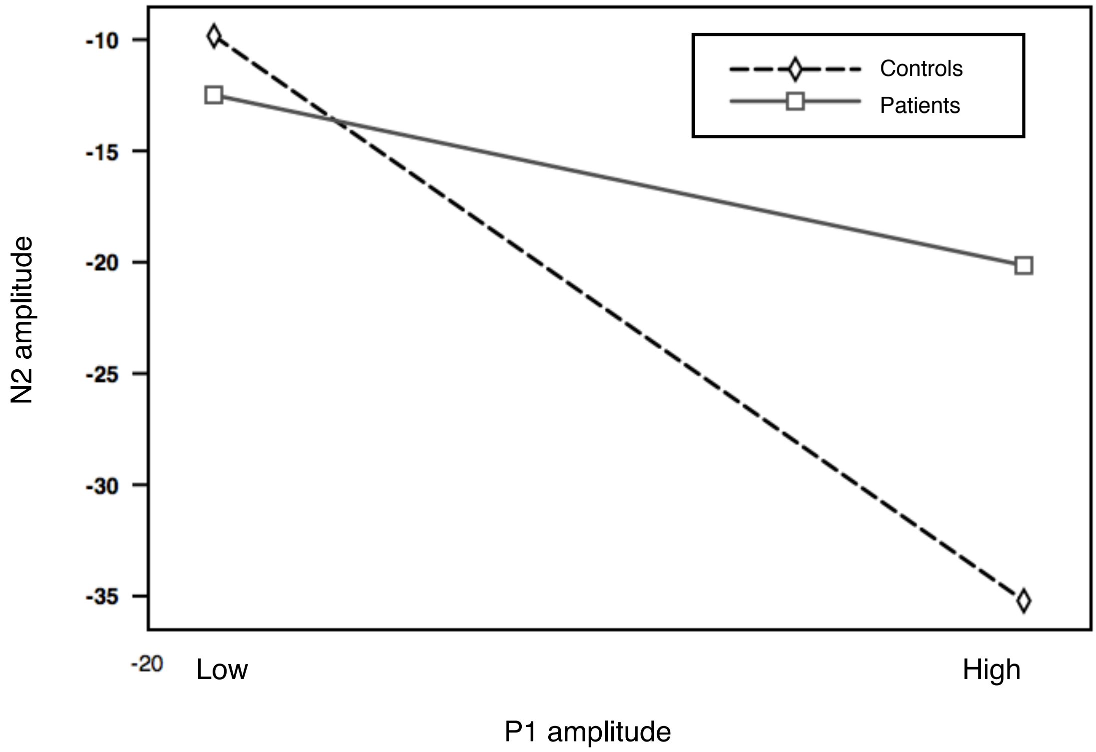

Figure 16. Depression moderates the relationship between prime-locked P1 amplitude and stimulus-locked N2 amplitude. Visualization is implemented using the Johnson-Neyman technique for probing interactions. Data for visualizing the conditional effect of P1 amplitude on N2 amplitude are based on the mean centered metric of P1 amplitude and the model-based predicted values of N2 amplitude.

Predicting clinical symptoms. Explicitly testing the effectiveness of all ERP components investigated in the present study in predicting depressive symptoms as assessed by BDI in an according linear regression analysis revealed that P1, LP, N2, P3, and LPP amplitude together explained 27% of the variance in clinical symptoms (R^2 = .39, F(5, 26) = 3.27, p = .02). LPP and P3 were the two predictors with the largest influence on the prediction of clinical severity (LPP: β = –0.32, t(31) = –1.79, p = .09; P3: β = –0.35, t(31) = –1.75, p = .09). Subgroup correlational analyses found no difference in the relationship between P3 and LPP amplitude respectively and severity of depression between groups, indicating that the results of the regression analysis was due to simple group effect.

The role of motivational structure. In Study 2, it was suggested that depressed patients may perform equally well in the ACI task compared to nondepressed individuals, in particular in the incongruent Stroop condition, because they may be highly motivated, not only in the specific task situation but more generally as a sign of a pronounced, dispositional achievement motivation. In the current study sample, on an explicit level and compared to depressed individuals, nondepressed individuals had a stronger power motive (t = 2.47, p = .02) as well as a stronger affiliation motive (t = 1.99, p = .06) as assessed by the Personality Research Form (Stumpf et al., 1985). With respect to achievement motive (ACH), however, both groups did not show any difference (t = 0.19, p = .85). A hierarchical multiple regression analysis revealed that scores of achievement motive and RUM scores independently predicted BDI scores: RUM: β = .87, $t(31)$ = 8.69, p < .001; ACH: β = .18, $t(31)$ = 1.83, p = .08; R^2 = .72, $F(3, 28)$ = 3.34, p = .08). Crucially, an additional moderation analysis revealed that neither achievement motive per se (c_1 = –2.24, p = .52), nor group (c_2 = 20.65, p = .66) could predict overall reaction time in the Stroop task. However, the Achievement Motive × Group interaction was highly significant (c_3 = 20.27, p = .007); total model: R^2 = .25, $F(3, 28)$ = 3.06, p = .04), indicating that a high achievement motive led to faster reaction times in depressed individuals, whereas in nondepressed individuals a more pronounced achievement motive resulted in slower reaction times (cf. Figure 17).

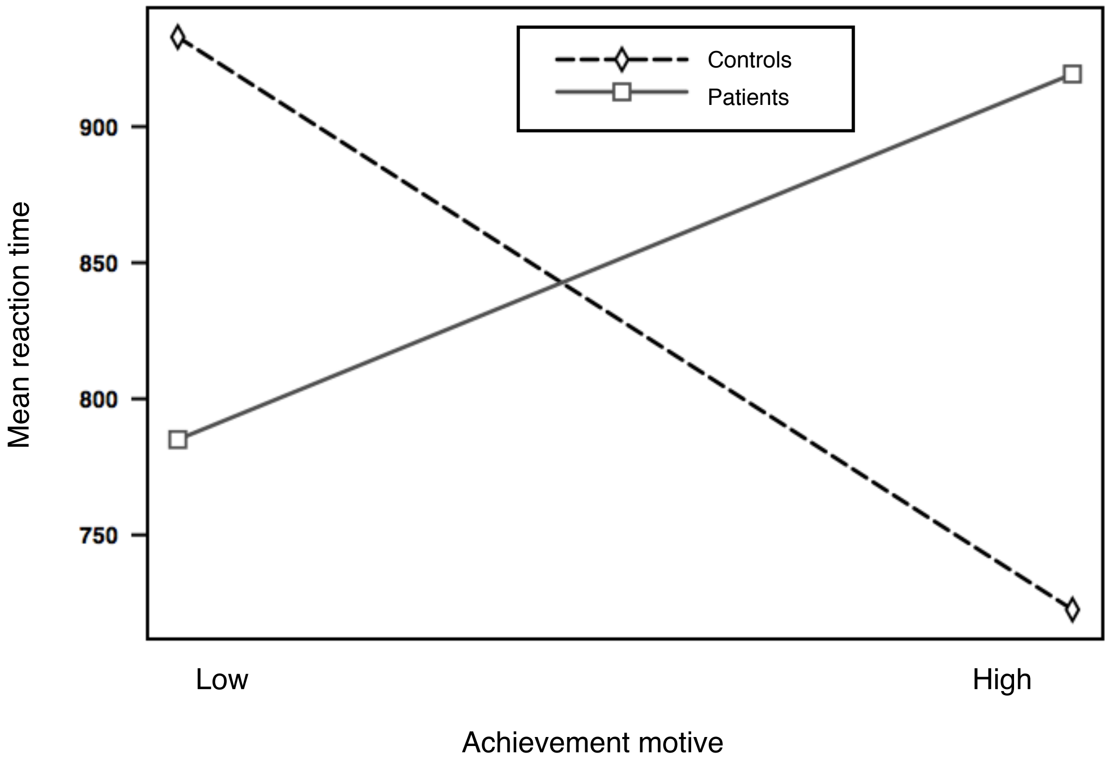

Figure 17. Depression moderates the relationship between achievement motive and overall reaction time in the ACI task. Visualization is implemented using the Johnson-Neyman technique for probing interactions. Data for visualizing the conditional effect of achievement motive on mean reaction time are based on the mean centered metric of achievement motive scores and the model-based predicted values of mean reaction time.

Discussion

Depression is thought to be associated with biased processing of affective information. However experimental studies have yielded mixed results with regards to this hypothesis. Previous research has demonstrated that depression may be associated with difficulties inhibiting the processing of emotional material and with impaired cognitive functioning resulting from interfering sustained information processing (Goeleven et al., 2006; Joormann, 2004; Siegle, Steinhauer, et al., 2002; Siegle, Ingram, & Matt, 2002). Importantly, previous studies have proposed that these processing biases, in particular for negative information, play a significant role in the maintenance of depressive episodes (Joormann et al., 2007). In order to further investigate the nature of sustained processing of affective information and the possible associated interference effects during subsequent executive cognitive functioning in depression, in the present study clinically depressed individuals and nondepressed controls matched for age, gender, and intelligence performed a modified version of the Stroop Color Naming Task, the “Affective-Cognitive-Interaction” (ACI) task (Kazén & Kuhl, 2005; Kuhl & Kazen, 1999), in which a series of two “classical” Stroop tasks were preceded by self-generated, or self-chosen respectively, affectively neutral, positive, and negative word primes. This task is designed to assess the modulating impact of affective primes on subsequent executive cognitive functioning. In addition, the present study was designed to examine the functional brain correlates of sustained information processing and affective interference and, more precisely, to investigate whether depressed and nondepressed individuals differ in their neural response to affective stimuli of different valence. Thus, to be able to elucidate the exact time course of the possible effects of sustained processing of affective information and to be able to investigate processes potentially not visible in overt behavior, the current study sought to determine the extent to which sustained information processing and related deficits in executive cognitive functioning are evident in event-related potentials (ERPs) elicited in depressed and nondepressed individuals while they performed the ACI task. ERPs were chosen, because they were assumed to be sensitive to the effects of sustained processing of affective information at various stages of the overall processing stream. Results revealed both affective interference effects in terms of differences in behavior and effects of sustained information processing and affective interference that were only evident in the ERPs. It was hypothesized that depressed individuals would exhibit sustained processing of affective stimuli reflected in enhanced prime-locked ERP components. Furthermore, it was predicted that results would show decreased late positive potentials and decreased N2 amplitudes in depressed individuals relative to nondepressed individuals as an index of sustained information processing interfering with ongoing executive cognitive function. Finally, it was hypothesized that higher levels of sustained information processing as well as higher levels of affective interference would both be related to higher levels of state orientation. Consistent with these hypotheses, results provide evidence that clinically depressed individuals devote increased attention in particular towards negative affective stimuli already early on in the course of information processing – as evidenced by increased amplitudes in the prime-locked P1 ERP component. Furthermore, increased amplitudes of a prime-locked, late positive component (LP) in depressed individuals compared to nondepressed individuals in response to valenced word primes, suggest that depressed individuals are not only characterized by an enhanced initial neural response to affective stimuli, but, crucially, depressed individuals are also characterized by tonic neural activation in response to affectively valenced stimuli in comparison to affectively neutral stimuli. This result is possibly indicative of sustained processing of affective information in depressed compared to nondepressed individuals. With regards to affective interference possibly resulting from sustained information processing in depressed individuals, behavioral performance significantly differed between groups in that depressed individuals demonstrated significantly slower reaction times for negatively primed, control Stroop stimuli in comparison to positively or neutrally primed, control Stroop stimuli. This effect did not reach significance in nondepressed individuals. Potential affective interference effects were also reflected in stimuli-locked ERP components. In each group, the amplitude of the N2 ERP component showed a distinct pattern in response to affectively valenced primes. In nondepressed individuals, the N2 amplitude was more negative after negative prime words compared to positive prime words. In contrast, in depressed individuals, N2 negativity was significantly larger after positive affective priming than after negative affective priming. For the P3 ERP component a general group effect was found: overall – that is, independently of prior affective priming and independently of Stroop condition – depressed individuals compared to nondepressed individuals had a significant smaller P3 amplitude when confronted with the Stroop task. Similarly, overall, depressed individuals showed a significantly smaller amplitude of the late positive potential (LPP) ERP component compared to nondepressed individuals. It was hypothesized that neural representations of sustained information processing and affective interference would be related to a state-oriented cognitive style, in particular to measures for failure-related state orientation. Consistent with this hypothesis, failure-related state orientation as assessed with the according subscale of the Volitional Component Inventory (VCI; cf. RUM) demonstrated a significant positive association with the amplitude of the prime-locked LP ERP component; independently of current depressive symptomatology. Contrary to expectations, RUM scores showed a significant, positive association to LPP amplitude. However, as expected, failure-related state orientation was negatively correlated to stimulus-locked P3 amplitudes. These results suggest that failure-related state orientation is indeed associated with neural measures for sustained information processing as well as with neural measures for impaired conflict resolution. Generally, the findings of the current study demonstrate the utility of the ACI task in combination with ERPs in investigations of sustained information processing and related effects in ongoing executive functioning in selected populations.

Sustained Information Processing

Evidence for distinct processing of affective information was obtained using prime-locked ERPs. Overall, patients had larger amplitudes in the P1 ERP component in comparison to nondepressed individuals. This difference reached significance after negative prime words. The P1 wave is associated with activation in the fusiform gyrus (Mangun et al., 1997) and in the dorsal occipital areas (Woldorff et al., 1997). P1 amplitude increases are generally observed when individuals pay full attention to a presented stimulus (Woldorff et al., 2002). It is assumed that this attention-related enhancement of the P1 ERP component reflects top-down processes amplifying the signals that arise from stimuli which are attended to. Thus, from the results of the present study, it can be concluded that depressed individuals initially focus more attention on prime words than nondepressed individuals, especially on negatively valenced prime stimuli. This bias in attentional focus, however, was not strongly shifted towards negative information; instead depressed individuals seemed to be in general more alert facing word primes relative to nondepressed individuals. Therefore, these ERP findings only partially confirm the predicted enhancement of initial attention in MDD patients confronted with affectively valenced stimuli. Nevertheless, these results are consistent with the idea that depressed individuals differ from nondepressed individuals in their processing of affective information, already early on in the information processing stream, and that this processing bias may be most reliably characterized by an enhanced attention paid to negative information.

Apparently, experiencing depressed mood additionally leads to increased tonic neural activity during processing of affective information. Depressed individuals, in the current study, exhibited an increased brain response to positive and negative stimuli relative to neutral stimuli that was reflected in a persistently enhanced late positivity (LP). Specifically, when a negatively or a positively valenced prime stimulus was presented, depressed individuals appeared to continue to process that information more intensely than controls for up to 800 ms. Since this specific activity was not predicted, interpretation of it is necessarily speculative. Perhaps, depressed individuals simply took the whole experiment and especially the instruction concerning the prime words more seriously than the nondepressed individuals and therefore tried harder to relive the events associated with the prime words. This interpretation would be consistent with the observation made in the current study that depressed inpatients often seemed to be more motivated to do the task and seemed to be more likely to comply with the experimental task than control participants. However, alternatively, the current data may suggest a relationship between mean LP amplitude and sustained processing of affective information. The findings may therefore be interpreted – as predicted – as individuals in a major depressive episode exhibiting sustained information processing in response to affectively valenced information in comparison to nondepressed individuals. Hence, after paying initial enhanced attention to affective prime words, subsequently, depressed individuals may also treat affective stimuli in a different way to nondepressed individuals. Put differently, depressed individuals seem to elaborate more on affectively valenced information, possibly indicative of a unique information-processing strategy that may exist among individuals with depression. The fact that, in the current study, increased LP amplitudes in depressed individuals were not only found after negative, but also after positive priming is more difficult to understand, though Siegle et al. (2001) found similar inconsistencies. In their study, also contrary to predictions, depressed individuals did not react more slowly to negative than to positive information in a lexical decision task, and depressed participants' cognitive load was not reliably higher for negative information than positive information, in comparison to nondepressed participants. Other researchers argued that cognitive deficits in MDD may stem from diminished brain responses during processing of positive information and may not be associated with an augmented response to negative stimuli (Shestyuk et al., 2005). Thus, at the moment, it may not be possible to completely rule out the possibility that depressed individuals may have a processing bias for affective information in general, rather than for negative information, in particular. However, it is important to emphasize that there is strong evidence that depression is associated with information-processing biases for negative information (cf., e.g., Gotlib & Krasnoperova, 1998). To the extent that the current results disagree with the majority of findings of the field, it may be speculated that – in accordance with relevant statements of patients in the current study – depressed individuals had serious difficulties in remembering achievement-related situations that they genuinely perceived as positive. Therefore, in the MDD group, self-generated "positive" primes, may actually have also functioned as negative priming, in that depressed individuals in the end associated these words with negative experiences as well, the longer they ruminated about them. However, this interpretation may be in conflict with the results on affective interference in the current study (cf. below).

Since LP amplitude was inversely correlated with the amplitude of the N2 ERP component ($r = -.40$, $p = .02$; cf. below) there is some support for the idea that depression might be characterized by sustained processing of affective information interfering with ongoing executive cognitive functioning (cf. "affective interference"). Yet, such a causality is difficult to infer from the findings of the current study. Nevertheless, although there is only little literature on this topic, the current findings in combination with findings from previous research are consistent with the idea that depression could involve, in part, sustained processing of affective information that in turn interferes with executive cognitive functioning. For example, Joormann & Gotlib (2008) demonstrated increased response times in depressed individuals in a short-term recognition task when they had to respond to especially negatively valenced items, which previously had been declared to be irrelevant. Researchers interpreted their results as reflecting the interfering effect of "residual activation" associated with the processing of negative information on ongoing cognitive performance. Joormann & Gotlib (2008) also found that the interference effect was associated with a ruminative response style. In the present study, correlational analyses confirmed that enhanced LP amplitudes are more associated with measures for failure-related state orientation (cf. RUM) than with increased depressive symptomatology as indexed by BDI scores. This may be tentatively interpreted as LP amplitude being an important indicator of sustained information processing underlying a state-oriented cognitive style. In any case, sustained information processing in terms of higher LP amplitudes was related to self-reported, failure-related state orientation, in particular in depressed individuals, suggesting that the observed biases are clinically relevant. However, although LP amplitude might point to an important process by which depression and rumination are related, it is likely that additional processes are involved in mediating/moderating the link between failure-related state orientation and depression, since exploratory analyses revealed that depressed and nondepressed individuals significantly differed in nearly every subscale of the VCI. In sum, the finding of the current study that the MDD group, relative to controls, showed increased brain activity in response to affectively valenced stimuli is consistent with the idea that depressive cognition is characterized by sustained processing of affective, in particular negative information. The current findings further demonstrate that sustained ERP signals are able to index valence phenomena in depression on the neural level, which may be occluded in more peripheral measures. More specific examination of valence-induced effects on the neural level are necessary to confirm those processes in depressed individuals' cognition that are related to the encoding and elaboration phases in the processing of affective information.

Affective Interference

Behavioral findings. Initially, in the current study, affective interference was assessed in terms of modulated reaction times in the Stroop task following affective priming. As in Study 2, the behavioral effects found in the current study were opposite to what was predicted from the "classical" findings related to the ACI task (Kazén & Kuhl, 2005; Kuhl & Kazen, 1999). However, broadly in line with the effects found in Study 2, depression effects on performance were found for the control Stroop condition. Depressed individuals demonstrated increased reaction times after negatively primed, control Stroop stimuli in comparison to positively or neutrally primed, control Stroop stimuli. In other words, depressed individuals showed less Stroop interference after they were confronted with self-relevant, negative prime words compared to neutral or positive prime words, and this effect was due to slower reaction times in the control Stroop condition.

More recent considerations go in the direction of assuming two different processes underlying facilitation in the congruent Stroop condition, on the one hand, and interference in the incongruent Stroop condition on the other hand (MacLeod & MacDonald, 2000). Similarly, it is possible that depressed and nondepressed individuals use unique strategies in dealing with the task, or even in dealing with each of the two Stroop conditions, which likely reflecting fundamental differences in information processing. However, even if patients and controls use different strategies in the ACI task (cf., e.g., Channon & Baker, 1994), this would not explain why affective interference would only be observed in the control Stroop condition after negative priming. Hence, here, an alternative interpretation is favored: if depressed individuals are not completely absorbed by an ongoing executive cognitive task, as may be assumed to be the case during the current control Stroop condition, affective interference may occur, because sustained processing of negatively valenced information still has leeway in exerting its influence. It may be further speculated that this effect may be exacerbated in depressed individuals, because, while they may have a specific strategy for dealing with incongruent Stroop stimuli, which allows them to perform as well as controls, they may lack a specific strategy with regards to the control Stroop condition.

This reasoning is in line with the earlier findings of Park et al. (2004), which implied that strategies to interrupt ruminative processes are helpful in minimizing cognitive impairment in depression. Other research findings also argue along these lines. Thus, for example, Hertel & Hardin (1990) hold that cognitive deficits in depression will most likely occur in tasks that allow the spontaneous use of strategies, whereas tasks that bypass or direct the use of strategies will not produce depressive deficits. Against this background, the results of the present study, which indicate sustained processing of negative information interfering with executive cognitive functioning if cognitive resources are not actively directed, may also fit well with general models previously outlined which postulate a dominance of the default-mode network over the task positive network as mechanism underlying cognitive dysfunction in depression (cf., e.g., J. P. Hamilton et al., 2011). However, it must be made clear that the current behavioral findings contradict study outcomes that indicate significant affective priming only when participants must respond on the basis of the valence of the targets but not when the semantic category of the targets is relevant (Houwer et al., 2002). The results also disagree with a number of studies which reliably demonstrated a general impairment of executive cognitive function in major depression (e.g., Lyche et al., 2011; Majer et al., 2004). Thus, the present findings may be interpreted as only partly meeting predictions derived from research on the debilitating effects of ruminative thought in depressed individuals. The current results may lead to the conclusion that at least some aspects of executive cognitive functioning are not fundamentally impaired in depressed patients, and cognitive impairments observed in depression may be related to task-irrelevant thoughts interfering with ongoing executive processing.

ERPs. The major findings of the current study with respect to ERPs associated with the Stroop task may be summarized as follows: compared with nondepressed individuals, patients suffering from MDD showed a higher N2 amplitude after positive primes relative to negative primes, whereas controls demonstrated the exact opposite pattern. Moreover, depressed individuals exhibited overall a smaller P3 amplitude as well as a smaller amplitude of the late positive potential (LPP).

The stimulus-locked ERP data revealed a specific group effect on the N2 amplitudes over fronto-central electrodes. Specifically, in the current study, reduced N2 amplitudes on Stroop stimuli after negative primes were observed that were specific to the MDD group. This valence effect is broadly consistent with what was predicted at the outset: it was expected that depressed individuals would show a decreased N2 amplitude, especially after negative priming, reflecting affective interference resulting from sustained information processing. Although the functional significance of the N2 ERP component is still not entirely clear, because some researchers argue that the N2 reflects response inhibition (e.g., Falkenstein et al., 1999), whereas other researchers assume that the N2 mirrors conflict monitoring (e.g., Donkers & van Boxtel, 2004), there is good reason to assume that the N2 amplitude indicates processes of inhibition or revision of inappropriate response tendencies (Ruchsow et al., 2008). Hence, the current findings suggest that, in depressed individuals, sustained processing of negatively valenced information interferes with inhibitory executive control. Or, put differently, the N2 effect observed in the present study may be indicative of the general difficulty depressive individuals have with allocating cognitive control related resources in face of persistent processing of negative information; which may result from initial over-elaboration of the affective aspects of the stimuli (cf. P1 and LP). A noteworthy aspect of the N2 effect in the current study is that its parameters were not related to reaction times. This may draw attention to the fact that the link between the cognitive process reflected in the N2 and overt behavior may be more complex than often assumed, or it may simply point to a too low power in the current sample for detecting such effects.

Another important point concerns the observation that nondepressed individuals differentially elaborated on positive and negative information as well. Specifically, in terms of N2 parameters, depressed individuals showed the opposite pattern to nondepressed individuals: in the control group, N2 negativity was greater after negatively primed Stroop stimuli compared to positively primed Stroop stimuli. Following the reasoning above, this pattern would suggest that nondepressed individuals are characterized by deficient inhibitory processes after processing positively valenced information. This interpretation, however, is contrary to a developing ERP literature demonstrating enhanced ERP components in response to positive stimuli compared to negative stimuli in nondepressed individuals (e.g., Deldin, Keller, et al., 2001). Thus, although a final interpretation of the current N2 effect must be left open at this point, the data nevertheless provide neurophysiological evidence for distinct processing differences between depressed and nondepressed individuals with respect to sustained processing of positively versus negatively valenced information.

In neither of the two groups was the N2 amplitude related to depressive severity (cf. BDI). However, N2 amplitude showed a significant negative relation to failure-related state orientation as indexed by the RUM subscale of the VCI in depressed individuals (($r = -.50$, $p = .05$)), whereas in nondepressed individuals no such relationship existed (($r = .03$, $p = .91$)). In other words, in depressed individuals, a state-oriented cognitive style was associated with an overall smaller amplitude of the N2 ERP component. This finding suggests that individual differences in state orientation play an important role in depression, and, since RUM was related to N2 amplitude irrespective of acute depressive symptomatology ($r = -.46$, $p = .09$), failure-related state orientation must be considered a potential vulnerability factor for depression. Future research using an experimental procedure similar to the current one may therefore consider using measures for state orientation to test for the impact of personality on executive cognitive functioning and associated brain correlates in depression.

Taken together, the findings on the N2 ERP component revealed important differences in the way depressed and nondepressed individuals process affective information on the neural level. Future research should further explore the role of the N2 ERP component in this modified Stroop task procedure. In order to improve upon the methods used in the current study, word primes could be substituted by stimuli of stronger affective valence, as for example by images of the International Affective Picture System, in order to more properly appraise valence effects on ERP components related to executive control in depression.

In the current study, the control group demonstrated a typical P3 response to Stroop stimuli (Ilan & Polich, 1999; Lansbergen & Kenemans, 2008; Rosenfeld & Skogsberg, 2006), together with an indication of differential effects of positive versus negative priming on P3 amplitude. Specifically, nondepressed individuals demonstrated an enhanced P3 amplitude in response to Stroop stimuli after previously being primed with negatively valenced stimuli, compared to previously being primed with positively valenced stimuli. Theoretical accounts of the P3 suggest that this ERP component reflects an increased activation of inhibitory processes to focus attention (cf., e.g., Polich, 2007). In other words, the P3 amplitude is affected by the allocation of attentional resources, such that actively attended stimuli elicit larger amplitudes than passively attended stimuli. Thus, since P3 amplitude reflects the amount of attention devoted towards processing a stimulus (Krompinger & Simons, 2009), nondepressed individuals seem to allocate more attentional resources to the processing of the negatively valenced stimuli. It has been shown in prior experiments that the P3 ERP component responds more strongly to motivationally relevant compared to neutral stimuli (Amrhein et al., 2004; Cuthbert et al., 2000). Therefore, the current finding suggests that negative affective stimuli assume high priority for processing within the attentional system in nondepressed individuals. The extent to which the P3 amplitude was modulated by persistent processing of negative rather than positive stimuli in the control group may be indicative of a better-developed capacity of nondepressed individuals to use negative affect to regulate their behavior. Thus, the current effect observed in nondepressed individuals could be interpreted as a commitment of attention to negative stimuli related to the activation of brain areas that facilitate action. This facilitation, however, will most probably be mediated by additional processes, because, in the present study, parameters of the P3 ERP component were not related to overt behavior; neither in the total sample, nor examined separately in each group.

However, although interpreting the difference in P3 amplitude in the control group as evidence of enhanced processing of negative stimuli offers a plausible explanation, this interpretation is, nonetheless, counterintuitive (cf. also Joormann & Gotlib, 2010). If valence effects associated with negative priming occurred in the P3, they would have been predicted for depressed rather than for nondepressed individuals. Moreover, if valence effects occurred in nondepressed individuals, these would have been expected to be related to positive priming, indicative of nondepressed individuals' rather than depressed individuals' ability to regulate their behavior via positive affectivity. It may be speculated that the current results point to a complementary process, namely that nondepressed individuals, in particular in the ACI task, are motivated by and accordingly pay increased attention to negative primes, because they want to do better than suggested in the failure-related primes. As was demonstrated in Study 2, in nondepressed individuals, the ACI task induces this type of behavior, instead of facilitating effects after positive priming, since relatively less depressed participants showed volitional facilitation after negative primes. Thus, it may be possible that the current experimental design creates a task in which nondepressed individuals use negative rather than positive stimuli to regulate their behavior, whereas in – maybe most – other situations they would build on their positive affectivity to regulate their behavior. Ultimately, because the current study is likely to be the first investigation evaluating P3 parameters in an ongoing executive cognitive task while residual processing of affective stimuli priorly presented may still be present, it is difficult to determine the extent to which the present results are really anomalous with regards to the existing literature.

In contrast to the differential processing of positive and negative information demonstrated by nondepressed individuals, depressed individuals, in the current study, demonstrated no differences in P3 parameters between different priming conditions. Crucially, however, in the MDD group, an overall reduced P3 amplitude relative to the control group was found. Many experiments examining the P3 in depressed and nondepressed populations found such an effect associated with depression (e.g., Bruder et al., 1995; Tenke et al., 2008). Devoting decreased attentional resources to executive cognitive functioning after both positive (cf. "approach") and negative (cf. "avoidance") based motivationally relevant stimuli as well as after affectively neutral prime stimuli may therefore be interpreted as indicative of a generally impaired executive functioning in depression. Nevertheless, prior priming may still have worsened depressed individuals' ability to allocate adequate attentional resources in the service of conflict regulation; and, in the end, the ACI task may have simply been too easy to induce the expected effects on the behavioral level in the current sample.

Considered together, the current findings suggest that the P3 amplitude may be a trait marker for depression (cf. also Gangadhar et al., 1993; Santosh et al., 1994). Here again, ERPs illustrated their unique insight into mechanisms that may not always be evident in overt behavior. The P3 elicited in the current study sample was parietally maximal (cf. "P3b") and therefore presumably related to context updating operations and subsequent memory storage (Polich, 2007). It may be useful to evaluate the amplitude of both P3b and the frontally distributed P3a within the same group of depressed individuals in order to evaluate whether depression-related amplitude abnormalities could differ across each component. Such a procedure would allow for greater specificity in describing the nature of dispositional executive function abnormalities in depression. Future manipulations in the ACI procedure may also include alternative instructions that direct attention towards and away from affective aspects of the prime words; this intervention may clarify whether affective priming has an impact on the P3 amplitude or not.

Similar to the P3 effects, a group effect was found for amplitudes of the late positive potential (LPP) ERP component. Individuals with no history of depression exhibited a sustained positivity at fronto-central recording sites in the Stroop task, consistent with previous research suggesting an enhanced late positive potential in nondepressed individuals, especially in response to affective words (e.g., Franken et al., 2009). Individuals meeting criteria for current MDD, however, overall, showed a smaller amplitude of the LPP relative to nondepressed individuals. The LPP is thought to reflect increased and sustained attention to salient visual stimuli (Foti et al., 2010). It exhibits its largest amplitudes in response to highly arousing unpleasant and pleasant stimuli (cf. Olofsson et al., 2008). Furthermore, the LPP is assumed to be related to attention and memory processes elicited by emotional stimuli (Olofsson et al., 2008), and, in particular, the LPP is assumed to be associated with brain processes of cognitive control (Larson et al., 2009). In this context, the LPP may reflect processes facilitating appropriate action as response to task-relevant stimuli (Moser et al., 2010). Consistent with this interpretation, in the current study, of all ERP components examined, the parameters of the LPP component had by far the largest predictive power with regards to overt behavior. Thus, to the extent that the LPP reflects cognitive control processes during the Stroop task, decreased LPP amplitudes in depressed individuals indicate impaired executive functioning, potentially related to sustained processing of affective primes priorly presented; thereby confirming the current P3 findings. In sum, the LPP findings suggest that depressed individuals fail to engage the neural networks typically associated with later processing stages in executive cognitive functioning, reflecting an impairment in controlled processing devoted to the resolution of conflict or devoted to the signaling for increased implementation of attentional control, respectively (cf. also Larson et al., 2009).

Interestingly, the LPP has recently been suggested as an index of emotion regulation (Moser et al., 2010). In their study, Moser et al. (2010) applied an experimental design that was broadly similar to the ACI task. The processing of affective stimuli was followed by a non-affective task of executive cognitive control. In their design, they tested the effects of cognitive emotion regulation on subsequent executive cognitive functioning. They could demonstrate that the LPP was significantly decreased under instructions to decrease negative emotion and was significantly enhanced under instructions to increase negative emotion. This finding is in good agreement with the fact that after negative priming LPP amplitude did not differ between nondepressed and depressed individuals, especially in the incongruent Stroop condition. It is possible, therefore, that both processes, namely, impaired cognitive control on the one hand, and increased negative affectivity on the other, interacted to bring about the current depression-related results.

Finally, it should be noted that the affective word primes used in the current study should be considered rather low-arousal stimuli that most probably represent only relatively weak manipulations for observing abnormalities in the neural correlates of affective interference. This may be the reason why, in the current study, no significant modulations of LPP parameters were found with respect to affective priming. Therefore, it may be necessary to use highly arousing pleasant and unpleasant stimuli in the ACI task, such as faces (cf. International Affective Picture System), to arrive at differential results for the comparison between depressed and non-depressed individuals with respect to this specific ERP component.

The Impact of State Orientation

The current results demonstrate that personality traits of action versus state orientation can be traced to basal brain processes. Moreover, the findings of the current study suggest that depression could involve, in part, altered brain processes associated with sustained processing of affective information which is characteristic of preoccupation with state-oriented (negative) thoughts. However, although there is growing empirical support for the association between MDD and a state-oriented cognitive style (Lyubomirsky et al., 1999; Nolen-Hoeksema et al., 2008; Siegle, Steinhauer, et al., 2002; Watkins & Brown, 2002) the direction of causality is still not well understood. It could be argued that MDD may cause a state-oriented mind set, with depressed mood causing an individual to disengage from his or her environment, become biased against taking action, and become focused on his or her present state. Conversely, it is also feasible that a disposition to state-oriented, ruminative response to aversive life experiences may be a risk factor for developing depression. Along these lines, there is now growing evidence that (failure-related) state orientation is indeed a vulnerability factor for depression. Different research approaches lend support for this hypothesis. For example, Spasojević & Alloy (2001) in a prospective investigation, demonstrated that state orientation mediates the predictive relationships of numerous variables known to be risk factors for depression. They concluded that a ruminative, cognitive style, as a special kind of self-focus, may act as a general proximal mechanism through which other vulnerability factors affect depression. Earlier, Hautzinger (1994) reported a decrease in state orientation in depressive patients when in remission. Notably, however, despite their improvement, formerly depressed individuals were still more state-oriented than healthy control participants. Nolen-Hoeksema et al. (2008) provided evidence that a state-oriented cognitive style is associated with psychopathologies in addition to depression, including anxiety, binge eating, binge drinking, and self-harm. Treynor et al. (2003) showed that reflective pondering and brooding differentially relate to depression in terms of predictive power.

While the current data cannot definitively address the question of causality, it is noteworthy that RUM score was associated with prime-locked late positivity irrespective of current depressive symptomatology. Likewise, RUM had an independent impact on the amplitude of the stimulus-locked LPP ERP component, which is strongly related to overt behavior. In addition, failure-related state orientation had a differential effect on P3 amplitudes in depressed and nondepressed individuals. Considered together, these data could suggest that the initial response to affective information (cf. P1 effect in the current study) serves as trigger or precursor for subsequent state-oriented cognitions (cf. "sustained information processing"; LP effect in the current study). Hence, the mechanisms underlying sustained information processing, which apparently begin in the seconds following the presentation of affective information, are potentially involved in the subjective experience of the "spinning mind" in depression, and in state-oriented individuals in general. It will be informative for future studies to examine potential causal associations more directly, and to this extent the ACI task combined with ERPs may be a particularly useful approach. Specifically, ERP research is a relatively inexpensive method to assess brain function as compared to fMRI. Therefore, ERP studies are especially well-suited for repeated measures designs that may be helpful in addressing whether patterns of brain activity associated with ruminative thought in depression may normalize upon recovery. Similarly, ERP studies seem entirely feasible for conducting longitudinal studies within high-risk samples to examine whether brain correlates of sustained information processing, or failure-oriented state orientation respectively, are predictive of future MDD.

At the very least, the current observations suggest that understanding brain processes underlying sustained processing of affective information may be important in understanding the phenomenology of depression. Of particular note, to the extent that the current results support a relationship between sustained processing of affective information and self-reported failure-related state orientation, there are also potential clinical implications, in particular with respect to the treatment of depression. For example, therapeutic approaches that focus on helping depressed individuals in getting control over their thoughts, such as thought stopping, controlled worry periods, cognitive re-appraisal or distraction techniques (cf. Wells & Davies, 1994), may help depressed individuals improve their executive control capacities. Failure-related state orientation and its association to brain activity could provide a process on the basis of which the action of such interventions could be explained.

Localization of Effects

Although, in the current study, the ERP components were not source-localized and therefore the current data cannot inform directly about which specific brain regions account for the observed group effects, the nature of the ACI task and the distribution of the ERP components observed allow to draw comparisons with those same ERP components observed in related studies.

ERP and fMRI studies so far suggest that the fronto-central N2 ERP component reflects activity in the anterior cingulate cortex (ACC) (van Veen & Carter, 2002). The ACC is assumed to be involved in tasks that require selective attention and conflict monitoring (Botvinick et al., 2001, 2004) and is assumed to play a critical role in the development of a depressive illness (Mayberg, 2009). The latter conclusion is consistent with findings indicating increased activation in the ACC, or increased amplitude in corresponding ERPs respectively, in depressed individuals when inhibiting a prepotent response (Chiu & Deldin, 2007; Langenecker et al., 2007). In this context, the results of the current study would suggest decreased activation of the ACC in depressed individuals during executive cognitive functioning after negative priming. That would further suggest that decreased ACC activity in depressed individuals would reflect enhanced affective interference resulting from sustained processing of negative primes. This, in turn, would point to depression-associated differences in the relative difficulty of disengaging from negative and positive material. The current N2 findings therefore indicate that depressed individuals' difficulty in disengaging attention from negative stimuli may be grounded in anomalous functioning of the ACC in subsequent executive cognitive control. In sum: considering existing neurophysiological and neuroimaging findings, the current study provides evidence that state-oriented cognitions cause abnormal conflict monitoring. The observed relationship between N2 amplitude and self-reported state orientation lends further support to this hypothesis. Since state-oriented individuals tend to dwell on negative events in an unproductive, repetitive manner, it is perfectly logical that depressed individuals, in particular, suffer from executive dysfunction due to affective interference. This formulation is supported by subsample correlational analyses. As shown above in the current study, particularly in the subsample of depressed individuals, a significant negative correlation between failure-oriented state orientation and N2 negativity was identified. In this group, higher levels of state orientation were associated with smaller N2 amplitudes, even if variance in BDI score was partialled out. In contrast, respective coefficients failed to reach statistical significance in the control subsample (all *p*s > .75). In both groups, current depressive symptomatology (cf. BDI) was not related to N2 parameters (*p*s > .37).

Importantly, in the current study, N2 amplitude in the Stroop task was decreased after positive affective priming in nondepressed individuals, but decreased after negative priming in the MDD group. Although not predicted, this double dissociation is important in suggesting that task situation may influence the way affective stimuli are used in normal functioning to regulate behavior. The findings suggest that after positive priming, conflict monitoring is improved in depressed individuals, whereas in nondepressed individuals the opposite pattern holds. Thus, during the Stroop task, depressed individuals effectively recruit the ACC when previously primed with positively valenced stimuli, whereas nondepressed individuals recruit this brain area more actively when previously primed with negatively valenced stimuli. This is in contrast to research suggesting that depressed individuals not only preferentially process negative stimuli, but also lack a bias for the preferential processing of positive stimuli (e.g., Leppänen, 2006).

Studies examining P3 modulation during both affective and non-affective executive function tasks mainly indicate that this component stems from parietal and inferior temporal areas (e.g., Bledowski et al., 2004; O'Connell et al., 2012). However, studies of P3 generation also suggest the hippocampus and the lateral prefrontal cortex as possible sources of the P3 ERP component, in addition to left middle temporal gyrus, the temporal-parietal junction and the medial temporal complex (O'Connell et al., 2012; Soltani & Knight, 2000; Zhang et al., 2007). In light of these findings, the decreased P3s observed in the MDD group in the current study, may be indicative of decreased activation of regions subserving cognitive control, namely the (dorso) lateral prefrontal cortex; subsequent to conflict detection by the ACC. Such an effect would be consistent with results from fMRI studies (Siegle et al., 2007) and, together with the current N2 data, indicate that affective interference from sustained information processing in depressed individuals occurs at both the conflict evaluation and the conflict regulation stage. Likewise, this interpretation would be in line with neural models of depression (Bar, 2009; Mayberg, 2009; Pizzagalli, 2011) suggesting abnormal activity in cortical and subcortical neural networks underlying MDD. More precisely, for example according to Mayberg's model (Mayberg, 1997, 2009), depression involves dysfunction in a network of brain regions, which among other things coordinates various aspects of attention. The specific brain regions assumed to be constituents of this network include the dorsal anterior cingulate, dorsal lateral prefrontal cortex, inferior parietal cortex, and the striatum. Thus, the present study's findings on the N2-P3-ERP complex give good reason to assume that depression is associated with abnormal activity in cortical and subcortical neural networks during executive cognitive functioning reflecting interference from sustained processing of affective stimuli.

Finally, Sabatinelli et al. (2007) suggested that modulation of the LPP indexes increased activity in a circuit of visual cortical structures, including lateral occipital, inferotemporal, and parietal visual areas. Since it was also proposed that the LPP reflects a perceptual sensitivity to the motivational relevance of stimuli (e.g., Schupp et al., 2000), it is tentatively suggested here – somewhat derogating from the interpretation offered above – that the decreased LPP amplitude during the Stroop task among depressed individuals offers neural evidence in support of an overall impaired top down executive control in terms of an impaired capacity in depressed individuals to regulate their behavior according to affective aspects of their environment (cf. Foti et al., 2010; Keil et al., 2002)

Taken together, these considerations underscore the interrelations between depression, sustained informations processing, affective interference, and abnormalities in ACC-DLPFC functioning. Future research may therefore examine more explicitly whether, for example, the magnitude of N2/ACC parameters during executive cognitive functioning may be predictive for treatment response in MDD (cf. Pizzagalli, 2011).

Limitations

A number of limitations to this study must be acknowledged. First of all, the samples were relatively small, so that the sample sizes were not large enough to test for higher-order interactions, in particular between personality variables, behavioral, and neural measures for sustained information processing and affective interference with sufficient statistical power (cf. structural equation modeling). Likewise, effects of personality variables may not have been detected due to low power. The cross-sectional design of the study does not allow to determine whether the observed group effects on the behavioral and the neural level must be regarded as a state or a trait marker of altered information processing in depression. To clarify this issue, a longitudinal study that also compares clinically remitted and non-remitted depressed individuals would be of high value. In this context, it is relevant to note that the administered measure for failure-related state orientation (cf. RUM) was highly correlated with depressive severity (cf. BDI), $r = .83$, $p < .001$, making it difficult to disentangle relationships between the observed group effects, state orientation, and depressive severity. Nevertheless, in some instances, appropriate statistical analyses could reveal differential effects of state orientation, independently of current depressive severity.

Another potential concern involves the absence of a volitional facilitation effect after positive priming, or a missing volitional inhibition effect predicted after negative priming respectively (cf. Kazén & Kuhl, 2005; Kuhl & Kazen, 1999). Perhaps, the ACI paradigm used in the current research failed to obtain expected effects because of the changes in the trial design that were required to adjust the original version of the task for use in an ERP study. In this regard, the emphasize should be placed on the fact that, considered together, the behavioral results of Study 2 and Study 3, although they could not replicate the typical pattern of volitional facilitation/inhibition, nevertheless yielded consistent results in that, in both cases, the relevant group effects were found in the low-interference Stroop condition. Since the current study is probably the first study explicitly investigating sustained information processing and resulting affective interference in depression, further empirical investigation, especially in larger samples, are necessary before the behavioral effects can be considered to be reliable.

Since there was no psychiatric control group in this study, the issue of the specificity of the findings to depression can not be addressed. Indeed, it is possible that information processing biases found in the current study are also involved in other disorders, such as post-traumatic stress disorder, anxiety disorder, or schizophrenia. Studies 1b and 1c, as well as the results of the current discriminant analysis made an attempt to show the differential relationship of failure-related state orientation to the depressive disorder. There are some indications that a state-oriented cognitive style plays a unique role in the development and maintenance of MDD; but clearly, more research is necessary to address this issue in particular by examining how neural correlates of sustained information processing and affective interference differ in individuals diagnosed with other psychiatric disorders.

The ancillary analyses suggest that medication status did not play an important role for the group effects observed. Nonetheless, the potential confounding factor of medication exposure in the current study cannot be completely refuted. Similarly, the possibility that different medication classes – among the several used by the patients who participated – do not have differential effects especially on ERPs, cannot be ruled out. The ideal study, of course, would contrast control participants with unmedicated depressed patients, but such a study would face substantial practical and ethical issues.

A final possible concern involves the possibility that the current results are due to the fact that participants did not consistently perceive the prime words according to the valence for which they generated them. It is not easy to rule out this potential confounding effect. The use of self-generated word primes may already be more valid than the use of the same set of affective words for every participant, even if in the latter case participants are instructed to associate each affective word with a personally relevant experience. To further rule out this possible disturbance, additional indicators of processing of affective information, such as pupil dilation, heart rate or skin conductance could be assessed (cf. Cuthbert et al., 2000; Siegle et al., 2003)

The results of the current study support the notion that a sample of clinically depressive individuals displayed impaired executive cognitive functioning at both conflict detection and conflict resolution stages. Specifically, this study suggests that a depressed person's processing of an affective stimulus could persist well beyond that stimulus and, in fact, could persist into the time he or she is required to engage in other activities. Thus, such prolonged processing could lead to interference with the subsequent activity. The current study showed that ERPs are useful in elucidating the time-course of processing of affective information and following affective interference in depression, and illustrated ERPs' unique insight into mechanisms that are not evident in overt behavior. The study lent further support for the hypothesis that depressed individuals devote increased initial attention to affective, in particular negative stimuli, which is followed by sustained processing of affective stimuli that will eventually interfere with subsequent executive cognitive functioning. The effects observed begin to explain possible reasons why state-oriented cognitions may arise specifically in MDD. More ERP research in depression is necessary, however, to further estimate the extent to which these effects can be observed in other clinically significant populations, whether they are affected by symptom reduction techniques including psychotherapy, and the extent to which they correlate with other cognitive dysfunctions in depression.

The limitations mentioned above not withstanding, this study, as already indicated, has a number of potentially important clinical implications. The increased sensitivity of depressed individuals at the initial prime evaluation stage, as indexed by the increased P1 and LP ERP components, and the relationship between this hypersensitivity and failure-related state orientation suggest that an initial target of treatment could be the reduction of ruminative thought. The relationship between failure-related state orientation and conflict resolution (cf. N2 and LPP effects) indicates that unproductive, persistent responses to aversive experiences reflect a key mechanism in depriving cognitive resources responsible for effective executive functioning, which, in turn, is required to manage problems efficiently. Hence, it could even be postulated that reducing state-oriented cognitions is necessary for a depressed individual to start a therapy in the first place.

By demonstrating a potential link between neural functioning, sustained information processing, and affective interference in MDD, the present study adds to a growing research pool which tries to develop a more comprehensive understanding of depression through the integration of neural and cognitive models of this disorder. In the long run, this approach will hopefully be able to provide a clearer picture of the causal role of personality styles and information processing biases in the onset of depression, i.e., whether the depression-associated effects observed point to possible vulnerability factors for depression or whether they are the result of an ongoing depressive episode. In light of the high comorbidity between MDD and anxiety disorder, it will be important for future work to examine unique influences as well as interactions between depression and anxiety symptoms on sustained information processing and affective interference, and the link of both of these symptomatologies to a state-oriented cognitive style.

Chapter 5: General Discussion and Conclusion

This thesis began by introducing the idea of action versus state orientation, which is central to the understanding of the functional significance of the “spinning mind”, in particular with respect to major depression. In this context, it was also necessary to summarize the degenerated-intention hypothesis as a mediating factor between state orientation and depressiveness. The helplessness model of depression was outlined in combination with its reformulation as functional helplessness. It was argued that functional helplessness provides a more plausible explanation for a developing depressive illness than the original formulation, because functional helplessness – based on the idea of a link between state-oriented cognitions and depressive symptoms – offers explanations for phenomena that were previously hard to explain. Despite this, the functional helplessness model of depression has been relatively little used in clinical research in its original formulation.

The aim of this work was to shed light on the role of state orientation in the development and maintenance of a depressive disorder by investigating personality, brain, and information processing correlates of this illness. The thesis should be regarded as a preliminary test of the hypothesis that state orientation, characterized by persistent, ruminative thought, or sustained information processing, interferes with normal cognitive functioning and thereby increases the risk for developing a depressive illness, aggravates depressive symptoms and prolongs depressive episodes. Put differently, this thesis has made the argument that state orientation as a personality disposition is a highly relevant factor in the development and maintenance of a major depressive disorder, because state-oriented cognitions impair adaptive, voluntary regulation of behavior by depleting cognitive resources necessary to employ executive control over ongoing cognitive functioning. Against this background, high levels of failure-related state orientation in particular were assumed to influence executive cognitive functioning. The extent to which an individual has a state-oriented cognitive style after aversive life experiences determines how much he or she will suffer from intrusions about these experiences in his or her cognitive functioning.

As predicted, failure-related state orientation was strongly associated with depressive symptomatology in clinical and subclinical populations (cf. Studies 1a and 1b) and individuals suffering from a major depressive disorder could be successfully distinguished from nondepressed individuals and individuals primarily suffering from anxiety disorder by the level of failure-related state orientation (cf. Study 1c). Thus, Studies 1a to 1c demonstrated that people high in depressiveness can be well characterized by their level of failure-oriented state orientation; this is true for subclinically and clinically depressed individuals as well as for the comparison of depressed patients and other psychiatric samples. In both Study 2 and 3 depressiveness was related to impaired executive cognitive functioning presumably related to sustained processing of affective information. In addition, in Study 3, both depressiveness and state orientation were associated with neural measures of sustained information processing as well as with neural measures of affective interference. Specifically, in Study 2, in a small sample of university students, evidence was found that depression is associated with distinct interfering effects of sustained processing of affective information on subsequent executive cognitive functioning. In the most comprehensive study of this thesis (cf. Study 3), sustained processing of affective stimuli and the possible resulting affective interference in a following cognitive task, was explored in a group of clinically depressed inpatients and their matched nondepressed control counterparts by investigating the performance in a Stroop task after prior affective priming while collecting EEG signals. It was found that manipulating the affective valence of prime words presented right before a task of executive cognitive functioning differentially influences neural processing for both the prime words and the target stimuli in depressed and nondepressed individuals. As predicted, depressed individuals showed sustained processing of affective, especially negative information, as indexed by increased prime-locked P1 and LP ERP components. Moreover, sustained information processing apparently resulted in affective interference, as assessed by increased reaction times, as well as decreased ERP components related to conflict detection, conflict monitoring, and conflict resolution (cf. N2, P3, and LPP effects). Moreover, also consistent with predictions, increased personal disposition towards failure-related state orientation was associated with increased neural measures for sustained information processing (cf. LP amplitude) and increased measures for affective interference, or decreased measures for executive control, respectively (cf. N2, P3, and LPP). Importantly, all of these significant effects occurred after controlling for levels of depression, indicating that the effects of sustained information processing, affective interference, and state orientation occur independently of the level of depression. In brief, the correlational and experimental findings of this thesis were quite consistent, essentially replicable, and were obtained in a number of different populations.

General Implications

The current data present the first evidence that state orientation is indeed differentially related to sustained information processing and affective interference in depressed compared to nondepressed individuals. As such, these results suggest that there are functional differences between depressed and nondepressed individuals in the way they deal with affectively valenced stimuli, with the former in particular showing interference from sustained processing of affective stimuli during following executive cognitive functioning consistent with the hypothesis advocated by Kuhl & Helle (1986). The current findings suggest that sustained information processing may indeed interfere with executive functioning, decreasing cognitive resources that are available for ongoing task accomplishment (cf. P1-LPP-RT complex). Moreover, the present findings suggest that at least one personality trait, that is, state orientation (alongside , e.g., self-access; cf. Study 3), may be of relevance to the effects of sustained information processing and affective interference, in contrast to previous research, which has not found a strong influence of measures for state orientation on these effects (Siegle, Steinhauer, et al., 2002). The present results add to a growing body of evidence that demonstrates the existence of different kinds of state orientation, each with distinct functional properties. In particular, the findings are suggestive of the characterization provided by Kuhl (1994b) of failure-related and decision-related state orientation as distinct modes of processing, with the former predicted to impair recovery from upsetting events more strongly relative to the latter. Critically, the current findings extend previous results demonstrating the close relationship of failure-related state orientation to depressive symptomatology (Kammer, 1994) to more direct measures of information processing, in this case, sustained information processing and affective interference in terms of reaction times and ERPs. Thus, the current research supports the idea that state orientation is a crucial factor involved in the development of a depressive disorder. The findings suggest that state orientation may be a unique contributor over and above other factors, which, in combination with environmental circumstances, may be a risk factor for developing a depressive illness.

In Study 3, group effects were associated with a specific pattern of brain activity. These effects are consistent with the idea that state orientation is associated with the recruitment of brain systems involved in conflict detection, monitoring, and resolution. Prior research has shown that in nondepressed individuals, the ACC and DLPFC are tightly coupled during executive task performance. The ACC is assumed to perform an evaluative role such that it monitors for conflict, whereas the role of the DLPFC is regulative in that this structure resolves conflict. In depression, however, these frontal brain regions seem to be compromised, and frontocingulate dysfunction may contribute to key cognitive and affective abnormalities, including maladaptive state-oriented tendencies, difficulty in disengaging from, and inhibiting of, negative information. As a possible cause for this frontocingulate dysfunction, a dominance of the default-mode network and limbic regions over task-positive network regions has been suggested. As the ACC and DLPFC are implicated in automatic responses to emotional stimuli, deficits in implementing top-down executive control processes seem to be a key component of depressive cognition. In sum, executive dysfunction in depressed individuals seems to be related to sustained processing of affective information. Thus, long-term state-oriented, ruminative thinking may strengthen connectivity of areas within the default-mode network, leading to a weakened influence of the frontocingulate executive control axis – constituted by ACC and DLPFC – and thereby making it more difficult for state-oriented, or depressed individuals, to disengage from thoughts when appropriate.

There is active interest in the variables that affect covariation between intentions and behavior. The majority of this research has focused on the relationship between attitudes or dispositions and behavior (e.g., Rhodes et al., 2003). Research has shown that attitudes and dispositions are important determinants of the behavior of some people but not others. For example, Powers et al. (2005) have established that those who report high socially prescribed perfectionism are significantly worse at implementing their intentions when they are asked to formulate concrete plans of reaching their goals compared to being instructed to complete a control exercise. Likewise, Churchill & Jessop (2010) demonstrated that a disposition for impulsivity can hinder individuals in achieving their intentions, and Koestner et al. (2006) found that implementation plans alone do not result in greater realization of intentions unless they coincide with a sufficient level of autonomy and/or self-efficacy. Research on "ego depletion" has suggested that the impact of many personality traits on overt behavior and realization of intentions, respectively, is moderated by a person's capacity to override and alter his or her response to environmental stimuli (cf. Baumeister et al., 2006). Carbonneau et al. (2012) have also argued that there are important individual differences in the degree to which behavior is intrinsically or extrinsically determined (cf. also Ryan & Deci, 2000). It was suggested that some people, specifically those high in neuroticism and psychoticism, typically attend to external cues when regulating their behavior (Ingledew et al., 2004). Other people, those high in extraversion, conscientiousness, and openness, tend more to base their behavior on their own internal states, attitudes, and dispositions (Ingledew et al., 2004). Since state orientation is positively related to constructs like neuroticism (e.g., Baumann & Kuhl, 2002), and since state-oriented individuals tend to ascribe intentions of others to themselves (Kazén et al., 2003), it follows that state-oriented people should show a lower correspondence between their intentions and behavior than action-oriented individuals. This hypothesis has been repeatedly confirmed (cf., e.g., Diefendorff, 2004). Importantly, results showed that state orientation predicts performance independently of goal orientation, cognitive ability, self-efficacy and self-set goals. In this regard, differences in state orientation are also postulated to affect depressive symptomatology (Kuhl, 1992). In fact, a considerable part of research on personality factors as risk factors for depression is concerned with precisely this issue. For example, it has been found that induced abstract, ruminative thinking impairs problem solving capabilities in depressed individuals (Watkins & Moulds, 2005). It has also been demonstrated that state-oriented thought processes decrease capacities for executive cognitive control specifically in dysphoric individuals (Philippot & Brutoux, 2008). Finally, the present research shows that a state-oriented cognitive style can indeed impair a person's ability to adaptively regulate his or her behavior. In brief, failure-oriented state orientation appears to be another important determinant of the degree to which an individual is able to willfully direct his or her behavior. The theoretical statement published by Kuhl (1981), and later revised by Kuhl & Helle (1986), primarily concerned a dysfunctional process that is characterized by intrusive, uncontrollable thoughts that reduce the cognitive capacities which are necessary for normal adaptive behavior. Specifically, those authors proposed that a state-oriented mind set predestinates an individual for "degenerated intentions", which draw attention to the fact that a specific (negative) experience could not be integrated into the individual's "self", i.e., into the extended network of the person's prior experiences (cf. Kuhl et al., 2006). Hence, the major outcome of increased state orientation is presumed to be a greater discrepancy between intention and behavior.

The fact that state orientation is strongly related to the "spinning mind", associated with a change-preventing mode of action control, is well documented. For example, studies have demonstrated that state orientation results in poorer work performance relative to action-oriented individuals (Diefendorff et al., 2000), is associated with less effective health promotion (Palfai, 2002), and that state-oriented people also show lower levels of perceived self-regulatory success relative to action-oriented people (Diefendorff et al., 1998). However, state orientation may not be the only aspects of action control relevant to depression. This thesis showed that depression may also be related to self-access and achievement motivation. It is only a small extrapolation to assume that state orientation can also modulate the functioning of these, as well as other aspects of personality in depression (e.g., self-esteem, perfectionism, guilt, and shame). Crucially, however, it is likely that the behavioral consequences of a state-oriented cognitive style for depression may be quite different, depending on gender (Nolen-Hoeksema, 2001), intelligence (Calero et al., 2007), or even cultural background (Hermans et al., 1994). A theory of action control needs to take these findings into account (cf. Kuhl, 2000). State orientation may not always impair executive cognitive functioning in depression, neither does it necessarily always lead to a discrepancy between intentions and behavior. In sum, the “self” is multifaceted, comprised of a variety of different dimensions and volitional components, and the state-oriented individual may be able to make use of certain volitional resources to adaptively regulate his or her behavior. The task for future theory and research is therefore to delineate more precisely the variables that influence the concrete manifestation, and those that mediate, or moderate respectively, the consequences of a state-oriented cognitive style, in particular with respect to the development of a major depressive disorder.

Clinical Implications

Current findings are consistent with the notion that it may be beneficial to teach state-oriented individuals not necessarily to suppress ruminative thought, but to teach them a form of self-reflection that provides the adaptive benefits of increased self-awareness and improved self-regulation, whilst avoiding the maladaptive effects of a brooding self-focus (Armey et al., 2009). Modern treatment approaches that target the improvement of executive function capability and reduction of ruminative thought in response to aversive life experiences seem very promising in helping individuals suffering from a depressive illness, in particular by speeding up the recovery from failure experiences. The results of this thesis imply that such interventions might be particularly suited for individuals scoring high on measures for failure-related state orientation, given that this form of state-oriented cognition was most predictive for depressiveness, whereas individuals characterized by a high level of decision-related state orientation may need a different therapeutic approach. Perhaps, reducing the dominance of state-oriented cognitions may be a very effective starting point in therapy, because such an intervention may demand a considerably less psychotherapeutic introspective effort from patients compared to other therapeutic approaches. A significant drop in a patient’s state orientation may, in addition, potentially be a robust marker for measuring treatment response.

It is particularly interesting in this context that the so-called metacognitve therapy (Wells, 2000, 2009), which has been shown to be associated with large improvements in patients with treatment-resistant depression in a variety of symptom measures (Wells et al., 2012), explicitly targets attentional control, rumination, worry, and metacognitive beliefs by encouraging external flexible attention to be practiced independently of the occurrence of internal or external events. Metacognitive therapy aims to remove state-oriented cognitions, rather than challenging the content of them. Stringent criteria showed 60% recovery rates among treatment-resistant depressed patients at follow-up assessments at six and twelve months post treatment (Wells et al., 2012). Thus, encouraging depressed patients, in particular, to adopt an external attentional focus in their thoughts (cf. Wells, 1990), and, thereby, preventing the “spinning mind”, may be one potential mechanism by which metacognitive therapy relieves depressive symptoms.

Standard therapies for depression are associated with remission rates of about 60% (Kennard et al., 2009) demonstrating especially that there cannot be a single effective therapeutic approach for all depressed patients. In this context, the diagnostic differences between major depressive and dysthymic individuals warrants further attention. Studies on the cognitive processes of clinically depressed individuals have focused on major depression; therefore, little is known about information processing in dysthymia, which is defined as a chronic depressive mood, lasting at least several years, but which is not sufficiently severe, or in which individual episodes are not sufficiently prolonged, to justify a diagnosis of severe, moderate, or mild recurrent depressive disorder (World Health Organisation, 2004). Previous reports indicate that there is higher personality disorder comorbidity among dysthymic individuals than among individuals with major depression (Sanderson et al., 1992), and this phenomenon may have implications for information processing biases in this groups as well. It is also possible that illness duration plays a role in modifying cognition in the dysthymic population: perhaps different strategies which are used to deal with the illness evolve over time. Since such distinct processing styles may have therapeutic implications, examining whether individuals with major depression and dysthymia differ in the processing of affective information is important.

Methodological Considerations

There are several methodological issues that merit further discussion: some empirical and others theoretical. At an empirical level, the effects that were sought to be demonstrated seem quite reliable. Nevertheless, present findings have implications for our knowledge of the “Affective-Cognitive-Interaction” paradigm (Kazén & Kuhl, 2005; Kuhl & Kazen, 1999). Study 3 is one of the very few studies that investigated both neural correlates associated with sustained information processing and neural correlates associated with affective interference in depression and demonstrated a link between both. To date, studies investigating the neural correlates of sustained information processing in depression have focused their efforts on determining how sustained information processing is reflected in measures of brain activity (Deldin, Deveney, et al., 2001; Siegle, Steinhauer, et al., 2002). They have not, however, explicitly investigated whether sustained processing actually interferes with executive cognitive functioning and if so, how such affective interference would be characterized in terms of altered brain function. The only other study relating neural correlates of sustained information processing to neutral correlates of affective interference in depression could not find a relation between both measures (Siegle et al., 2007). Nevertheless, (Siegle et al., 2007) could, on the level of brain function, demonstrate that depression involves increased and sustained processing of affective information as well as impaired executive control during subsequent executive cognitive functioning.

The affective priming used in the current ACI paradigm, although most probably related to people's daily lives, was relatively mild. Therefore it is not known whether the present findings could be generalized to more severe and major life events. Another methodological limitation is the absence of a second stimulus onset asynchrony (SOA). An interval three to five seconds between the end of the prime word presentation and the onset of the Stroop stimulus as a test to determine the possible decay of the impact of sustained information processing on following executive cognitive functioning could be very informative. Without this, despite the current results suggesting that sustained processing of affective information interferes with subsequent executive functioning, it is not possible to decide whether it is really adequate to talk of "sustained processing" of affective information. Future research will need to examine the effects of different SOAs on "recovery" from being confronted with affectively valenced stimuli, in particular in depressed individuals. In this regard, an obvious first step will be to analyze data obtained from the second Stroop task of the ACI paradigm used in Studies 2 and 3. Likewise, it would be beneficial to try to make sure that affective stimuli in the ACI task are related to clinically relevant, recent, upsetting life events; e.g., participants could be instructed to only use words reminding them of situations they experienced during the last four weeks. In this way, it could be avoided that participants choose situations that are possibly several years apart. In this context, further investigations should also consider the inclusion of the total duration of illness as a covariate in the various statistical analyses. Perhaps, follow-up studies should also try to replicate the current results using only one Stroop task in the ACI paradigm and/or using a similar but different task of executive cognitive functioning instead of the Stroop task; maybe different behavioral effects would be revealed in a more cognitively demanding task. Finally, finding a way to assess within-task rumination would be a very important methodological improvement to counter some of the major shortcomings of the ACI paradigm in its current version (cf. Watkins & Brown, 2002).

On a theoretical level, the methodological issues are more complex. The issue here mainly concerns the consequences of being exposed to brief, affective stimuli – in the present case, self-generated, affectively charged words. Affective priming researchers have maintained that the effect of such a procedure is to automatically activate affect from memory (e.g. Hermans et al., 1994). A parallel literature suggests that especially depressed individuals tend to show a preferential processing of affectively-loaded information (Leppänen, 2006). Thus, in this thesis, it was assumed that a depressed individual exposed to affectively valenced stimuli would elaborate more on this stimuli, in particular on negatively valenced ones, than an individual that is not in a depressive state. In other words, the heightened salience of (negative) affect was expected to cause depressed individuals to engage in elaborative processing of affective information in the seconds following its perception (cf. Mineka & Sutton, 1992). Although the data were consistent with this reasoning, it may nevertheless be argued (i) that ERPs within a time window of 1500 ms cannot assess sustained information processing, at least not in a way that it may be related to the phenomenology of state-oriented cognitions, (ii) that even if prime-locked ERPs indicated sustained information processing, it would be still unclear whether they are related to later interference effects, and (iii) that even if interference effects were observed in the Stroop task, and even if, additionally, it was assumed that these effects were related to the affective priming, still, those effects could not be due to an elaboration on the affective stimuli, but due only to the affect associated with the prime word; put simply: affective interference may not be caused by brooding, but merely by (negative) affect. With respect to the latter objection, it may be further argued that, especially because the prime word is presented for such a short time, "cognitive elaboration" as such is not possible. Furthermore, even if an individual really recollected the corresponding situation at the beginning of the experiment, after several presentations of a prime word in the course of the experiment, in the best case, the words would inevitably be associated only with their respective affective valence or it is possible that they would simply be ignored.

In the present context, it can hardly be denied that talking of "sustained processing" with respect to prime-locked ERP components in Study 3 is problematic. Perhaps, effects in prime-locked ERP components should rather be regarded as indicators that different prime types are processed in unique ways and only together with corresponding later interference effects those ERP effects may be counted as signs of sustained information processing. Against this background, it will also be important for future research to include systematic assessments of first-person reports in terms of qualitative post-experiment interviews to be able to better relate the subjective experience of ruminative thought and neural and behavioral measures of sustained information processing (cf. Gallagher, 2003; Lutz et al., 2002).

Whether prime-locked and stimulus-locked ERPs reflect one stream of processing, or whether they are rather associated with two different mechanisms, is a question of empirical research. Initially, as has been done in Study 3 as well as in other relevant research (e.g., Siegle et al., 2007), several statistical analysis methods can be used to determine the relationship of prime-related processing and target-related processing. In the next stage, it is necessary to find a way to intervene on specific ERP components directly. In this way, hypotheses regarding the causal link of neural correlates of prime-related processing and neural correlates of target-related processing could be directly addressed.

With regards to the third objection, besides the possibility mentioned above of collecting qualitative evidence for state-oriented cognitions during the task in post-experiment interviews, there is one important consideration that weakens an interpretation based on affect alone. Research has shown that affective primes processed without awareness induce effects strongly related to affect per se, whereas effects of conscious affective priming are related to actively dealing with the content of the stimulus on a cognitive level (Rotteveel et al., 2001; Murphy & Zajonc, 1993; Wong & Root, 2003). This finding would seem to contradict the assumption that effects of affective interference, as they were found in this research, would be related solely to an induced affective state and not to the sustained processing of the affective stimuli. Or in other words, if the results obtained here by the use of affective word primes were due to induced affect per se, one may expect individual differences in mood at the beginning of the experiment to show similar relations to ERP components as measures for failure-related state orientation. Interestingly, in the MDD group, explicit negative affect assessed directly before the experiment – in terms of situational mood (Kuhl & Kazén, 2003) – was related to LP, N2, and LPP parameters in the exact same way as failure-related state orientation as assessed by the RUM subscale of the VCI. Crucially, however, although the relation between RUM score and LP and N2 parameters respectively was no longer significant, when variance due to explicit negative affect was controlled for, RUM scores were still significantly related to LPP parameters, even when controlling for the influence of negative affect. It is difficult to determine which explanation offers the best account of the current findings. An interpretation exclusively based on affect may possibly provide a viable explanation for the LP and N2 effects, but it cannot account for the LPP effects. An interpretation based on sustained information processing alone, or state-oriented cognitions respectively, can explain the LPP effect, but not the LP and N2 effects. Thus, as with the relation between BDI and RUM scores, also the relationship between RUM scores and negative affect (here: $r = .70$, $p < .001$) is difficult to disentangle. Nevertheless, the results indicate that both variables make an important contribution to understanding processing biases in depression. At the same time, they indicate that the processes underlying depressive cognition are complex and multidimensional and further research is needed to better understand the interrelations between the different processes suggested so far.

Adaptiveness

Kuhl (1994b) holds that state orientation may turn maladaptive, “when the globality and stability of an acquired disposition towards state orientation develops to the extent that state-oriented periods occur compulsively, that is, even when the actor wishes to stop them” (p. 32). However, even chronic and uncontrollable forms of state orientation should not be considered maladaptive per se, but rather only relatively maladaptive, because state orientation can be highly adaptive in coping with critical life-events, or when “existential problems” confront individuals with questions about the meaning of life. Or as Kuhl (1981) put it:

> All industrialized societies (...) exert great pressure on individuals to behave in an action-oriented way. Solving a life crisis, say a serious marital problem, after a prolonged period of state-orientation may make up for debilitated performance on anagram or d2-tasks. (p. 169)

Until now research suggests that the key maladaptive aspect of state orientation or rumination respectively, may be its abstract analytical aspect, whereas a more experiential form of self-reflection may be not maladaptive (cf. Watkins, 2008). Watkins (2004) suggests a possible process for the adaptive value of state orientation: beneficial and adaptive outcomes of state orientation may become possible, if focusing on upsetting and emotional events and associated thoughts and feelings promote greater self-awareness and greater self-knowledge. This way, in the long run, state orientation may produce improvements in mental and physical health and may also lead to more effective self-regulation.

Limitations

There are important limitations to the investigation of the current research topic. Depression is a very heterogeneous, multi-faceted disorder. As the characteristics of study samples may vary significantly between different investigations, this heterogeneity will most likely introduce inconsistencies between the current study and related research. Especially due to varying acquisition and data analysis parameters, brain imaging and electroencephalographic methods are probably also an important source of inconsistencies found between the results of this thesis and other relevant studies. Besides these two problems, differences in experimental designs used to induce a cognitive challenge may introduce further inconsistencies between the current results and previous research.

The empirical part of this thesis was based on relatively small samples. Consequently, issues explicitly relating to the heterogeneity of depression and to drug and duration effects have not been addressed. Finally, the valid assessment of state orientation also represents a significant challenge to empirical research.

At present, it is still not possible to give a definitive answer to the question of whether state orientation is a mere correlate of depression or rather a vulnerability factor for depression, that is, whether state orientation is a signature of a depressive state, or rather a signature of a depressive trait. It is tempting to try to separate depression status from state orientation, but this can be quite challenging considering that depression and state orientation are strongly correlated. Thus, despite growing evidence that state orientation is related to major depressive disorders irrespective of acute symptomatology, it is still difficult to disentangle the relationships between information processing biases, state orientation, and depressiveness.

Future directions

Given the current results, future studies of sustained information processing in depression would benefit from considering the role of personality variables such as failure-related state orientation. Future studies should also examine state- versus trait characteristics of prime-locked and stimulus-locked ERP components in the ACI task, their predictive role for the development, and clinical course, of depression, and its sensitivity to therapeutic change. Furthermore, studies including a simultaneous assessment of EEG and fMRI are needed to link exaggerations of these ERP components in depressed individuals to functional neuroanatomical models of depression. In addition, future work could usefully extend the current work to more naturalistic settings in order to examine further the clinical relevance of sustained information processing in individuals suffering from MDD.

Although the results of the current thesis cannot shed much light on gender differences in the effects described, there is nevertheless evidence that gender may play an important role in moderating the relationship between state orientation and depression (cf., e.g., Study 3, Ancillary Analysis), a finding consistent with previous research (Kammer, 1994; Nolen-Hoeksema et al., 1999, 2008). Determining the role of gender for the relationship between state orientation and depression should therefore be another part of future research.

Since Study 3 represents the first EEG study investigating the interplay of state orientation, sustained processing of affective information, and affective interference in clinically depressed individuals, further empirical investigation, especially in larger samples, along with more systematic manipulations of specific ERP components, will be important before the phenomena observed can be considered to be reliable, and concrete links between initial processing of affective information and later interference effects can be isolated.

The finding that affective priming influenced at least two prime-locked ERP components, which in turn were differentially related to individuals' levels of failure-related state orientation could indicate that the ACI task may involve more processing stages than just the processing of affective information and executive cognitive functioning. Other possible processes may involve memory processes and processes of emotion regulation. This suggests that future research on the relation between ruminative thought, cognitive functioning, and depression needs to find a way to more carefully delineate the particular stages of processing under consideration, because group effects will probably not be the same throughout the processing continuum.

In short, there are still a number of potential factors to explore that may have contributed to the findings of this thesis. Future work investigating the role of state orientation in major depressive disorders and the corresponding neural correlates will hopefully provide insight into a number of lingering issues, in particular into the biological basis of depression subtypes, and hopefully will allow for a deeper understanding of abnormalities in brain activity that constitute depression.

Concluding Remarks

As with most research, this thesis has answered questions as well as raised new ones. At the very least, the observations made in this thesis suggest that understanding brain processes underlying a state-oriented cognitive style may be important to understanding dysfunctional information processing in depression. Furthermore, it could be demonstrated that recording of neurophysiological data during task performance is a useful and complementary technique compared to traditional methods used in personality research. It reveals intimate insights into individual aspects of the regulation of goal-oriented behavior.

Since its original version, the concept of action versus state orientation underwent crucial refinements and the integration of this concept with related concepts – especially with the work on ruminative thinking and on propositional versus implicational rumination – will help to further differentiate the construct and its functional significance. The present work suggests that considering the role of personality variables such as action versus state orientation in the research on major depressive disorder has great potential to explain processing differences among phenotypically similar clinical pictures. Emphasis in future research should be on continuing to apply the theory and methodology developed for the investigation of action versus state orientation to study the mediating processes leading to a major depressive disorder. In particular, this includes investigating the conditions under which state orientation has positive, and under which conditions it has negative, effects on performance and well-being.

Though state orientation must not be regarded a sufficient condition to develop a depressive disorder, the causal role of state-orientation for depression is suggested by converging evidence. Importantly, the construct action versus state orientation relates to a core psychological function that affects every goal-directed human action: “Action orientation fosters concentration on action- and/or intention-relevant information, parsimonious information processing, and the arousal of positive, action-promoting affects as well as the avoidance of negative, action-hindering emotions” (Stiensmeier-Pelster & Schürmann, 1994, p. 333). To prevent dispositional state-oriented people from becoming seriously depressed when confronted with repeated failure or critical life events, it is crucial to teach them to interrupt the ruminative way they think about themselves and their problems (cf. Nolen-Hoeksema et al., 2008). It is essential that state-oriented individuals, and depressed individuals in particular, develop a form of self-reflection that avoids the maladaptive effects of brooding (cf. Watkins & Brown, 2002).

Future work examining high- versus low state-oriented depressed individuals may help clarify whether the neural profile of depressed individuals during sustained information processing is unique to this disorder. Most importantly, greater understanding of these neural patterns will hopefully help to find evidence-based brain biomarkers allowing us to refine our ability to diagnose and treat MDD. Thus, although further replication of results such as the current ones are necessary, ultimately this line of research may inform modern, targeted treatments of depression. The hope is clearly that by defining a specific brain circuit signature, a therapeutic road map for optimal treatment selection in individual depressed patients can eventually be provided.

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