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Thought suppression
as a cognitive vulnerability factor for depression
– an fMRI study

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ACC	Anterior cingulate cortex
ADS	Allgemeine Depressionsskala [Hautzinger & Bailer, 1993; German version of the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977)]. Self-report questionnaire to assess the existence of and the duration of depressive symptoms.
BA	Brodmann's area
CASL	Continous arterial spin labelling
CBF	Cerebral blood flow
dACC	Dorsal anterior cingulate cortex
DAS	Dysfunctional Attitude Scale (Weissman, 1979), questionnaire that assesses dysfunctional cognitions
DLPFC	Dorsolateral prefrontal cortex
DMPFC	Dorsomedial prefrontal cortex
DSM-IV	Diagnostic and Statistical Manual, 4th ed. (American Psychiatry Association, 1994)
DSQ	Depression Screening Questionnaire (Wittchen & Perkonigg, 1997)
EPI	Echo-planar imaging
fMRI	Functional magnet resonance imaging
FWE	Family-wise error correction
FWHM	Full width half maximum
HEM	Hemisphere
ICD-10	International Classification of Mental and Behavioural Disorders, 10th ed. (World Health Organization, 2000)
MANOVA	Multivariate Analysis of Variance
MPFC	Medial prefrontal cortex
mSST	modified SST during fMRI session
mSSTscore	The percentage score of negative sentences in the mSST during scanning
OFC	Orbitofrontal cortex
PET	Positron Emission Tomography
PFC	Prefrontal cortex
PRRT	Personal relevance rating task (Steinhauer & Thase, 2007)
rCBF	Regional cerebral blood flow
SMA	Supplementary motor area
SRET	Self-referent encoding/evaluation task (Kuiper & MacDonald, 1983)
SST	Scrambled Sentences Task (Wenzlaff, 1993)

SSTscore	The difference percentage score of negative sentences in SST; that is the percentage score of negative sentences in the load condition minus the percentage score of negative sentences in the no-load condition.
TPJ	Temporal parietal junction
vACC	Ventral anterior cingulate cortex
VLPFC	Ventrolateral prefrontal cortex
WBSI	White bear suppression inventory (Wegner & Zanakos, 1994)
WM	Working memory

1. Introduction

Depression is predicted to become one of the highest disease burdens in the future (Lopez & Murray, 1998). It is highly comorbid with other psychiatric and somatic disorders, such as coronar heart diseases (O'Connor & Joynt, 2004). It is important to understand the psychological and neurobiological mechanism underlying the onset and the development of this disorder. The present study focuses on cognitive risk factors for depression in subjects who are vulnerable to depression. Furthermore, the neural correlates of cognitive risk factors are investigated to shed more light on individual differences in information processing in vulnerable and healthy people.

1.1. Depression

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 1994) and the International Classification of Mental and Behavioural Disorders (ICD-10; World Health Organization, 2000), Major Depressive Episodes are characterized by following symptoms that have been present during the same 2-week period and represent a change from previous functioning:

- Depressed mood most of the day nearly every day,
- markedly diminished interest or pleasure in all, or almost all, activities of the day, nearly every day,
- significant weight loss when not dieting or weight gain, or decrease or increase in appetite nearly every day,
- insomnia or hypersomnia nearly every day,
- psychomotor agitation or retardation nearly every day,
- fatigue or loss of energy nearly every day,
- feelings of worthlessness or excessive or inappropriate guilt nearly every day,
- diminished ability to think or concentrate, or indecisiveness nearly every day,
- recurrent thoughts of death, recurrent suicidal ideation without a specific plan, or a suicide attempt or a specific plan for committing suicide.

Conditions for meeting a diagnosis are the presence of at least two of the three following symptoms: depressed mood, diminished interest or pleasure and fatigue or loss of energy (ICD-10) or the presence of either the depressed mood or the loss of interest and pleasure (DSM-IV). Both classification schemes, DSM-IV and ICD-10, distinguish between mild, modest, and severe Depressive Episodes. The severity of episodes differs by the number of symptoms and the degree of functional disability and distress. Mild episodes are characterized by the presence of four (ICD-10) or five (DSM-IV) depressive symptoms and either mild disability or capacity to function normally but with substantial and unusual effort. Severe episodes without psychotic features are characterized by the presence of most of the criteria symptoms and clear-cut, observable disability (e.g., inability to work or care for children). Moderate episodes are intermediate between mild and severe.

The prevalence of depression among women is typically between 1.5 and 3 times higher than among men (Weissman & Klerman, 1977, cf. Angold & Worthman, 1993). The lifetime risk for Major Depression in adults varies from 10 - 25% in women and from 5 - 12% in men (DSM-IV; American Psychiatric Association, 1994). According to DSM-IV the point prevalence of Major Depressive Disorder ranges from 5 - 9% in women and 2 - 3% in men. Major Depressive Disorder episodes are often recurrent. Epidemiological data suggest that at least 50% of patients who recover from an initial episode of depression will relapse at least once, and for patients who have had two or more depressive episodes, the risk of relapse rises up to 80% (Shea et al., 1992; Judd, 1997; Mueller et al., 1999).

Important for the present study, the DSM-IV classification involves the distinction of Minor depressive disorder which is characterized by one or more periods of depressive symptoms that are identical to Major depressive episodes in duration, but which involve fewer symptoms and less impairment. An episode involves either sad or depressed mood, loss of interest or pleasure in nearly all activities. In total, at least two but less than five additional symptoms must be present to meet the diagnosis.

Minor depression has also been found to affect the quality of life to a considerable extent (Rapaport & Judd, 1998; Wells et al., 1992; cf. Cuijpers, de Graaf & van Dorsselaer, 2004), to result in increased utilization of health services (Wagner et al., 2000), to cause large-scale economic damage because of disability days (Broadhead et al., 1990), and to result in a strongly increased risk of developing Major Depression (Wells et al., 1992; Horwarth et al., 1992; cf. Cuijpers, de Graaf & van Dorsselaer, 2004). A longitudinal study of Cuijpers, de Graaf and van Dorsselaer (2004) reported an increased risk of Minor depressed subjects for developing a Major depressive episode (8.0% vs. 1.8% for subjects with no depressive symptoms after 2 years). Similarly, Broadhead et al. (1990) found that 10% of Minor depressed individuals with mood disturbance developed Major Depression one year later. Cuijpers, de Graaf and van Dorsselaer (2004) supported the approach of depressive symptomatology as a continuum (for further support, see e.g., Kessler, Zhao, Blazer & Swartz, 1997; Solomon et al., 2001). Many investigators stated that Minor Depression is seen as a milder form of Major Depression (e.g., Sherbourne et al., 1994; Judd, 1997; Kessler, Zhao, Blazer & Swartz, 1997; Wagner et al., 2000) suggesting the notion of different clinical manifestations of the same underlying disease process. The characterisation of minor forms of depression provides also an opportunity to identify individuals potentially at risk for more severe forms of the disorder and to develop interventions that prevent more extensive morbidity (for a review, see Pincus, Davis & McQueen, 1999; Judd, Aksikal & Paulus, 1997). In line with this concept, in the present study a past Minor Depressive episode is considered as a vulnerability for depression.

1.2. Cognitive Theory of Depression

To account for symptom development and maintenance of depression, the cognitive model of depression developed by Beck (1967, 1976) ascribes the onset of this disorder in large parts to cognitive biases, contending that dysfunctional cognitive processes represent a significant vulnerability factor for depression. According to the model, individuals who experience loss or adversity early in life develop negative schemata concerning loss, failure, or abandonment. A commonly accepted definition within depression theory and research holds that schemata consist of organized elements of past reactions and experience that form a relatively cohesive and persistent body of knowledge capable of guiding subsequent perception and appraisals (Segal, 1988). These schemata act as screeners or filters that are used to organize new information in a meaningful way thereby determining how events are perceived, evaluated, attended to, and remembered. They also determine the biases in information processing and ultimately shape the interpretations of experience and expectations on a preattentive or preconscious stage of information registration (Gotlib & Krasnoperova, 1998).

It is proposed that depression involves hyperactive idiosyncratic depressogenic schemata that displace more appropriate schemata in the cognitive organization because of their greater strength of activation. The term activation is defined as the process of matching situation or stimulus input features to schemata that increase their prominence within the information processing system. Schemata that are a good match to the stimulus input features will become activated.

A second type of activation called indirect activation occurs when the stimulus matches only one element of a schema but nonetheless activates the entire schema.

For example, assume an individual has the dysfunctional belief “I am worthless unless I succeed at everything I do”, which remains latent and inactive until a triggering event occurs. Direct activation might occur if the person experiences a very significant life stressor, such as “being passed over for promotion”, as this event matches the content of the “must succeed at career” schema. Indirect activation of this schema may occur whenever the person is confronted with a much milder experience, such as “hearing of the accomplishments of another person”. In this case, the idea that others should be less successful than oneself is possibly an element of the “must succeed” schema that, if activated, serves to prime the entire schema (for further details see Clark, Beck & Alford, 1954) (see figure 1).

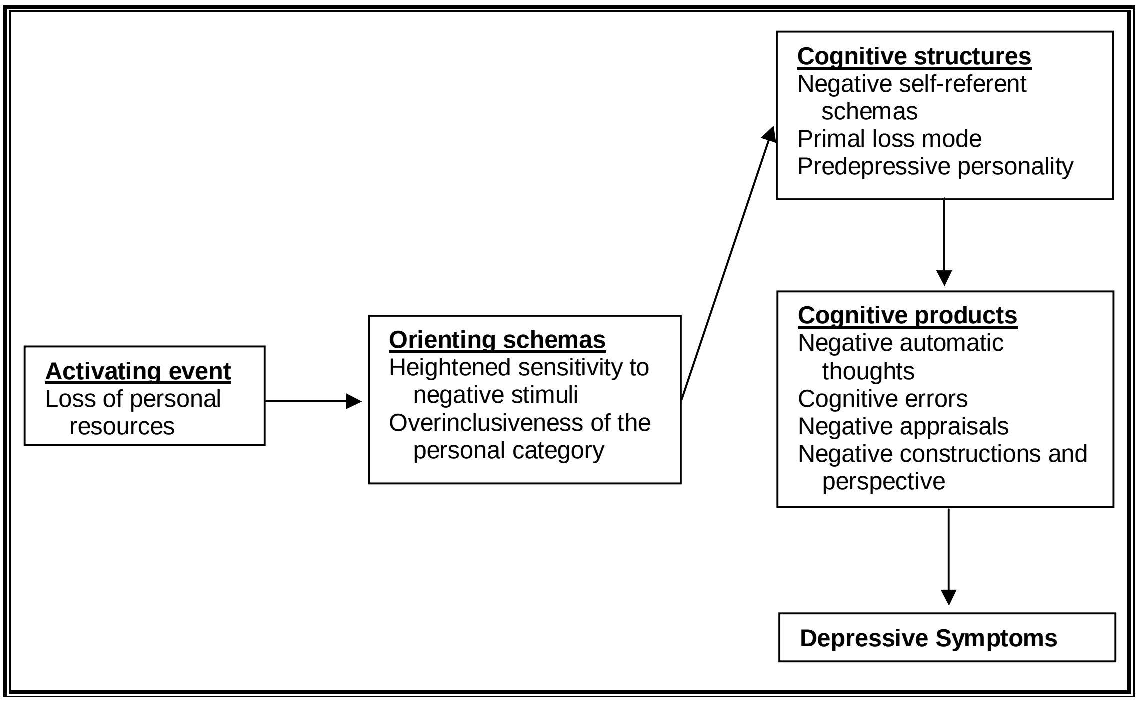


Figure 1. Cognitive model of depression.

(Adapted from Clark, Beck & Alford, 1954, p. 78)

Schemata differ in the degree of interrelatedness, in the degree of complexity, and the number of ideas (elements) that comprise it, as well as in the degree of flexibility or rigidity, permeability or impermeability, concreteness or abstraction, valence and breadth. In depression, the negatively oriented schemata that represent the self tend to be more rigid, absolute, and impermeable (Beck, 1967). Depressed individuals are furthermore expected to have negative self-referential beliefs that are more tightly interrelated and more complex than the negative self-constructs of nondepressed people. These schemata shape the conceptualizations of a particular experience and in turn are reinforced by these biased interpretations. Furthermore, the continuous activation of these schemata can account for the prolonged lassitude, sadness, and chronic inactivity. Characteristics can be attributed to the continuous operation of the negative cognitive schemata as reflected in the nihilistic attitudes and sense of futility. Negative attitudes such as “Nothing will work out” promote loss of initiative; “It’s not worth the effort” fosters fatigability; “I can’t be happy without somebody to share it with” accentuates anhedonia; and “My whole life is empty and meaningless” leads to apathy (Clark, Beck & Alford, 1954).

In the nondepressed state, meaningful activities usually evoke positive affects (enthusiasm, joy); the depressed patient, however, has already discounted the value of all activities. Hence, his affect is consistent with his cognitive appraisal: apathetic, discouraged. Although the cognitive schemata directly regulate behaviours by deactivating behavioural systems, these negative affects also play a role. When sadness, frustration, or apathy emerge when constructive action is contemplated or undertaken by the depressed person, these negative affects enhance the negative expectations (Clark, Beck & Alford, 1954).

Empirical support for negative information processing biases in depression has been reported in many investigations. Most focused on cognitive functions like attention and memory. They used the Stroop task (e.g., Gotlib & Cane, 1987; cf. Gotlib & Krasnoperova, 1998) showing that depressed subjects had greater color-naming interferences, self-referent encoding tasks (SRET; e.g., Kuiper & MacDonald, 1983; cf. Segal, 1988) indicating that depressed recall more negative, self-referential adjectives compared to never-depressed subjects who recall more positive words, and dichotic listening tasks (e.g., McCabe & Gotlib, 1993; cf. Gotlib & Krasnoperova, 1998) showing that depressed persons performed a disproportionate slowing on the reaction time when the distractor words were negative (for more details see Gotlib & Krasnoperova, 1998; Segal, 1988).

It is important to note that the reported studies investigated negative information processing biases only in currently depressed people. However, according to Beck et al. (1979), “The theory proposes that early experiences provide the basis for forming negative concepts about the self… These… may be latent but can be activated by specific circumstances which are analogous to experiences initially responsible for embedding the negative attitude” (p.16) (cf. Segal, 1988). Because of the persistence of the interconnection among the individual elements, the schema could be activated in the absence of depressed mood. Further, an individual’s negative self-schemata could persist beyond the depressive episode itself and into the period of recovery (Segal, 1988). Therefore, in the remitted state it is expected that schemata are “hypovalent” but remain potentially reactive in the face of triggering events or specific stressors (Segal, 1988) and represent a risk factor for a recurrent depressive episode.

To sum up, in depressed as well as in remitted depressed people the negative bias in information process is thought to play a central role in the onset maintenance of depression. This negative bias becomes latent in remission of depression but represents a risk factor or a vulnerability for a recurrence.

1.2.1. Background of cognitive theories of depression

The theory of cognitive theory of depression is based on a long-standing concept of cognitive psychology, namely the distinction between automatic and effortful processes. It might be important to bear in mind for better understanding and integrating the results revealed from psychological and neuroimaging investigations. The concept involves the notion that individuals have a limited capacity to process information (Ingram, 1984; cf. Hartlage, Alloy, Vázquez & Dykman, 1993). Automatic processes require few attentional resources, whereas effortful processes use attentional capacity.

The following criteria are defined for automatic processing: (1) The operation takes place without requiring attention or conscious awareness. (2) Automatic processes occur in parallel without interfering with other operations or stressing the capacity limitations of the cognitive system (many automatic processes can take place at one time). And (3) automatic processes occur without intention or control. Further, once activated, automatic processes run to completion and are difficult to suppress, modify, or ignore (Hasher & Zacks, 1979; cf. Hartlage, Alloy, Vázquez & Dykman, 1993). Note the important distinction between cognitive or automatic processes (i.e. the processes by which the information-processing system operates) and thoughts or cognitive products (i.e. the end results of the operations of the cognitive system) (Ingram & Wisnicki, 1991; cf. Hartlage, Alloy, Vázquez & Dykman, 1993) that are produced by automatic processes. The first two criteria of automatic processes are that they take place without conscious awareness and do not interfere with ongoing mental activity. However, in contrast to automatic processes, the thoughts themselves can reach conscious awareness and interfere with ongoing mental activity. The failure of this distinction has led to confusions in research of automaticity (Ingram & Wisnicki, 1991; cf. Hartlage, Alloy, Vázquez & Dykman, 1993). In contrast to automatic processes, the characteristics of effortful processes (also named as control processes, conscious strategies, or serial processes) include following criteria: (1) They require attention and thereby take place serially, inhibit other pathways, and are influenced by cognitive capacity limitations, (2) their efficiency improves with practice, and (3) effortful processes can be used to cause learning. Most important for present purposes, Hasher and Zacks (1979, 1984; cf. Hartlage, Alloy, Vázquez & Dykman, 1993) argued that effortful processes were reduced under conditions of stress, including depression, because stress was thought to decrease cognitive capacity required for effortful processing.

Hartlage, Alloy, Vázquez & Dykman (1993) reviewed that automatic and effortful processes in depression and reviewed that (a) depression interferes with effortful processing, and that this interference is determined by the degree of effortfulness of the task, the severity of depression, and the valence of the stimulus material to be processed; and (b) depression interferes only minimally with automatic processes.

1.2.2. Cognitive risk factors for depression

The attempt to measure dysfunctional cognitions directly in depressed people who are in remission has proven difficult. Much of the early work relied on self-report methodologies. For instance, scores on dysfunctional cognition questionnaires like the Dysfunctional Attitude Scale (DAS; Weissman, 1979) have not been found to distinguish between never depressed and previously depressed individuals (Blackburn, Roxborough, Muir, Glabus & Blackwood, 1990; Dykman, 1997; Eaves & Rush, 1984; Persons & Rao, 1985). Moreover, the elevated DAS scores typically observed during depression generally return to normal or near to normal levels when the depressive mood subsides, either following treatment (Bowers, 1990; Hamilton & Abramson, 1983; Imber et al., 1990; Simons, Garfield & Murphy, 1984; Thase et al., 1992) or simply after the passage of time (Dohr, Rush & Bernstein, 1989; Reda, Carpiniello, Secchiaroli & Blanco, 1985; Silverman, Silverman & Eardley, 1984; cf. Wenzlaff, Rude & West, 2002). The bulk of evidence indicates that dysfunctional attitudes fluctuate, increase with depression and decrease as the emotional disturbance vanish (Gotlib, Kurtzman & Blehar, 1997; Ingram et al., 1998; Segal & Dobson, 1992). Thus, investigations using self-report measurements have largely failed to support the role of cognitive biases as a vulnerability factor for depression. There are two main limitations associated with this methodology: First, questionnaires are not well appropriate to examine cognitive processes. Second, it is unlikely that questionnaires, which require subjects to make conscious, deliberate, and thoughtful responses, are able to assess the existence and functioning of schemata or associative networks, which are hypothesized to be activated automatically and to operate outside of individuals' awareness (for an extended discussion see Gotlib & McCabe, 1992; cf. Gotlib & Krasnoperova, 1998).

Cognitive theory has clear ideas about how dysfunctional schemata develop (Segal, William, Teasdale & Gemar, 1996) and postulates that depressive cognitions may not disappear (Beck, Rush, Shaw & Emery, 1979; Miranda & Persons, 1988; Teasdale, 1988), but it is less clear about how an existing dysfunctional schema becomes latent. In one line of investigations, a set of procedures is used that involves the experimental manipulation of mood. The idea behind is that sadness may reactivate the dysfunctional attitudes by triggering relevant associations (Miranda & Persons, 1988). Partial support for the mood-state hypothesis comes from correlational studies that find that formerly depressed individuals display more dysfunctional attitudes during naturally occurring negative mood shifts (Miranda & Persons, 1988; Miranda, Persons & Byers, 1990; Roberts & Kassel, 1996; cf. Wenzlaff, Rude & West, 2002). However, the correlational nature of these studies raises several alternative explanations. To provide a more precise test of the mood-state hypothesis, several studies have used mood induction procedures with formerly depressed and never-depressed individuals. With some exceptions (e.g., Dykman, 1997; cf. Wenzlaff, Rude & West, 2002), most of these studies have shown that never depressed individuals and recovered depressed patients typically experience similar changes in mood, but only the latter group show increases in dysfunctional cognition scores (e.g., Miranda, Gross, Petersons & Hahn, 1998; Miranda & Persons, 1988; Van der Does, 2002; for a review, see Ingram et al., 1998). Similar findings have been obtained from studies where cognitions were assessed during naturally occurring mood fluctuations (Miranda, Persons & Byers, 1990) as well as in experimentally induced negative mood (Hedlund & Rude, 1995; Taylor & Ingram, 1999). For example, Neubauer and Gotlib (1997; cf. Gotlib & Krasnoperova, 1998) found that currently and formerly depressed individuals exhibited greater attentional bias for negative than for positive words in negative priming task, a pattern not demonstrated by the never depressed controls. Ingram, Bernet and McLaughlin (1994) found that formerly depressed individuals exhibited a negative attentional bias on a dichotic listening task if they first participated in a negative mood induction procedure.

In addition, there are many investigations that failed to show a negative bias in recovered state without a sad mood induction. For example, with respect to attentional biases, Gotlib and Cane (1987; cf. Gotlib & Krasnoperova, 1998) examined depressed patients on the Stroop color-naming task twice, once while they were in episode and again when they had recovered symptomatically. They found depression-associated attentional interference to negative-content words only while the patients were depressed, not when in remission. Similar results were obtained in another longitudinal study using a dichotic listening task (McCabe & Gotlib, 1993; cf. Gotlib & Krasnoperova, 1998), as well as in cross-sectional comparisons of formerly depressed and nondepressed individuals using an emotional Stroop task (Gilboa & Gotlib, 1997; cf. Gotlib & Krasnoperova, 1998). Although mood-priming studies support the idea that remitted depressed individuals possess latent dysfunctional attitudes, the mood-state hypothesis is vague concerning how the attitudes become dormant. The prevailing explanation seems to be that when external circumstances improve negative cognitions ebb and eventually become dormant, thereby facilitating a return to a normal emotional state. Thus, it is unclear whether the findings stem from a match between word content and mood state or from a latent cognitive structure (Segal, 1988). Additionally, this explanation does not consider depressed individuals' own potential struggles to effect changes in their cognitive and emotional states. This omission is noteworthy because self-motivated attempts to regulate moods are common and play a crucial role in emotional life.

However, a different approach was proposed by Wenzlaff and Bates (1998) who argued that depression-related cognitions may not only become inactive, but are actively suppressed. In this view, remission of depression equals regaining mental control over negative cognitions. According to the ironic process theory of thought suppression (Wegner, 1994), mental control is more likely to fail when mental capacity is taxed. In other words, under conditions of mental load, the effortful process of suppressing depressive cognitions is hindered, and negative cognitions are more likely to become active and conscious.

1.3. Theory of ironic processes of thought suppression

Wegner and Smart (1997) assume the mind as a two-tiered system. Derived from different methods and investigations, they proposed (1) consciousness and (2) accessibility of a thought as the two tiers.

(1) Consciousness is the most obvious sort of activation. If a person can report having a thought, then it is evident that it is active in the person's mind. Only a limited amount of material can be conscious in this sense at any one time, of course, as the size of this window of attention is restricted during a particular instant. Consciousness can be assessed with methods like thought sampling, stream-of-consciousness or think aloud. (2) The second sort of activation is accessibility, i.e. the readiness to think of

something consciously. The accessibility is measured by observations of the unconscious or preconscious influences of the thought on related judgement or behaviour. These measures assume that an accessible thought is so quickly and easily brought to mind that it can influence a variety of mental processes before the conscious recognition of the thought's occurrence. The notion of accessibility is related to the concept of priming – the idea that exposure to one thought may make another more likely to occur (Segal, 1967; cf. Wegner & Smart, 1997). However, accessibility may occur for reasons other than prior exposure (e.g., habit) and so is the broader concept. In summary, a person's state of cognitive activation can be characterized completely by knowing both what is conscious and what is accessible (see figure 2).

	Conscious Presence	Unconscious Accessibility
Full Activation	✔	✔
Surface Activation	✔	
Deep Activation		✔
No Activation		

Figure 2. Modes of cognitive activation.
(Taken from Wegner & Smart, 1997, p. 985)

Resulting from the distinction of the two ways of cognitive activation, there are different modes of cognitive activation. One can speak of 'full activation' of a thought if it is both conscious and accessible. This state of complete absorption appears when one is deeply preoccupied with the topic that one is currently thinking about consciously. This state would seem to be most likely for pleasant topics, as these things might well be kept in consciousness for some time, not to be suppressed or avoided in some cases. Unpleasant thoughts, in contrast, might only achieve full activation when a person is forced by circumstances.

A 'surface activation' is existent when a thought is consciously present but not highly accessible. Such a state of mind could easily accrue when the person is actively pursuing mental control. For example, with the exertion of effort, one might concentrate consciously on something that is basically not very interesting. Or, one might suppress some other thought - as when one uses a particular conscious thought (e.g., the thought of a beach) as a distracter from something else that is more accessible (e.g., the thought of the dentist working on one's tooth). The thought that achieves such surface activation is often irrelevant to whatever is being suppressed or avoided, and may soon be pushed out of consciousness by the more insistently accessible suppressed thought.

One can speak of ‘deep activation’ when a thought is consciously not present but unconsciously accessible. These thoughts are intended to assess by projective tests. This state of deep activation requires some sort of temporary circumstance that keeps the thought out of consciousness at any time. It may often be that deep activation occurs for brief periods as a point of transition before full activation, when the accessible thought does come into conscious presence. Research has uncovered evidence of deep activation not only in response to mental control instructions, but also as a result of the natural desire people have to control their minds. Greenberg, Pyszczynski, Solomon and Breus (1994, Experiment 4) asked people to think about death, and then measured accessibility by examining the tendency to complete word fragments (e.g., COFF__) in death-related ways (i.e. COFFIN) or unrelated ways (i.e. COFFEE). It was found that accessibility was low immediately following the task, and then climbed to a higher level following a distraction task. The distraction task apparently undermined the efforts at suppression of the thought of death, and thus ironically enhanced subsequent accessibility. This appears to be a case of the natural production of deep activation. Further studies by Arndt, Greenberg, Solomon, Pyszczynski and Simon (1997) have substantiated this conclusion and indicate that deep activation is particularly likely to result from death thoughts when people experience a mental load when death is made salient. People who are released from such load, in contrast, do not show the ironic activation of the unwanted thought of death.

Another important feature of the theory is the source of activation. Wegner and Smart (1997) distinguish three sources of activation: perceptual input, chronic/ habitual activation and intentional activation.

Perceptual input, the first source of activation, is the most obvious sort of activation. Some stimuli enter the mind via the visual, auditory, olfactory, gustatory or kinaesthetic perceptual system and activate directly accessible thoughts.

During chronic or habitual activation, depending on a person’s motivation to allow chronically active thoughts into consciousness or to try to control them, chronically accessible thoughts may or may not appear in consciousness as well. For many thoughts that are chronically accessible, their occurrence in consciousness sets off no special alarm. A person may have certain interests or preferences, for example, that often move directly from unconscious accessibility to conscious thought, and these are therefore often fully activated. It would be especially difficult to live a life in which chronically accessible thoughts are not desired – but this is probably true for many individuals who suffer from certain psychopathologies (Wegner & Zanakos, 1994). Unwanted thoughts keep coming to mind, only to be ushered out of consciousness through intentional thought suppression.

The intentional activation, the third source of cognitive activation, follows from the operation of mental control (Wegner & Pennebaker, 1993; Wegner & Wenzlaff, 1996). Mental control occurs when people influence their conscious thoughts in accord with their conscious priorities for thinking. In the case of thought suppression, the person attempts intentionally to remove some item from conscious presence, and usually does so by trying to concentrate attention on distracters (e.g., Wegner, Schneider, Carter & White, 1987). In the case of concentration, in turn, the person attempts intentionally to retain some item in conscious presence, and may do so by rehearsing it or elaborating on it in consciousness, and by suppressing distracters (Wegner, 1997). These various activities require mental capacity, and so can only be achieved when the person has the mental resources to devote to the task. But with proper resources, mental control often does work quite effectively, at least in the sense that it can produce intervals in which the desired state of mind is achieved.

The odd feature of mental control is what it does to accessibility, even while it influences consciousness in the intended direction. Intentional mental control introduces an ironic monitoring process that increases the accessibility of the very thoughts that are least desired in consciousness (Wegner, 1994). The attempt not to think about a house, for example, ironically increases the accessibility of that very thought, in that it increases the likelihood that the word house will be given to prompt such as home in a speeded word association task, and decreases the speed with which the individual will be able to name the colour in which the word house is printed during a Stroop Interference Task (Wegner & Erber, 1992). These effects accrue primarily when the person is under mental load (such as during a parallel task, under stress, during distraction, or with time pressure), as such load interferes with the person's strategic mental control activities while leaving the more automatic ironic monitoring process unscathed. There is a wide array of such ironic effects of mental control (for further details, see Wegner, 1994), indicating that ironic activation is a likely pathway to accessibility whenever mental control is attempted during cognitive load.

Ironic activation can yield conscious presence, for example, a person tries not to think about a white bear and then finds it returning frequently to mind (Wegner et al., 1987). The recurrence of unwanted thoughts in consciousness is a clear indication that the accessibility prompted by ironic activation can yield full activation of a thought. If, however, a person remains motivated to influence consciousness through mental control, the continued exertion of mental control yields a state of deep cognitive activation. This is the consequence of the ironic monitoring processes that are marshalled in the pursuit of mental control. When a person tries to suppress a thought, distracters will be intentionally activated in consciousness, while, at the same time, the unwanted thought itself will be ironically activated below consciousness; this is the surface activation of the distracters, with deep activation of the unwanted thought. This ironic occurrence of deep activation may be why trying to diet, to control a drug habit, to overcome a phobia, to stop having morbid thoughts, to fall asleep, or to serve any of a variety of other mental control goals can be so vexing. Ironic activation always runs counter to what the person desires to have in consciousness, yielding the troublesome state of deep cognitive activation. Further, consequences of deep activation can be sorted into the categories of conscious intrusions, emotion intensification, direct and indirect effects on behaviour and judgement and the renewal of mental control (Wegner & Smart, 1997).

The ironic process theory of thought suppression (Wegner, 1994) suggests that because of the architecture of the system people achieve intentional control of their mind. Such mental control proceeds through the interaction of an intentional operation process and an ironic monitoring process. The operating process is conscious, effortful and capable of being inhibited, and so can be undermined by distracters or other forms of mental load. The ironic monitor, in turn, is unconscious, less effortful, and not open to inhibition as long as mental control is exerted, and so runs automatically in the background without being influenced by mental loads. Normally, the processes function together as a feedback unit to produce mental control (Wegner & Smart, 1997).

Consider a person trying not to be depressed. This individual might expend conscious effort in the form of an operating process that searches for nondepressed thoughts, and the search could succeed, thereby launching the person into happy or at least neutral thoughts and affect. Meanwhile, however, the monitoring process would search automatically for preconscious depressed thoughts by scanning memory and environmental cues. When monitor encounters such sad thoughts, it brings them into consciousness to restart the operating process, and the person begins again to think of things that are not so sad. Over time, the cyclic interplay of the processes moves, in fits and starts, to keep depressing thoughts out of mind. The monitoring process serves as a watchful eye for failure of mental control. With the imposition of mental load, however, the inefficient and effortful operating process is disabled, thus yielding ironically depressed intrusions due to the monitor (Wegner, Erber & Zanakos, 1993). Mental load imposed in the laboratory may include tasks such as rehearsing a number, listening to distracting music, or taking a stressful mental test. Mental loads that produce ironic effects in daily life might include not just stresses or distractions, but also alcohol or other drugs that influence attention, and any dispositional tendencies toward poor attention.

1.3.1. The Scrambled Sentences Task (SST)

The ironic process theory of thought suppression has been applied to explain the inconsistent findings regarding latent negative information processing biases in recovered depression (Wenzlaff & Wegner, 2000). The Scrambled Sentences Task (SST) has proven to be useful to test the hypothesis that depression-related cognitions may not become inactive, but are actively suppressed. In the SST, subjects have to process emotional ambiguous verbal material. The subjects are presented with a list of scrambled sentences and instructed to write down a grammatically correct sentence with five out of six words. Each scrambled sentence is emotional ambiguous, that is, each sentence can form either positive ("I am a born winner") or negative ("I am a born loser") statement. The task is taken under time pressure. A second condition is included where participants have to remember a six-digit-number while unscrambling sentences (cognitive load condition). The production of a negative sentence is thought to reflect a negative bias in the information processing. Hedlund and Rude (1995) compared currently, formerly and never depressed subjects using the SST. The mental load condition consisted of counting aloud to limit subjects' attentional processing capacity. The investigators found a significantly higher percentage of negative sentences in formerly depressed compared to never depressed people. Standard self-report measures of mood and depressive thinking revealed no differences between groups of remitted and never depressed, but they did reveal the expected large differences between the currently and remitted depressed groups and between the currently and never depressed. This was interpreted as evidence that the formerly depressed group was indeed free of residual depressive symptomatology as it is traditionally assessed. Furthermore, it was shown that depressive cognitive processing is not only a concomitant of depression but that it can be observed in depression-vulnerable individuals, even when they are not currently symptomatic for depression (Hedlund & Rude, 1995). The idea that thought suppression masks a cognitive vulnerability to depression that can be revealed when mental control is disabled has also been examined by Wenzlaff and Bates (1998). They compared depressed, never depressed and formerly depressed persons. Half of the participants were given a six-digit-number to remember while performing the task. Consistent with the ironic process theory, they found that previously depressed individuals in the cognitive load condition formed a higher percentage of negative statements (17%) than those in the no-load condition (5%). For the currently depressed and the never depressed groups, cognitive load did not affect the percentage of negative statements. Furthermore, in the at-risk group the percentage of negative statements was correlated with self-reported thought suppression frequency. Another study stem from Van der Does (2005) who also found an increase of negative sentences under cognitive load in formerly depressed compared to never depressed individuals. This effect correlated with a self-report measure of habitual thought suppression. It has been argued that under normal conditions, a monitoring system for negative thoughts works in the background of consciousness, serving to renew or intensify distraction effects. However, when mental control is taxed and begins to falter, the vigilance system intrudes on awareness and makes unwanted thoughts more accessible than they would have been if mental control had never been attempted (Wenzlaff & Bates, 1998).

Ironic process theory would explain the inconsistent results of the studies using paradigms like mood-priming, mood induction and direct assessment of dysfunctional attitudes like the DAS by the process of thought suppression. That is, vulnerable individuals are trying to suppress the very thoughts investigators are attempting to detect. An important difference between the SST and the other paradigms is the methodology. While the SST is an implicit test where participants are not explicitly instructed to refer the emotional ambiguous sentences to themselves, other paradigms used self-report measurements where vulnerable subjects are confronted with the very cognitions they are trying to avoid. Bargh and Tota (1988) suggested the use of tests whose variables reflect a greater degree of automaticity in the processing of personal information. This is fulfilled by the SST. The test might also be considered as ecologically valid because the stimuli consist of emotional ambiguous sentences that include potentially meaningful content (Hedlund & Rude, 1995). Hedlund and Rude (1995) stated that this paradigm is useful in tapping processes that are thought to be relatively automatic and involves interpretation and reflection. The type of measures seems to be crucial seeing that even when the volitionally controlled thinking and explicit self-knowledge is “normal”, recovered depressives continue to exhibit subtle, automatic biases that can only be detected using processing measures like the SST. This might occur if individuals attempted mood repair by altering their conscious, controlled thinking and if these new thinking patterns had not become fully automatized. Over time and with the occurrence of negative life events, such biases might come to dominate thinking and thereby influence relapse (Hedlund & Rude, 1995). It might also be that the self-focusing manipulation is essential to observe formerly and never depressed group differences. Such a possibility is consistent with work of Nolen-Hoeksema (e.g., Morrow & Nolen-Hoeksema, 1990), who has found ruminative self-focused attention to be a factor in the persistence and enhancement of depressed mood, as well as with the results of several investigations of processing in formerly depressed individuals (Ingram, Bernet & McLaughlin, 1994; Neubauer & Gotlib, 1997).

In summary, cognitive theory of depression sees latent negative cognitive biases in remission of depression as vulnerability factor for relapse. However, experimental studies often failed to show negative biases in the information processing of formerly depressed. The ironic process theory of thought suppression – in line with the concepts of effortful and automatic processes - reasons that negative (and automatically occurring) cognitions are present but actively and effortfully suppressed, thus latent. Several investigations that used the SST found that formerly depressed unscrambled more negative sentences when under mental load that stresses the cognitive capacity. The results of SST are interpreted in that way that the process of suppressing a negative thought is an effortful one that can be disturbed under stress, such as time limitation or depressive mood. Therefore, the suppression of negative thoughts represent a vulnerability factor for depression. With respect to Minor Depression as a milder form of depression, the question arises whether remitted minor depressed individuals also show a negative bias in their information processing. As far as it is known, this is the first study to address this issue. A second focus is what brain regions are involved when emotional ambiguous sentences like in the SST were unscrambled by formerly minor depressed and never depressed subjects. Knowledge of the neurobiological bases of negative cognitive biases in depression could shed some light on the information processing touched by the SST. In addition, it could yield valuable information about neurocognitive markers in subclinical depression and potentially enhance the ability to identify individuals who are at particular risk for developing a full-blown depressive episode.

1.4. Neuroimaging evidence

In the SST, the subjects are instructed to unscramble as many sentences as possible in a given time. The stimuli are emotional ambiguous verbal material, i.e. the valence of sentences that are possible to build are either positive or negative. The production of a negative sentence is thought to reflect a negative bias in the information processing. Furthermore, when under mental load, there are some individuals who show an increase in negative sentences. It is assumed that their cognitive capacity is taxed by the additional cognitive load, and as a consequence more negative sentences are built. The neural correlates of processing emotional ambiguous sentences and especially of scambling negative sentences will be investigated to shed more light on to the concept of thought suppression that has been postulated to be the reason by the ironic process theory.

1.4.1. Thought suppression

A lot of neuroimaging studies investigated the processing of emotional and cognitive information. As far as it is known, only three investigated the neural correlates of the suppression of a particular thought. One study from Mitchell et al. (2007) investigated the neural correlates of thought suppression, using the White bear paradigm (Wegner, 1992, 1994). They found an activated right dorsolateral prefrontal cortex (DLPFC) when contrasting the condition “suppress the thought of a white bear” with ”think freely”, indicating that the DLPFC represents the function of cognitive control. Another study using a paradigm where subjects had to suppress a particular thought derived from Wyland et al. (2003). The investigators alternated between three conditions: in the suppress task, subjects were directed to suppress a particular, personally relevant, thought they had generated prior to the scanning; in the clear task, subjects were directed to clear their minds of all thoughts and to think of nothing at all; the free-thought task served as control task in which subjects were permitted to think about anything at all. They found increased activation in anterior cingulate cortex (ACC) [Brodmann’s area (BA) 32] when comparing the suppress condition with the free-thought condition. Looking at the clear over free-thought condition, increases were found in right insula (BA 44), left inferior frontal/insula (BA 45/46), ACC (BA 32/24) and right parietal gyrus (BA 40). A third study using a thought suppression paradigm was Andersen et al.’s (2004). They adapted the think/no-think paradigm to investigate the neural correlates of the suppression of unwanted memories. Subjects learnt word pairs (e.g., Ordeal Roach) and then performed a think/no-think task while being scanned. On each trial, subjects were presented with one member of a pair (e.g., Ordeal) and asked either to recall and think about the associated response (e.g., Roach) (Respond condition), or to prevent the associated word from entering consciousness at all (Suppression condition). When contrasting the suppression and the respond trial, a network of brain regions was more active during suppression than during retrieval, including bilateral DLPFC and ventrolateral prefrontal cortex (VLPFC) (BA 45/46, stronger on left), ACC (BA 32), the contiguous pre-supplementary motor area (preSMA, BA 6), a lateral premotor area in the rostral portion of the dorsal premotor cortex (BA 6/9), the parietal cortex (BA 7), also in BA 47/BA 13 bilateral, and right putamen. The authors reasoned that the large number of prefrontal regions more active for stopping rather than achieving memory retrieval supported the view that suppression might be an active process that recruits brain regions known to be important for executive control functions, such as inhibition (Andersen et al., 2004).

In total, there are only few investigations exploring the neural correlates of thought suppression. Because of different thought suppression paradigms, there is a variety of activated regions found to be active. Conjoint regions in previous studies were the DLPFC, the VLPFC, the ACC and the insula.

1.4.2. Executive control

It is assumed that the process of thought suppression requires a controlling and monitoring of incoming stimuli and thoughts (e.g., Andersen et al., 2004). These functions are often associated with executive control which in turn is often referred to the ACC by many neuroimaging studies. The ACC is often subdivided into a cognitive [dorsal ACC (dACC)] and an affective [ventral ACC (vACC)] part (see figure 3). Bush, Luu and Posner (2000) reviewed that the cognitive subdivision of ACC (dACC) is part of a distributed attentional network. It maintains strong reciprocal interconnections with lateral PFC (BA 46/9), parietal cortex (BA 7), and premotor and SMA. Various functions have been ascribed to the dACC, including modulation of attention or executive functions by influencing sensory or response selection (or both), monitoring competition, complex motor control, motivation, novelty, error detection, working memory (WM), and anticipation of cognitively demanding tasks. The affective subdivision (vACC), by contrast, is connected to the amygdala, periaqueductal gray, nucleus accumbens, hypothalamus, anterior insula, hippocampus and orbitofrontal cortex (OFC), and to autonomic, visceromotor and endocrine systems. The ventrolateral ACC is primarily involved in assessing the salience of emotional and motivational information and the regulation of emotional responses.

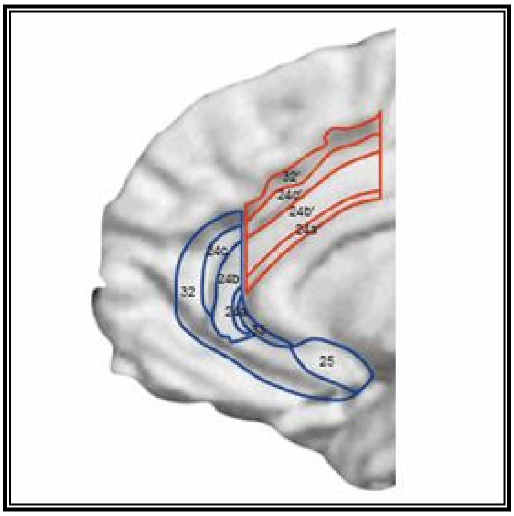


Figure 3. Functional subdivisions of the ACC.

The ACC is often subdivided into a cognitive (red) and an affective (blue) part. Taken from Bush, Luu and Posner (2000).

A second region which has often been found to be involved in control processes is the DLPFC. Similar to Wegner and Wenzlaff's (1996) theory, theories of the regulation of cognition suggest a system with two necessary components: one to implement control and a second to monitor performance and signal when adjustments in control are needed. MacDonald III, Cohen, Stenger and Carter (2000) could extract two distinct neural regions for these two entities. The left DLPFC (BA 9) was more active when top-down support for task-relevant processes was required. In contrast, greater right ACC (BA 24 and 32) activation was engaged by attentionally demanding stimuli (e.g., incongruent trials in the Stroop paradigm), indicating an involvement in evaluative processes when control needs to be more strongly engaged.

In summary, there are many studies focusing on executive control and monitoring performance processes. These functions are often ascribed to the DLPFC, the vACC and the dACC.

1.4.3. Current and remitted depression

In depression, aberrant activations in DLPFC and ACC –the same regions responsible for control processes-, as well as functional abnormalities in dorsal and lateral parts of the PFC at rest, have been reported by several neuroimaging studies (for a review, see Mayberg, 1997; Liotti & Mayberg, 2001). For example, Harvey et al. (2005) investigated depressed patients performing at levels comparable to healthy subjects, using the *n*-back task that strongly recruits control processes. Compared to control subjects, depressed patients exhibited hyperactivity in dACC (BA 32), in left inferior frontal gyrus (BA 44/6) and the left middle frontal gyrus (BA 46). Within the working memory network, these three regions have been linked to complementary cognitive functions, such as a subvocal rehearsal system mediated by the left inferior PFC (BA 44/45), an executive component mediated by the DLPFC (BA 9/46) and error monitoring and/or attentional processing system supported by the ACC (BA 24/32). In addition, statistical significance was specific to the 3-back condition, task difficulty, in both the left inferior frontal gyrus (BA 44) and the ACC (BA 32). The investigators suggested a potential explanation that depressed patients might need greater cognitive control in order to process information as efficiently as non-depressed subjects. In line with this notion, Ridderinkhof, van den Wildenberg, Segalowitz & Carter (2004) proposed two different types of trial-to-trial performance adjustments that could be supported by the dACC: (1) shifts in the trade-off between the speed and accuracy of responding that place the cognitive system in a more cautious mode, and (2) increases in control that improve the efficiency of information processing. The authors proposed that changes in control and efficiency of information processing, induced by effortful trials, could be associated with the capacity to reduce interference from distracting information (Ridderinkhof, van den Wildenberg, Segalowitz & Carter, 2004). Therefore, hyperfrontality in depression could represent changes in cognitive control in response to greater interference. Consistent with the strong connections between ACC and DLPFC, the dACC activation might signal the need for controlled processing, which the DLPFC would be critical in initiating (Davidson, Pizzagalli, Nitschke & Putnam, 2002).

In remitted depression, limbic (subgenual cingulate, anterior insula) metabolic decreases and neocortical (right DLPFC, inferior parietal) increases were seen (Mayberg et al., 1999) during a resting state where patients were instructed to relax, but avoid rumination on any one topic. The authors stated that this approach aimed to examine regional effects associated with a sustained shift in overall mood state accompanying remission of illness without any overt acute manipulation of either cognitive or affective state. The reverse pattern was found in disease-associated shifts in negative mood state (Mayberg et al., 1999). Liotti, Mayberg, McGinnis, Brannan and Jerabek (2002) compared in a positron emission tomography (PET) study remitted, but medicated, depressed with acutely depressed and healthy subjects in negative mood state. They found a unique deactivation in pregenual anterior cingulate (BA 24a) in remission of depression. The resting metabolism of BA 24a was found to predict response to fluoxetine treatment: it was higher than normal in responders and lower than normal in nonresponders. Therefore, mood provocation in their remitted group appeared to unmask a functional marker associated with severe refractory depression (Mayberg et al., 1997; Brannan et al., 2000). Against their hypotheses, they did not find any significant changes in subgenual anterior cingulate (BA 25). Further analyses showed that resting CBF in BA 25 in the remitted group was significantly lower than that in the healthy comparison group, suggesting that BA 25 becomes deactivated at rest and remains suppressed after mood provocation. They proposed that full recovery in unipolar depression is accompanied by a functional reorganisation of limbic-cortical pathways, resulting in sustained suppression of BA 25 and an absence of transient recruitment of the same region during negative mood shifts. The authors also proposed that BA 24a and occipitofrontal 10/11 represent sites of vulnerability in patients with unipolar depression. This conclusion is consistent with the identified role of pregenual 24a as a predictor of treatment response in acutely depressed patients (Mayberg et al., 1997; Brannan et al., 2000). They argued that the regional changes observed in the remitted group may be due to residual, subsyndromal depression symptoms rather than to the purported disease marker. “It is not known whether the observed changes represent a marker of disease vulnerability or if there is a reorganization in brain function because of disease.” (p. 1838; Liotti, Mayberg, McGinnis, Brannan & Jerabek, 2002).

To sum up, regions that are often reported as disturbed in depression are the ACC and the DLPFC –well in line with the behavioural results that the executive control functions in depressed are disturbed. However, the functional meaning of these abnormal activations is still unknown.

1.4.3.1 Cognitive negative bias in current and remitted depression

Studies investigating the neural correlates of negative cognitive information biases in recovered depression are rare. Ramel et al. (2007) scanned remitted and never depressed individuals while performing a SRET before and after a sad mood challenge. After each SRET, participants' free recall was assessed. Following sad mood induction, bilateral amygdala response during encoding of valenced words predicted recall of negative self-referential words in the remitted depressed group. This suggests that the amygdala modulates mood-congruent and self-referential memory biases during transient mood in individuals who are vulnerable to depression relapse. There was preliminary evidence that amygdala may be part of a neural mechanism modulating mood-memory associations in individuals with a history of recurrent major depressive episodes. A limitation of the study was the focus on one single brain structure. "It is also important to extend the analysis of the neural basis of emotional memory to other areas of the brain associated with memory, emotion, and self-referential processing, such as the hippocampus, anterior cingulate, and medial prefrontal cortex" (p. 238; Ramel et al., 2007). This notion is considered by a study of Siegle, Thompson, Carter, Steinhauer and Thase (2007) who investigated the whole brain when processing emotional and cognitive information, not in remitted but in current depression. Currently and never depressed subjects completed tasks requiring executive control (digit sorting) and emotional information processing (personal relevance rating of words; PRRT) while scanned. Depressed compared to control subjects displayed sustained amygdala reactivity on the emotional tasks and decreased DLPFC activity on the digit-sorting task. An increased ACC (BA 24) activation was obtained in response to negative words in depressed individuals. This area accounted for the majority of variance in the observed relationships between sustained amygdala and DLPFC activity. Siegle et al. (2007) suggested that abnormal BA 24 activity reflects a greater need for emotion regulation in depression, consistent with the low level of amygdala reactivity in the control subjects during the PRRT. Indices of functional connectivity between BA 24 and both the amygdala and DLPFC were reduced in depression, potentially reflecting inefficient communication between these structures. In other words, apparent deficits in emotion regulation could stem from impaired functional relationships between the DLPFC and structures more proximally responsible for regulating the amygdala. In this sense, decreased DLPFC activity during digit sorting and decreased PRRT BA 24-DLPFC functional connectivity may reflect multiple convergent mechanisms for disrupted emotion regulation. Siegle et al. (2007) stated that the results would suggest that disruptions in cognitive and emotional information processing are integral to the experience of depression. In particular, depression is characterized by decreased engagement in slowly presented executive control tasks and sustained processing of emotional information.

An interesting investigation of Wolfensberger et al. (2008) examined emotion processing, memory performance, and brain activation longitudinally during an encoding and recognition paradigm using emotionally salient words in a cohort of monozygotic twins. These twins were selected to be at low or high risk for anxiety and depression based on their ratings on neuroticism, anxiety and depression in longitudinal surveys. They found increased left inferior frontal gyrus activation by negative words in high-risk subjects, most prominently during recognition. However, no group differences were found on a behavioural level that did not support the existence of a negative response bias in subjects at high risk. The authors suggested that the activation in left inferior frontal gyrus in a verbal emotional memory task may be a useful vulnerability marker for anxiety and depression.

To put it briefly, the studies exploring the neural correlates of negative cognitive information processing bias in depression are scarce, and even scarce in remitted depression. The existing results suggest an involvement of amygdala, DLPFC, ACC in depression and increased left inferior frontal gyrus activation in high-risk groups for depression.

In summary, this is the first study exploring the neural correlates when performing the SST. It is not known what brain regions are associated to processing emotional ambiguous verbal material and especially to the unscrambling of negative sentences, which is thought to reflect a cognitive negative bias. The neuroimaging evidence that used paradigms where emotional ambiguous material had to be processed or thought suppression was required suggest a requirement of executive control and monitoring performance during these tasks. These same functions have also been found to be disturbed in depression – on a behavioural as well as on a neuronal level. The empirical evidence in remission of depression is also unclear. It has been suggested that those subjects at high risk would need additional engagement in order to perform at normal levels, that is the reduction of interfering distracting information and the regulation of emotion. However, it is still unknown whether the remission of depression involves a cognitive reorganization or a suppression of activation. Interestingly, there are investigations that suggest the inferior frontal gyrus and the ACC as specific regions for a vulnerability marker of depression.

1.5. Hypotheses

One aim of the present study is the investigation of cognitive negative bias in the information processing of individuals who are vulnerable for depression. The negative bias in depressive disorder is postulated by Beck (1967). This negative bias is represented by negative schemata which are responsible for the onset and recurrence of depressive episode - depending on the activated states of these negative schemata. This cognitive vulnerability is latent when not currently depressed. The model of thought suppression (Wegner et al., 1987; Wegner, 1994, 1997; Wenzlaff & Wegner, 1996) explains this latency by a mental control mechanism, namely thought suppression. In the SST - an implicit task to measure the negative bias - a cognitive load condition provokes a break-down of this mental control mechanism and as a consequence, the negative thoughts become manifest.

Less is known about remitted Minor Depression. In terms of a dimensional view of mood disorders, a recovered Minor Depressive episode also represents a vulnerability for developing depression. Therefore, the first question regards whether there is a latent negative cognitive bias in the group vulnerable to depression or not. It is presumed that even groups at mild risk for relapse show a negative biased information processing since Minor Depressive episodes are similar to Major Depressive episodes, only less pronounced. Consistent with cognitive theory and ironic process theory, it is assumed that people who suffered such a Minor Depressive episode may also have activated negative schemata responsible for the automatic production of negative thoughts and that these thoughts have to be suppressed in an effortful way. Stress would distort the process of thought suppression as will be measured with the SST. Therefore, it is hypothesized that remitted Minor Depressed people unscramble more negative sentences in the load condition relative to the no load condition than their healthy counterparts.

The second question is whether the increase in percentage of negative sentences in the load condition is associated with habitual thought suppression as found by Wenzlaff and Bates (1998). It is hypothesized that the increase in negative sentences under mental load is associated with habitual thought suppression, measured by a questionnaire.

To contribute to the question of mood dependence, the current depression score will be investigated, too. The current depression score is thought to reflect a current mood state. It is expected that the higher the depression score, the more negative sentences will be unscrambled, independently of the presence of a cognitive load. This serves as a manipulation check.

On a neuroimaging level, the brain activity when processing emotional ambiguous material will be explored. Looking at the existing brain imaging studies, the neural correlates of processing emotional ambiguous material and processes like thought suppression in the face of vulnerability for depression are not well understood. As far as it is known, this is the first study investigating the neural correlates when processing emotional ambiguous verbal material with the SST. Therefore, the present study explores the neurobiological correlates during unscrambling emotional ambiguous sentences. The SST is a task which is thought to require various cognitive and emotional processes simultaneously, like controlling, monitoring and suppression of stimuli, thoughts, emotions as well as a conflict of all of them. Studies often reported an activation of the VLPFC, the MPFC, and the insula during emotional processes (Phan, Wager, Taylor & Liberzon, 2002). For executive control tasks, the ACC and the DLPFC are often found to be involved (e.g., Bush, Luu & Posner, 2000; MacDonald III, Cohen, Stenger & Carter, 2000).

A third aim of the present study regards the neural correlates when building negative sentences. There are two scores of interest. One is the unscrambling of negative sentences which is thought to reflect a cognitive negative bias. This score is assessed during the scanning procedure. The individual increase (or decrease) of negative sentences when under mental load – compared to no load – is the second score that will be investigated. The increase of negative sentences when cognitive capacity is taxed by the additional cognitive load is thought to reflect the failure of a mental control process. This score is measured before scanning. There might be conjoint processes of both scores but also different ones. A common aspect might be the cognitive processes like the attemption of cognitive control and monitoring of errors and conflicts. Therefore, it is expected that the dACC which has often been reported as connected to these functions (Ridderinkhof, van den Wildenberg, Segalowitz & Carter, 2004; Harvey et al., 2005) will be associated to both conditions. The unscrambling of negative sentences which is thought to reflect a negative bias is expected to be linked to brain areas involved in more affective processing, like the MPFC, the VLPFC, the PFC, and the insula (Phan, Wager, Taylor & Liberzon, 2002). In contrast, the increase of negative sentences when under a mental load is expected to be associated with the DLPFC, the insula, the inferior frontal, the ACC and the parietal cortex. These areas has been shown to be involved when trying to suppress thoughts (Mitchell et al., 2007; Wyland et al., 2003).

Another aim of the present study is the investigation of the neural correlates of individual differences, regarding the current depressive state, the habitual suppression score, and an existent remitted Minor Depressive episode. Regarding the actual depression score, it is expected that those regions associated with control and monitor processes (DLPFC and dACC) are abnormally activated; in line with the empirical evidence that in depression these same functions are disturbed. Because the White Bear paradigm has been found to be correlated with habitual thought suppression (Wegner et al., 1987), it is expected that WBSI is associated to the DLPFC, like Mitchell et al's investigation (2007) during the process of thought suppression have shown. The remitted state of a Minor Depressive episode is expected to correlate with hyperactivation in subgenual cingulate, insular regions, the DLPFC as well as the inferior frontal gyrus (Siegle et al., 2007; Wolfensberger et al., 2008) since the processing of emotional ambiguous material might require more affective and cognitive control in vulnerable subjects.

In summary, this study addresses several questions on a behavioural and a neuroimaging level, trying to integrate results from brain activation during the processing of emotional ambiguous material with results from SST, a task proved to be useful in order to assess a negative cognitive bias in remitted depression. On the behavioural side, following hypotheses are of particular interests:

1. Remitted Minor Depressed people unscramble more negative sentences under a cognitive load compared to healthy, never depressed subjects.
2. The increase of negative sentences under mental load is associated to habitual thought suppression.
3. The more currently depressed an individual, the more negative sentences will be unscrambled - independent of a mental load. This serves as a manipulation check.

On the neuroimaging level, following contrasts will be investigated:

4. Processing emotional ambiguous material - compared to neutral material - is expected to activate brain regions known to be involved in cognitive and emotional processes, like the VLPFC, the MPFC, the ACC, the insula and the DLPFC.
5. The unscrambling of negative sentences is expected to be associated with the MPFC, VLPFC, and the insula. The increase of negative sentences under a cognitive load, i.e. the failure of mental control, is expected to be associated to activation in DLPFC, insula, inferior frontal gyrus, ACC and the parietal cortex. Furthermore, it is hypothesized that there might be conjoint activated brain areas like the dACC.
6. The association between several individual differences (i.e. the habitual thought suppression, the remission of minor depression, the current

depressive state) and processing of emotional ambiguous material will also be investigated. It is expected that habitual thought suppression is correlated with activation of the DLPFC which has also been found to be activated during thought suppression paradigms. For the vulnerable group, an association to subgenual cingulate, insular regions, the DLPFC as well as the inferior frontal gyrus/VLPFC is hypothesized, reflecting an activation of a network to process emotional and cognitive information. The current depressive state is expected to be linked to a hypoactivation of the DLPFC and the dACC, those regions responsible for controlled and efficient information processing since these have often been reported as being impaired in depression.

2. Materials and methods

2.1. Participants

49 volunteer participants responded to a public notice. Nine data sets have been dropped out because two subjects discontinued the experiment during the functional magnetic resonance imaging (fMRI) scanning, while five subjects were under antidepressant medication. The other 20 (10 male, 10 female) participants showed a remitted Minor Depressive episode in their lifetime and served as the at risk or vulnerable group. 20 (12 male, 8 female) subjects did not report any past subclinical depressive episodes (see table 1). Exclusion criteria were psychotropic medication, age under 18 and the usual MRI counterindications. All subjects had normal or corrected-to-normal vision, were right-handed and German native speakers. Approval was obtained from the ethics committee at the University of Ulm. Subjects received in exchange to their participation two cinema vouchers and a CD with the structural images of their brain.

The groups were checked for reasonable balance. No significant differences regarding age were found for both groups or sexes (see table 2). Importantly, both groups did not differ in ADS scores (see table 3). Regarding WBSI scores, significant main effects of groups and gender occurred as well as a significant groups x gender interaction (see table 4, 4.1. and figure 4). The significant interaction indicates that healthy female subjects have significantly lower WBSI scores than their male counterparts. Further, males and females at mild risk as well as males at no risk did not differ in their self-report of habitual thought suppression.

Figures 5 demonstrated the variances of both individual differences resulting from the SST before and during scanning. The first score is the increase of negative sentences under a cognitive load which is thought to reflect the failure of mental control in vulnerable persons. This is operationalized by the difference percentage score of the SST before scanning (in the following labelled as SSTscore). The second score is the amount of scrambled negative sentences in the modified SST (mSST) during scanning. These conditions are performed without a mental load. This is operationalized by the percentage score of negative sentences in the modified SST (modified SSTscore; mSSTscore).

Table 1. Descriptive data

	Males	Females	Total
At risk	10	10	20
Control	12	8	20
Total	22	18	40

Note. At risk: Subjects who have a remitted Minor Depressive episode but are free of symptoms. Control: subjects with no depressive episode in lifetime.

Table 2. Differences in groups and sexes regarding age

		N	M	SD	df	F	p[a]
Age	At risk	20	24.60	4.86			
	Control	20	25.35	6.31	39	.177	.676
Age	Males	22	25.41	5.97			
	Females	18	24.44	5.16	39	.291	.593
	Total	40	24.98	5.57			

Note. At risk: Subjects who have a remitted Minor Depressive episode but are free of symptoms. Control: subjects with no depressive episode in lifetime. *p< .05, **p< .01. [a]Note that the reported p-values are two-tailed.

Table 3. Differences in groups and sexes regarding ADS scores

		N	M	SD	df	F	p[a]
ADS	At risk	20	16.55	4.86			
	Control	20	13.65	9.33	39	1.04	.315
ADS	Males	22	15.41	9.25			
	Females	18	14.72	8.94	39	.056	.814
	Total	40	15.10	9.00			

Note. At risk: Subjects who have a remitted Minor Depressive episode but are free of symptoms. Control: subjects with no depressive episode in lifetime. *p< .05, **p< .01. [a]Note that the reported p-values are two-tailed.

Table 4. Descriptive data regarding WBSI scores

Sex	Group	N	M	SD
Male	At risk	10	47.60	9.96
	Control	12	46.58	8.96
	Total	22	47.05	9.21
Female	At risk	10	46.90	5.61
	Control	8	34.75	8.83
	Total	18	41.50	9.34
Both	At risk	20	47.25	7.87
	Control	20	41.85	10.51
	Total	40	44.55	9.57

Note. At risk: Subjects who have a remitted Minor Depressive episode but are free of symptoms. Control: subjects with no depressive episode in lifetime.

Table 5. ANOVA for WBSI scores

Sources of variance	df	F	p^a
Sex	1	5.32	.027*
At-risk factor	1	5.87	.021*
Sex x At-risk factor	1	4.20	.048*

Note. At-risk factor: At risk group, i.e. subjects who have a remitted Minor Depressive episode, and control group, i.e. subjects who never had a depressive episode before. *p< .05, **p< .01. [a]Note that the p-values reported here are two-tailed.

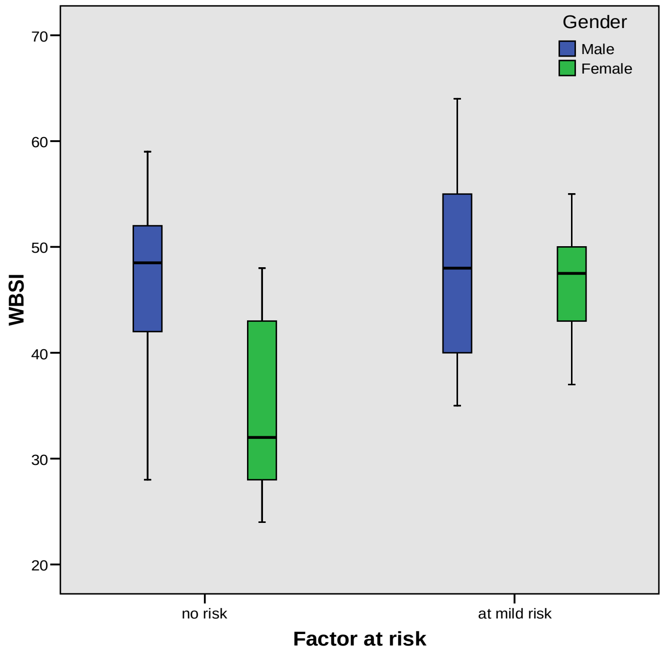


Figure 4. WBSI: Significant interaction between gender and at-risk factor.

This figure demonstrates a significant interaction between gender and at-risk factor regarding WBSI scores. In present population, female control subjects (green on left hand side) - compared to their healthy male counterparts - self-reported significantly less habitual suppression of negative thoughts measured with the WBSI questionnaire. On the other hand, males (blue) at mild risk and no risk for developing depression did not differ in their habitual thought suppression scores.

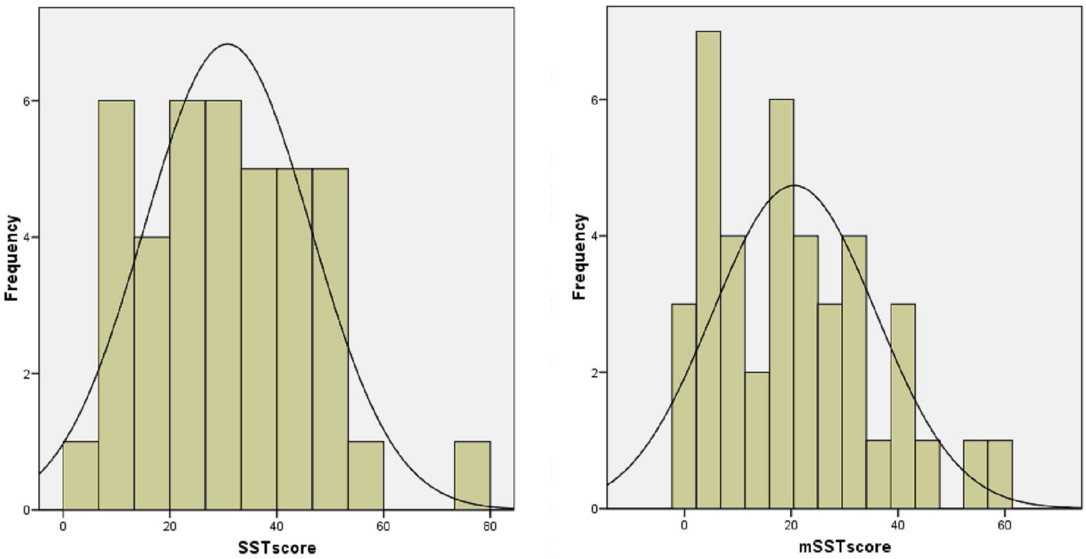


Figure 5. Distribution of SSTscore and mSSTscore.

These histograms show the distribution of SSTscore (left graph) and of mSSTscore (right graph) over all subjects. Note that the scores are percentage scores. SSTscore: the difference percentage score between the negative sentences with cognitive load and without cognitive load before the fMRI session, i.e. the increase under load. mSSTscore: the percentage score of negative sentences when unscrambling emotional ambiguous sentences during the fMRI session.

2.2. Procedure

Individual sessions took place at the MRI laboratory of the Department of Psychiatry at the University of Ulm. At first, all subjects were informed about the study procedure and potential side effects of the MRI scanning. Informed written consent was obtained from all subjects before the study began. In addition, they filled out questionnaires regarding handedness (Oldfield, 1971), demographic variables and the presence of a past Minor or Major Depressive episode (DSQ; Wittchen & Perkonigg, 1997). Before the fMRI scan, they performed the SST (Wenzlaff, 1993) on a computer. After the fMRI session, subjects filled out the ADS and WBSI on a computer.

2.3. Instruments

2.3.1. Self-report questionnaires

The *Depression Screening Questionnaire* (DSQ; Wittchen & Perkonigg, 1997) is suitable for a rough screening of depressive disorders such as Major Depression. It contains 15 items; 12 questions apply to depression specific symptoms and three questions pertain to the onset of the actual phase, to previous phases and to the first onset in life. The items are based on criteria and formulations of the DSM-IV (American Psychiatry Association, 1994) and ICD-10 (World Health Organization, 2000) Major Depression. The items are rated on a three-point-Likert scale (0= no, 1= some days, 2= present on most days). They are referred to the period of the last two weeks. Developed on the basis of the WHO-Composite International Diagnostic interviews as part of the CIDI methodological work, questions reflect the content of the nine DSM-IV (American Psychiatry Association, 1994) and 10 ICD-10 (World Health Organization,

2000) depression criteria. Consistent with DSM-IV conventions, a diagnosis of Major Depressive syndrome is assigned whenever at least five of the respective items (at least two applying to a depression specific symptom) are coded ‘most days’ by the respondent (total score of at least 10). A Minor Depression is present when two to four items (at least one applying to a depression specific symptom) are rated ‘most days’. The internal consistency of the DSQ is 0.83 (Cronbachs alpha; Höfler & Wittchen, 2000), the test-retest reliability (Kappa) varied between .68 to .92 on both the symptom level and the diagnostic level (Wittchen & Perkonigg, 1997). The validity by comparison with a DIA-X (German CIDI version) diagnosis of Major Depression was .76 (Wittchen & Perkonigg, 1997). Procedural validity of the DSQ diagnostic scores as compared to the CIDI DSM-IV and ICD-10 diagnosis of depressive episodes is kappa 0.89 (DSM-IV) and 0.84 (ICD-10), respectively (Wittchen, Höfler & Meister, 2001). A German version is published by Wittchen and Perkonigg (1997). For this study, the original DSQ was slightly modified. The three questions regarding the course of the depressive episode were left out and the remaining questions were altered to refer to lifetime (see Appendix). However, the DSQ helped to reveal participant’s former, at least two weeks lasting depressive episodes.

The *Allgemeine Depressionsskala* (ADS; Hautzinger & Bailer, 1993) is the German version of the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977). The 20-item self-report questionnaire assesses the existence of and the duration of disturbances caused by depressed mood, feelings of guilt and worthlessness, feelings of helplessness, hopelessness, psychomotor retardation, loss of appetite, and sleep disturbance during the last seven days. Each item was rated on a scale indicating the extent of the disturbance (0= not at all, 1= sometimes, 2= often, 3= most of the time) (see Appendix). Total scores range from 0 to 60, with higher scores indicating more depressive symptoms. Scores above 29 represent clinically significant depressive symptoms. Scores above 23 represent a subclinical depressive mood. It is worth noting, that the ADS has been proven to be useful in non-clinical settings to assess subclinical depressive symptoms. The internal consistency and the split-half reliability is high (.89 and .81, respectively; cf. Hautzinger & Meyer, 2002). Correlations with other depression scales (e.g., Beck Depression Inventory (BDI); Beck, Ward, Mendelson, Mock & Erbaugh, 1961) are also high (up to .90).

The *White Bear Suppression Inventory* (WBSI; Wegner & Zanakos, 1994; German version: Horn, Pössel & Hautzinger, 2002) was used to assess participants’ tendency to suppress unwanted negative thoughts. The WBSI is a 15-item self-report questionnaire with items such as “Sometimes I wonder why I have the thoughts I do” and “I always try to put problem out of mind”. Participants rate each item using a five-point-Likert scale (1= strongly disagree; 5= strongly agree). Total scores range from 15 to 75, with higher scores representing higher levels of thought suppression (see Appendix). The WBSI has also been shown to have strong internal consistency and test-retest reliability (Muris, Merckelbach & Horselenberg, 1996; Spinhoven & van der Does, 1999; Wegner & Zanakos, 1994). Recent research (Blumberg, 2000) indicates that the 15-item scale consists of three related factors: “thought suppression”, “unwanted intrusive thoughts” and “self-distraction” that best account for the common variance among the WBSI items. The WBSI appears to be highly correlated with self-report measures of trait-anxiety, neuroticism, depression, obsessive-convulsive symptomology, and intrusive thinking (Muris, Merckelbach & Horselenberg, 1996).

2.3.2. Implicit task: Scrambled Sentences Task

The SST was run on a computer to ensure comparable stimulus presentations before and during the fMRI session (see Rude, Covich, Jarrold, Hedlund & Zentner, 2001). The 40 scrambled sentences used by Wenzlaff (1993) were translated into German and displayed separately in white lowercase letters on a black computer screen for three seconds each and in a randomly generated presentation order using Presentation 9.20 01.28.05 (see http://www.neurobs.com). In line with Rude et al. (2001), the neutral distracter sentences were not used. Participants were instructed to build a meaningful and grammatically correct sentence with five out of the six presented words. The experimenter told participants that it was important for them to work quickly and they should not correct mistakes but try to finish as many of the scrambled sentences as possible. They had 12 seconds to write down the sentence on a sheet of paper. A cross in the middle of the screen alerted them to the appearance of the next stimulus. As in prior studies using the SST (e.g., Wenzlaff, 1993), a cognitive load procedure was used in the second block of sentences administered to each participant. In this condition, immediately prior to the second block of scrambled sentences they were given a nine-digit-number and told to retain this number in memory while doing the task. Although size of the load was not adjusted for each individual, the current procedure has been proven in prior studies to produce predicted effects (Wenzlaff & Wegner, 2000). After each block the participants rated their current mood state. On completion of the second block, participants were asked to recall the nine-digit-number. In line with the ironic process theory of thought suppression (Wegner, 1994), the increase of negative sentences under mental load reflects the failure of mental control.

2.4. fMRI assessment

After a first sequence to localize the subject's brain and an anatomical T2 weighted sequence for diagnostical purposes, an 8-min-long baseline condition was measured. The subjects were instructed that they would see only a black screen and that they could close their eyes for 8 minutes. This baseline condition served as an additional control condition for further analysis (e.g., Wang et al., 2005a). After that, four blocks of unscrambling sentences (mSST) followed.

2.4.1. Modification of SST (mSST)

To explore the neural correlates of thought suppression, the SST has been modified for the fMRI session in three ways: the instruction of the task, the content of the sentences and the introduction of a manipulation check.

1. To avoid motion artifacts when writing or speaking out loud, the subjects were instructed to build the sentences in mind and to press a button when the sentence was built. For this, the presentation time of the scrambled sentences has been slightly modified. The total time of 2.5 minutes per block as well as the stimulus presentation of three seconds remained as in the original SST. Only the interstimulus interval has been shortened to three seconds to ensure that the time pressure is still existent *(*see van der Does, 2005*).* This resulted in a total of 22 sentences per block. Pilot studies helped to optimize the timing.
2. Additional modification of the paradigm has been done regarding the content of the sentences. Blocks of neutral sentences (e.g., "man thirsty this is hungry very") were presented. These neutral blocks were used in the analyses as a baseline condition for contrasting the brain imaging data. Therefore, four blocks of neutral and ambiguous sentences were presented alternately: ambiguous-neutral-neutral-ambiguous.
3. To obtain a measure of how many positive and negative sentences were built, a manipulation check was introduced after each block. There, six potential sentences of one previously scrambled sentence were presented on the screen. The subjects were instructed to read all the sentences and to indicate which sentence they have built before. In order to shorten the scanning procedure, only 11 of 22 sentences per block were questioned. On completion of the manipulation check, the mood state was rated.

In total, 44 ambiguous and 44 neutral sentences were generated. They were checked for counterbalanced sequence of appearance of the positive and the negative word of each stimulus.

2.5. Data analyses

2.5.1. Behavioural data analysis

Inferential statistics were computed using the software package SPSS 15.0. A 2x2 Multivariate Analysis of Variance (MANOVA) with repeated measurements was conducted. The percentage of negative statements - calculated by dividing the number of negative statements by the total number of statements (Wenzlaff & Bates, 1998) – was used as the dependent variable. The factor at risk (remitted Minor Depressed vs. normal) was used as between-subject factor. The factor cognitive load (no load vs. load condition) served as within-subject factor. Furthermore, a second model was fitted, with ADS, WBSI and gender as covariates.

For a better understanding of the following analyses and discussion, it is important to bear in mind the difference between both scores of negative sentences resulting from the SST before and during scanning. The first score is the increase of negative sentences under a cognitive load which – consistent with ironic process theory - would reflect the failure of mental control in vulnerable persons. This is operationalized by the difference percentage score of the SST *before scanning* (SSTscore). The second score is the amount of unscrambled negative sentences in the modified SST (mSST) during scanning. These conditions are performed without a mental load. This is operationalized by the percentage score of negative sentences in the mSST (modified SSTscore; mSSTscore).

To make sure that there were no group differences regarding mSSTscore, a third MANOVA with repeated measurements with WBSI and gender was conducted. The percentage of negative statements was used as the dependent variable. The factor at risk (remitted Minor Depressed vs. normal) was used as between-subject factor. The factor ambiguous sentences [negative sentences during first condition of ambiguous sentences (mSSTscore1) vs. negative sentences during second condition of ambiguous sentences (mSSTscore2)] served as within-subject factor. WBSI and gender were included as covariates.

2.5.2. Neuroimaging data analysis

2.5.2.1. MRI acquisition

All magnetic resonance imaging (MRI) data were obtained with a 3-Tesla Magnetom Allegra (Siemens, Erlangen, Germany) MRI system equipped with a head coil. Images were individually screened to exclude pathology. A continuous arterial spin labelling (CASL) technique was used as described in Wang et al. (2005b). CASL has been proven to be suitable for studying slowly developing processes (e.g., mood changes, psychological stress or procedural learning) in brain function. In addition, it has the advantage of a stable noise characteristic and less inter-subject variability, most likely due to measurement of task-induced flow changes directly and quantitatively. It is better for task periods longer than 1-2 minutes (for more details see Wang et al, 2003; Wang et al., 2005a). CASL has been proven to be an appropriate method to investigate deactivation which is important information in research of individual differences (e.g., Raichle et al., 2001). Interleaved images with and without labelling were acquired for 8 minutes in baseline condition (120 acquisitions) and 2.5 minutes for each of the unscrambling task conditions (38 acquisitions) by using a gradient-echo echo-planar imaging (EPI) sequence (TR/TE: 4000/17, anterior-to posterior phase encoding, flip angle 90°, bandwidth 3005 Hz/Pixel, field of view 22 cm). Image size was 64 x 64 x 15 voxels, slice thickness 6 mm with a gap of 1.5 mm, giving a voxel size of 3.44 x 3.44 x 7.5 mm. A delay of 1 sec was inserted between the end of labelling pulse and image acquisition to reduce transit artefacts.

2.5.2.2. Data analysis

The SPM5 package (Wellcome Department of Cognitive Neurology, London; online at http://www.fil.ion.ucl.ac.uk) was used for realignment and stereotactic normalization to an EPI template (Montreal Neurological Institute, resampling size: 2 x 2 x 2 mm). Reconstruction of cerebral blood flow (CBF) values was obtained using the Perf_reconstruct_V02 SPM add-on software by H.Y. Rao and J.J. Wang, from the Department of Radiology and Centre for Functional Neuroimaging at the University of Pennsylvania (http://www.cfn.upenn.edu/perfusion/software.htm). The software implements eq. (1) of Wang et al. (2003). The ‘simple subtraction’ method was used. All volumes were smoothed using an isotropic Gaussian kernel of full width half maximum (FWHM) of 8 mm. An explicit mask was obtained by thresholding the a priori tissue probability maps provided by SPM package at 0.25 for gray or white matter, and manually excluding the cerebellum and the brainstem up to the pons to exclude artefactual signal present in the data. Preprocessed regional CBF (rCBF) images were averaged in each individual to produce coefficient images for second level tests. Images were generated with the free software package MRIcroN, obtained from http://sph.sc.edu/comd/rorden/mricron/.

All analyses were performed using the individual global perfusion as a nuisance covariate (Friston, Frith, Liddle, Dolan, Lammertsma & Frackowiak, 1990). To investigate the activated and deactivated regions when unscrambling sentences in comparison to a baseline condition, one-sample t-tests were first conducted across all subjects for the contrast (ambiguous + neutral) vs. baseline for the activated regions, baseline vs. (ambiguous + neutral) for the deactivated regions. The contrast ambiguous vs. neutral was then examined across the entire sample to examine regions that are associated with the unscrambling of emotional ambiguous material. Clusters were defined *a priori* by the univariate significance level of p = .001.

Because this study focused on individual differences that modulate the brain activation, multiple regressions were conducted across all subjects for the contrast ambiguous vs. neutral, i.e. individual differences that modulate the brain activation when unscrambling emotional ambiguous verbal material. The first model included the difference percentage score of negative sentences before scanning (SSTscore) and the percentage score of negative sentences during scanning (mSSTscore). The second model included the individual scores derived from questionnaires, namely the DSQ as an indicator whether a Minor Depressive episode was present in the past or not, ADS for a current depressive score and WBSI, a score reflecting the habitual thought suppression. Because the effects of individual differences in a whole-brain analyses were expected to be smaller, clusters were defined *a priori* by the significance level of p=.01 for both models.

3. Results

3.1. Behavioural results

3.1.1. SSTscore

To investigate whether remitted Minor Depressed people also show a negative bias in their information processing, a MANOVA with repeated measurement was fitted. Significant main effects for the factors at-risk and cognitive load as well as a significant interaction occurred (see table 6.1.). The significant main effect for the factor at-risk derived from the fact, that vulnerable participants built more negative sentences than the control group. The significant main effect of cognitive load showed that overall more negative sentences were built under the load condition relative to the no load condition. The significant interaction between the factors at-risk and cognitive load showed that this effect tends to be stronger in the vulnerable group (see figure 6). For descriptive data see table 6.

In sum, the remitted Minor Depressed in the present study also showed a negative bias that was enhanced under a cognitive load, similar to people who are in remission of a Major Depressive episode.

Table 6. Descriptive data regarding percentage of negative sentences scores with and without cognitive load

Condition	**Group**	**N**	**M**	**SD**
Without load	At risk	20	31.17	15.91
	Control	20	24.74	14.28
	Total	40	27.96	15.28
With load	At risk	20	40.18	17.30
	Control	20	26.99	16.38
	Total	40	33.59	17.92

Note. At risk: Subjects who have a remitted Minor Depressive episode but are free of symptoms. Control: subjects with no depressive episode in lifetime.

Table 6.1. MANOVA with repeated measurements

Sources of variance	**F**	**p**[a]
At-risk factor	4.30	.045*
Cognitive load factor	9.71	.003**
At-risk x Cognitive load	3.51	.069*

Note. At-risk factor: At risk group, i.e. subjects who have a remitted Minor Depressive episode, and control group, i.e. subjects who never had a depressive episode before. Cognitive load factor: no load and load condition. df = 1, 38. *p< .05, **p< .01. [a]Note that the p-values reported here are two-tailed.

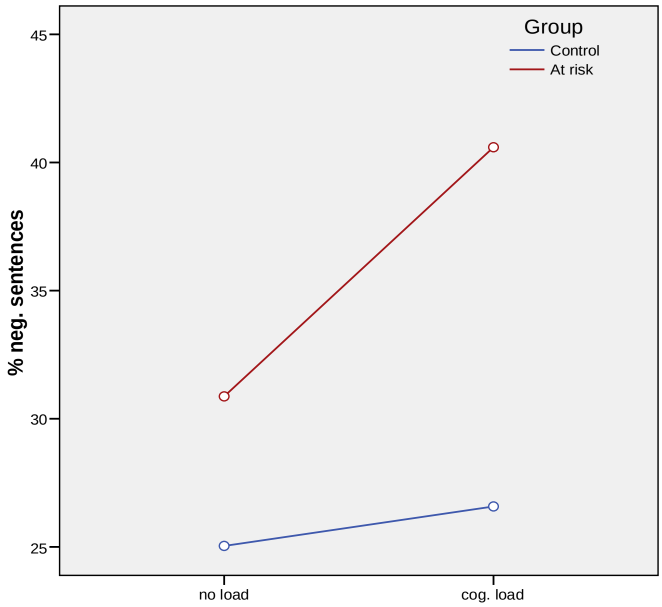


Figure 6. SST: Significant interaction between cognitive load and at-risk factor. The significant interaction of the factors cognitive load and at-risk indicates that those subjects vulnerable for depression (dark red) built significantly more negative sentences under load (SSTscore) than those subjects with no vulnerability for depression (blue).

3.1.2. Second model SSTscore with gender, ADS and WBSI as covariates

To test the effect of gender, ADS and WBSI to the unscrambling of negative sentences, a second model was fitted with these variables as covariates. It was expected that the increase of negative sentences under mental load is associated with WBSI. Furthermore, the more currently depressed a subject is, the more negative sentences will be unscrambled, independent of a mental load. The main effect of cognitive load as well as the interaction cognitive load x at-risk remained significant (see table 7.1.). Additionally, a significant main effect of gender indicated that female participants built less negative sentences overall (for descriptive data see table 7). A significant main effect of ADS hinted to the fact that the higher the ADS score, the more negative sentences were produced (for descriptive data see table 8). The significant interaction cognitive load x gender derived from the fact that male participants built more negative sentences under a cognitive load in comparison to their female counterparts.

Thus, the significant interaction between the both factors cognitive load and at-risk improved when controlling for gender, ADS and WBSI. While an unexpected gender effect occurred, WBSI did not show an effect in this sample. The significant main effect of ADS supports the hypothesis that the more currently depressed the subjects, the more negative sentences are built overall.

Table 7. Descriptive data regarding percentage of negative sentences scores of men and women with and without cognitive load

Condition	Gender	N	M	SD
Without load	Male	22	31.70	12.58
	Female	18	23.38	17.31
	Total	40	27.96	15.28
With load	Male	22	39.95	15.57
	Female	18	25.81	17.92
	Total	40	33.59	17.92

Table 7.1. MANOVA with repeated measurements with gender, ADS and WBSI as covariates

Sources of variance	**F**	**p[a]**
At-risk factor	2.07	.159
Cognitive load factor	4.94	.033**
Gender	10.33	.003**
ADS	29.9	.000**
WBSI	.169	.684
Cognitive load x at-risk	4.55	.040*
Cognitive load x Gender	3.74	.061*
Cognitive load x ADS	.093	.732
Cognitive load x WBSI	.451	.506

Note. At-risk factor: At risk group, i.e. subjects who have a remitted Minor Depressive episode, and control group, i.e. subjects who never had a depressive episode before. Cognitive load factor: no load and load condition. df = 1, 35. *p< .05, **p< .01. [a]Note that the p-values reported here are two-tailed.

3.1.3. Post-hoc analyses

3.1.3.1. Correlations SSTscore, mSSTscore, WBSI and ADS

Because previous analyses did not show an effect of WBSI on the increase of negative statements under cognitive load, further analyses were conducted in accordance to the study of Wenzlaff & Bates (1998). WBSI – reflecting habitual thought suppression - did not correlate with the SSTscore i.e. before scanning (r=.09; p=.58), but showed a significant correlation with mSSTscore (r=.41; p=.008). However, both percentage scores before and during the fMRI scan were also highly correlated (r=.41; p=.009).

In addition, WBSI correlated with ADS (r=.39; p=.012), suggesting a conjoint variance of both individual differences.

To sum up, WBSI did not effect the increase of negative sentences under load (SSTscore) but the mSSTscore. Moreover, WBSI and ADS shared the same variance.

3.1.3.2. SSTscore with ADS and WBSI

Because WBSI as a covariate did not show a significant effect and WBSI and ADS were correlated, the effects of ADS and WBSI were conducted separately. Two ANOVAs were fitted, one with ADS and one with WBSI scores as between-subject factor. For this reason, the sample was first subdivided via median split (ADS: Median = 14, SD = 9; WBSI: Median = 46.5, SD=9.57). Significant main effects of condition showed that in the load condition more negative sentences were built as in the no load condition (ADS: main effect condition: $F(1,38)=9.06$, $p=.005$; WBSI: main effect condition: $F(1,38)=8.89$, $p=.005$). Additionally, significant main effects of group indicated that those subjects with a higher ADS score and higher WBSI score built more negative sentences overall (main effect ADS: $F(1,38)=13.35$, $p=.001$, main effect WBSI: $F(1,38)=7.75$, $p=.008$). There were neither a significant interaction of Condition x ADS ($F(1,38)=.142$, $p=.71$) nor Condition x WBSI ($F(1,38)=.000$, $p=.99$). The descriptive data are summarized in table 8 for ADS and in table 9 for WBSI.

In sum, ADS and WBSI showed an effect of the overall amount of negative sentences but did not effect the increase of negative sentences under load.

Table 8. Descriptive data regarding percentage of negative sentences scores of subjects with high and low ADS scores

Condition	**ADS**	**N**	**M**	**SD**
Without load	high	18	36.23	16.25
	low	22	21.19	10.63
	Total	40	27.96	15.28
With load	high	18	42.65	14.64
	low	22	26.17	17.18
	Total	40	33.59	17.92

Note. high: Subjects who reported high ADS scores, that is a score > 14. low: Subjects who reported low ADS scores, that is a score ≤ 14.

Table 9. Descriptive data regarding percentage of negative sentences scores of subjects with high and low WBSI scores

Condition	WBSI	N	M	SD
Without load	high	20	34.27	16.14
	low	20	21.65	11.60
	Total	40	27.96	15.28
With load	high	20	39.93	17.53
	low	20	27.24	16.35
	Total	40	33.59	17.92

Note. high: Subjects who reported high WBSI scores, that is a score > 46.5.
low: Subjects who reported low WSBI scores, that is a score ≤ 46.5.

3.1.3.3. mSSTscore with WBSI and gender as covariates

Because WSBI did only show a significant correlation with the mSSTscore, an MANOVA with repeated measurement was fitted. The factor ambiguous sentences (mSSTscore1 vs. mSSTscore2) was used as within-subject factor and the factor at-risk factor (vulnerable vs. healthy subjects) was used as between-subject factor. As covariates, WBSI and gender were included. Table 10 shows the amount of negative sentences for both blocks of ambiguous sentences separately. The significant main effect of the factor at-risk showed that also during the scanning, vulnerable subjects built more negative sentences than their healthy counterparts. The main effect of mSSTscore was not significant, indicating that there were no differences between the first and the second block of emotional ambiguous sentences. Only the covariate WBSI showed an effect, suggesting that the higher the WBSI score the more negative sentences were built during the mSST during scanning (see table 10.1. for descriptive data). There were no significant interactions (see table 10.3.).

The same model including ADS did not change the main effects. Only the significant effect of WBSI disappeared (F(1,35)=.988, p=.327). Instead, ADS as covariate reached significance (F(1,35)=4.47, p=.042) (see table 10.2. for descriptive data).

In summary, in the mSST subjects vulnerable for depression – compared to healthy subjects - built more negative sentences when told to unscramble emotional ambiguous sentences. In addition, WBSI showed a significant main effect, suggesting that the higher the habitual thought suppression, the more negative sentences were built during the scanning procedure. This effect disappeared when ADS was included as a covariate in the model.

Table 10. Descriptive data regarding percentage of negative sentences scores separated for vulnerability for depression

Condition	Group	N	M	SD
mSSTscore1	At risk	20	22.27	20.32
	Control	20	10.00	11.76
	Total	40	16.14	17.53
mSSTScore2	At risk	20	33.64	16.97
	Control	20	16.36	14.02
	Total	40	25.00	17.68

Note. At risk: Subjects who have a remitted Minor Depressive episode but are free of symptoms. Control: subjects with no depressive episode in lifetime.

Table 10.1. Descriptive data regarding percentage of negative sentences scores separated for WBSI

Condition	WBSI	N	M	SD
mSSTscore1	low	20	12.27	13.60
	high	20	20.00	20.35
	Total	40	16.14	16.98
mSSTScore2	low	20	19.55	16.50
	high	20	30.45	17.52
	Total	40	25.00	17.01

Note. low: Subjects who reported low WSBI scores, that is a score ≤ 46.5. high: Subjects who reported high WBSI scores, that is a score > 46.5.

Table 10.2. Descriptive data regarding percentage of negative sentences scores separated for ADS

Condition	ADS	N	M	SD
mSSTscore1	low	22	15.29	19.11
	high	18	17.17	15.87
	Total	40	16.23	17.49
mSSTScore2	low	20	22.31	14.50
	high	20	28.28	20.89
	Total	40	25.30	17.70

Note. high: Subjects who reported high ADS scores, that is a score > 14. low: subjects who reported low ADS scores, that is a score ≤ 14.

Table 10.3. MANOVA with repeated measurements

Sources of variance	F	p[a]
At-risk factor	8.10	.007**
mSSTscore	.953	.335
Gender	.159	.692
WBSI	3.32	.077*
At-risk x mSSTscore	1.07	.308
At-risk x Gender	1.40	.244
At-risk factor x WBSI	.057	.813

Note. At-risk factor: At risk group, i.e. subjects who have a remitted Minor Depressive episode, and control group, i.e. subjects who never had a depressive episode before. mSSTscore: there were two blocks of ambiguous sentences during the fMRI scan. df = 1, 36. *p< .05, **p< .01. [a]Note that the p-values reported here are two-tailed.

3.2. Brain imaging results

3.2.1. Brain regions associated with unscrambling sentences

The first question regards which brain regions were involved when unscrambling sentences. For this, the contrast (ambiguous + neutral) vs. baseline was conducted. The unscrambling of sentences activated significantly the left inferior frontal gyrus, the left superior frontal gyrus (BA 6), the inferior occipital gyrus bilaterally (BA 17, 18), the left superior parietal lobe (BA 7), the right insula (BA 13), the left temporal lobe and the right middle frontal gyrus (BA 6) (see table 11).

Deactivated regions, that is the contrast baseline vs. (ambiguous + neutral), included the right superior temporal gyrus (BA 42), the left insula (BA 13), and the left superior frontal gyrus (BA 10). At a significant uncorrected cluster-level, the right parietal lobe (BA 7), the right inferior temporal gyrus (BA 20), the right cerebellum, and the left parahippocampal gyrus (BA 35) were also deactivated when unscrambling sentences (see table 11.1.). Figure 7 shows the pattern of activation and deactivation when unscrambling sentences.

Table 11. Brain areas activated when unscrambling sentences

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
L, Inferior frontal gyrus	-48 16 0	9.83	<0.001	5773	<0.001	<0.001°
L, Superior frontal gyrus (6)	-6 12 52	9.12	<0.001	1864	<0.001	<0.001°
L, Inferior occipital gyrus (17)	-24 -96 -8	8.50	<0.001	2429	<0.001	<0.001°
L, Superior parietal lobe (7)	-30 -56 50	7.57	<0.001	1408	<0.001	<0.001°
R, Inferior occipital gyrus (18)	34 -90 -6	7.24	0.001	2843	<0.001	<0.001°
R, Insula, 13	32 22 6	7.17	0.001	998	<0.001	<0.001°
L, Temporal lobe	-46 -44 2	6.58	0.003	920	<0.001	<0.001°
R, Middle frontal gyrus	30 2 54	5.51	0.053	1176	<0.001	<0.001°

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
(6)						
R, Caudate	20 12 14	3.96	0.920	30	0.912	0.251
R, Caudate Head	16 14 0	3.96	0.926	27	0.931	0.276
R, Rectal gyrus (11)	9 18 -24	3.95	0.926	32	0.898	0.237
R, Supramarginal gyrus (40)	48 -40 32	3.60	0.996	13	0.987	0.454
R, Superior frontal gyrus	34 46 16	3.58	0.997	22	0.957	0.325

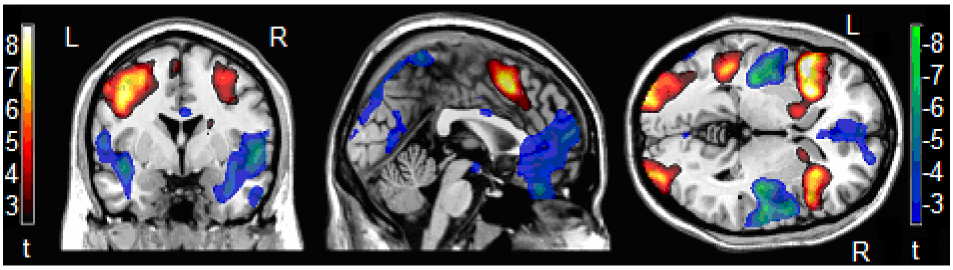
Note. HEM=hemisphere; L=left; R=right; BA=Brodmann's area; *k*=cluster extent (in 2 x 2 x 2 mm voxels). Clusters were *a priori* defined at *p=0.001*. ° reported region that reached significance either on a voxel (corr.) or a cluster (corr./uncorr.) level.

Table 11.1. Brain areas deactivated when unscrambling sentences

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
R, Superior temporal gyrus (42)	62 -20 8	8.37	<0.001	4056	<0.001	<0.001°
L, Insula (13)	-40 -22 0	6.95	0.001	2796	<0.001	<0.001°
L, Superior frontal gyrus (10)	-20 64 16	6.90	0.001	2087	<0.001	<0.001°
R, Parietal lobe (7)	4 -48 68	5.38	0.075	234	0.041	0.004°
R, Inferior temporal gyrus (20)	-60 -64 -16	5.32	0.086	90	0.421	0.057°
R, Cerebellum	4 -68 -16	4.46	0.541	94	0.395	0.052°
L, Parahippocampal gyrus (35)	-20 -16 -28	4.37	0.623	90	0.421	0.057°
R, Middle temporal gyrus (21)	58 2 -32	4.01	0.896	50	0.750	0.144
R, Superior frontal gyrus (8)	12 52 44	3.95	0.923	30	0.912	0.251
L, Superior frontal	-22 32 48	3.92	0.937	37	0.861	0.204

HEM (BA)	Coordinates x y z (MNI)	t	Voxel-level p (FWE)	k (vol.)	Cluster-level p (corr.)	p (uncorr.)
gyrus (8)						
R, Occipital Lobe, Cuneus (19)	6 -82 36	3.82	0.967	173	0.108	0.012
R, Superior frontal gyrus (8)	18 38 52	3.82	0.968	11	0.991	0.493
R, Cingulate gyrus (24)	4 2 28	3.61	0.996	11	0.991	0.493
L, Precuneus (31)	-15 -52 28	3.46	0.999	6	0.998	0.624

Note. HEM=hemisphere; L=left; R=right; BA=Brodmann's area; *k*=cluster extent (in 2 x 2 x 2 mm voxels). Clusters were *a priori* defined at *p=0.001*. ° reported region that reached significance either on a voxel (corr.) or a cluster (corr./uncorr.) level.



x=0, y=0, z=0

Figure 7. Activated and deactivated brain regions when unscrambling sentences.

The yellow-red indicates the activated brain regions when contrasting sentences vs. baseline. The green-blue marks indicate the deactivated brain regions, i.e. the contrast baseline vs. sentences, when unscrambling sentences. L=left; R=right; t = t-value.

3.2.2. Brain regions associated with processing emotional ambiguous material

To answer the question which brain regions are associated with the processing of emotional ambiguous verbal material, the contrast ambiguous vs. neutral was conducted. There were no significant brain regions at a significant corrected voxel-level. At an uncorrected cluster-level the left parietal lobe (BA 3) and the right vACC (BA 32) showed a positive association between blood flow and the processing of emotional ambiguous material (see table 12). Because the previous contrast (ambiguous + neutral) vs. baseline showed deactivations in BA 3, it can be reasoned that the processing of emotional ambiguous material - compared to neutral sentences - leads to a smaller deactivation (greater activation) in the left parietal lobe. The positive association with right vACC (BA 32) seems to be specific to the processing of emotional ambiguous material.

The processing of emotional ambiguous sentences was negatively associated (contrast: neutral vs. ambiguous) with the middle frontal gyrus (BA 6), bilaterally, and the right parietal lobe (BA 3) at a corrected cluster-level significance. At an uncorrected cluster-level, the left superior parietal lobe (BA 7) and the right putamen showed a negative association to the ambiguous condition of the mSST (see table 12.1.). Compared to the contrast (ambiguous + neutral) vs. baseline, it can be summarized that the processing of emotional ambiguous sentences – relative to a neutral condition - leads to smaller activations of the DLPFC (BA 6) and the left superior parietal lobe (BA 7), while the right putamen showed a smaller deactivation (greater activation). The negative association to the right parietal lobe (BA 3) seemed to be specific to the unscrambling of emotional ambiguous sentences. Figure 8 shows the pattern of activation and deactivation when unscrambling emotional ambiguous sentences.

Table 12. Brain areas activated when processing emotional ambiguous sentences

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
L, Parietal lobe (3)	-68 -10 26	4.54	0.443	319	0.761	0.039°
R, Anterior cingulate (32)	4 36 26	4.27	0.679	1511	0.004	<0.001°
L, Cingulate gyrus (24)	-4 6 -30	3.83	0.952	85	1.000	0.261
R, Inferior temporal gyrus (20)	50 -10 -32	3.75	0.974	61	1.000	0.341
L, Inferior frontal gyrus (45)	-58 28 18	3.50	0.998	86	1.000	0.258
L, Uncus (28)	-10 0 -30	3.30	1.000	32	1.000	0.497
R, Inferior temporal gyrus (20)	64 -8 -22	3.24	1.000	30	1.000	0.511
R, Extra-nuclear	22 -24 -4	3.14	1.000	23	1.000	0.570
R, Postcentral gyrus	54 -28 20	3.09	1.000	88	1.000	0.253

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
(40)						
R, Insula	40 -10 -6	3.08	1.000	42	1.000	0.432
L, Inferior parietal lobe (40)	-52 -32 26	3.01	1.000	168	0.998	0.121
L, Occipital lobe, Lingual gyrus (18)	-8 -98 -10	2.95	1.000	19	1.000	0.610
L, Inferior temporal gyrus	-52 -22 -22	2.93	1.000	26	1.000	0.544
L, Middle temporal gyrus (39)	-44 -60 24	2.86	1.000	16	1.000	0.643
L, Superior frontal gyrus (6)	-22 36 58	2.83	1.000	15	1.000	0.655
R, Orbital gyrus (47)	18 26 -26	2.82	1.000	42	1.000	0.432
R, Superior temporal gyrus (38)	32 22 -26	2.72	1.000	18	1.000	0.621
R, Middle temporal gyrus (21)	62 -20 -4	2.70	1.000	14	1.000	0.668
L, Substantia nigra	-10 -28 -10	2.61	1.000	12	1.000	0.695
R, Cingulate gyrus (23)	2 -20 30	2.54	1.000	2	1.000	0.896
L, Orbital gyrus (11)	-8 46 -32	2.53	1.000	3	1.000	0.865
L, Superior temporal gyrus (42)	-60 -24 8	2.53	1.000	4	1.000	0.839

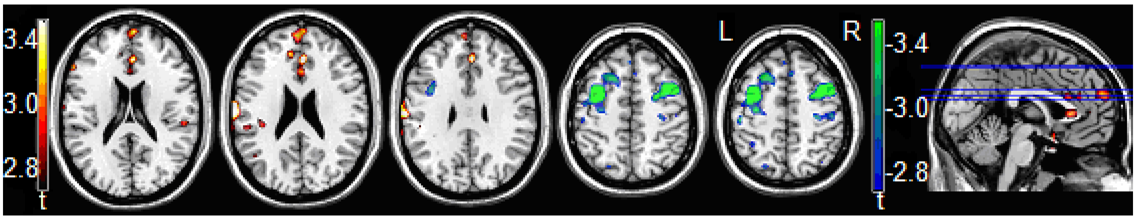
Note. HEM=hemisphere; L=left; R=right; BA=Brodmann's area; *k*=cluster extent (in 2 x 2 x 2 mm voxels). Clusters were *a priori* defined at *p=0.01*. Contrast ambiguous vs. neutral. ° reported region that reached significance either on a voxel (corr.) or a cluster (corr./uncorr.) level.

Table 12.1. Brain areas deactivated when processing emotional ambiguous sentences

HEM (BA)	Coordinates x y z (MNI)	*t*	Voxel-level *p* (FWE)	*k* (vol.)	Cluster-level *p* (corr.)	*p* (uncorr.)
L, Middle frontal gyrus (6)	-34 2 52	5.55	0.044	1731	0.002	<0.001°
R, Middle frontal gyrus (6)	44 6 54	5.46	0.054	798	0.089	0.003°
R, Parietal lobe (3)	46 -20 60	4.98	0.177	548	0.295	0.010°
L, Superior parietal lobe (7)	-30 -46 64	4.25	0.689	378	0.621	0.026°
R, Putamen	32 -10 6	4.24	0.702	425	0.514	0.020°
R, Precuneus (19)	36 -72 40	3.54	0.997	226	0.938	0.076
L, Claustrum	-26 14 8	3.51	0.998	68	1.000	0.314
R, Medial frontal gyrus (10)	16 56 0	3.28	1.000	53	1.000	0.375
R, Posterior frontal gyrus (6)	4 20 56	3.19	1.000	60	1.000	0.345
L, Inferior frontal gyrus (9)	-38 6 30	3.18	1.000	144	0.996	0.148
L, Caudate	-14 -2 16	3.13	1.000	85	1.000	0.261
L, Middle occipital gyrus (19)	-26 -98 16	3.09	1.000	19	1.000	0.610
L, Precuneus (7)	-22 -70 54	2.96	1.000	39	1.000	0.450
R, Occipital lobe, Cuneus (17)	10 -96 0	2.86	1.000	17	1.000	0.632
L, Middle frontal gyrus (10)	-20 52 -8	2.83	1.000	24	1.000	0.561
R, Middle frontal gyrus (11)	42 56 -12	2.83	1.000	12	1.000	0.695
L, Postcentral gyrus (3)	-40 -22 42	2.80	1.000	23	1.000	0.570
R, Superior frontal gyrus (8)	14 44 46	2.80	1.000	19	1.000	0.610
L, Parahippocampal gyrus (21)	-18 -50 -2	2.65	1.000	40	1.000	0.444
L, Middle temporal	-64 -58 10	2.64	1.000	11	1.000	0.709

	Coordinates		Voxel-level		Cluster-level	
HEM (BA)	x y z (MNI)	*t*	*p* (FWE)	*k* (vol.)	*p* (corr.)	*p* (uncorr.)
gyrus (21)						
L, Middle frontal gyrus (9)	-46 32 30	2.60	1.000	4	1.000	0.839
L, Middle frontal gyrus (46)	-54 32 30	2.57	1.000	4	1.000	0.839
L, Precuneus (7)	-24 -70 38	2.56	1.000	5	1.000	0.816
R, Parahippocampal gyrus (36)	28 -28 -28	2.53	1.000	2	1.000	0.896
R, Inferior temporal gyrus (20)	36 -4 -44	2.53	1.000	7	1.000	0.776
R, Cerebrum, Sub-lobar	12 6 -8	2.52	1.000	3	1.000	0.865
R, Inferior occipital gyrus (18)	50 -84 0	2.50	1.000	1	1.000	0.993
L, Middle occipital gyrus (19)	-44 -72 10	2.44	1.000	2	1.000	0.896

Note. HEM=hemisphere; L=left; R=right; BA=Brodmann's area; *k*=cluster extent (in 2 x 2 x 2 mm voxels). Clusters were *a priori* defined at *p=0.01*. Contrast ambiguous vs. neutral. ° reported region that reached significance either on a voxel (corr.) or a cluster (corr./uncorr.) level.



Slices: z = 20, 24, 30, 52, 54.

Figure 8. Associated brain regions when unscrambling emotional ambiguous sentences.

The yellow-red mark regions are those regions that are positive associated to the unscrambling of ambiguous sentences (contrast: ambiguous vs. neutral sentences). The green-blue highlight regions that are negatively asoociated to the unscrambling of ambiguous sentences (contrast: neutral vs. ambiguous sentences). L=left; R=right; t = t-value.

3.2.3. Modulation of brain activation by individual differences

Because of an interest in the neural modulation by individual differences, two contrasts were conducted. In the first contrast, SSTscore and mSSTscore were regressed on the ambiguous vs. neutral condition. At a corrected voxel-level, no regions were significantly associated with the SSTscore. However, at an uncorrected cluster-level significance level, the SSTscore was positvely associated to the left temporal parietal junction (TPJ; BA 40) (see table 13). The mSSTscore also showed a positive association to the left TPJ (BA 40), but also to the insula (BA 13), bilaterally, the OFC, bilaterally (BA 10), and the right occipital lobe (BA 18), but only at an uncorrected significance cluster-level (see table 13.1.).

The second contrast was conducted with the same trait measurements as in the behaviour analyses. These were the severity of a past Minor Depressive episode, ADS and WBSI. Overall, these significances were weaker. Significant positive assocations to the individual differences were only obtained at an uncorrected cluster-level. A past Minor Depressive episode was positively associated to the right inferior frontal gyrus (VLPFC; BA 47) (see table 14). ADS showed a positive association to the left parahippocampal gyrus (BA 36) (see table 14.1.). There were no significantly associated brain regions to WBSI (see table 14.2.).

Table 13. Brain areas activated when unscrambling more negative sentences under cognitive load

	Coordinates		*Voxel-level*		*Cluster-level*	
HEM (BA)	x y z (MNI)	*t*	*p* (FWE)	*k* (vol.)	*p* (corr.)	*p* (uncorr.)
L, Inferior parietal lobe (40)	-36 -44 56	3.98	0.906	1570	0.003	<0.001°
L, Temporal lobe, Fusiform gyrus	-52 -12 -26	3.44	0.976	72	1.000	0.296
R, Frontal lobe (47)	18 28 -10	3.55	0.997	106	1.000	0.207
R, Superior parietal lobe (7)	32 -62 56	3.34	1.000	117	0.999	0.186
L, Middle frontal gyrus (8)	-34 26 44	2.82	1.000	21	1.000	0.585
L, Middle frontal gyrus	-28 -6 52	2.78	1.000	51	1.000	0.380

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
(6)						
R, Limbic lobe, Cingulate gyrus (24)	6 -10 36	2.72	1.000	19	1.000	0.606
R, Rectal gyrus (11)	4 12 -26	2.70	1.000	4	1.000	0.837
R, Superior temporal gyrus (38)	38 10 -46	2.69	1.000	15	1.000	0.652
R, Limbic lobe, Cingulate gyrus (24)	10 0 34	2.59	1.000	7	1.000	0.773
L, Superior frontal gyrus	-22 52 -6	2.58	1.000	5	1.000	0.814
L, Limbic lobe, Cingulate gyrus (24)	-10 -14 36	2.55	1.000	13	1.000	0.678
L, Cerebrum	-2 4 2	2.45	1.000	2	1.000	0.894
L, Middle frontal gyrus (6)	-42 12 48	2.45	1.000	1	1.000	0.932

Note. HEM=hemisphere; L=left; R=right; BA=Brodmann's area; *k*=cluster extent (in 2 x 2 x 2 mm voxels). Clusters were *a priori* defined at *p=0.01*. The fitted model (contrast ambiguous vs. neutral) included SSTscore (before scanning) and mSSTscore (during scanning) as regressors. ° reported region that reached significance either on a voxel (corr.) or a cluster (corr./uncorr.) level.

Table 13.1. Brain areas activated when unscrambling negative sentences

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
R, Inferior frontal gyrus (10)	42 48 0	5.10	0.153	753	0.104	0.003°
L, Insula (13)	-42 -8 6	4.74	0.335	310	0.773	0.040°
L, Medial frontal gyrus (9)	-2 46 14	4.52	0.498	208	0.957	0.084°
L, Inferior parietal lobe (40)	-64 -42 22	4.38	0.614	1268	0.010	0.000°

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
R, Insula (13)	52 -28 18	4.34	0.647	1297	0.009	0.000°
L, Inferior frontal gyrus (10)	-48 46 -2	4.26	0.713	232	0.927	0.070°
L, Hippocampus	-30 -28 -8	4.06	0.865	175	0.984	0.111
R, Occipital lobe, Cuneus (18)	12 -78 26	3.83	0.961	420	0.513	0.019
L, Inferior frontal gyrus (13)	-40 26 4	3.53	0.998	191	0.973	0.097
R, Middle frontal gyrus	44 10 30	3.45	0.999	153	0.993	0.133
L, Precuneus (31)	-18 -66 26	3.11	1.000	199	0.966	0.091
R, Limbic lobe, Cingulate gyrus	14 -14 30	3.00	1.000	17	1.000	0.628
R, Temporal lobe	42 -60 4	2.97	1.000	19	1.000	0.606
R, Corpus callosum	10 -2 22	2.92	1.000	4	1.000	0.837
L, Middle frontal gyrus (10)	-24 62 8	2.89	1.000	22	1.000	0.575
R, Precentral gyrus (6)	48 -8 34	2.82	1.000	35	1.000	0.471
R, Fusiform gyrus (19)	36 -66 -12	2.80	1.000	34	1.000	0.478
R, Precentral gyrus (6)	60 2 18	2.74	1.000	17	1.000	0.628
L, Precentral gyrus (6)	-58 0 20	2.73	1.000	12	1.000	0.691
R, Precuneus (19)	32 -80 38	2.64	1.000	13	1.000	0.678
L, Superior frontal gyrus (10)	-32 56 26	2.54	1.000	3	1.000	0.864
L, Occipital lobe, Cuneus (18)	-12 -80 28	2.43	1.000	1	1.000	0.932

Note. HEM=hemisphere; L=left; R=right; BA=Brodmann's area; *k*=cluster extent (in 2 x 2 x 2 mm voxels). Clusters were *a priori* defined at *p=0.01*. The fitted model (contrast ambiguous vs. neutral) included SSTscore (before scanning) and mSSTscore (during scanning) as regressors. ° reported region that reached significance either on a voxel (corr.) or a cluster (corr./uncorr.) level.

Table 14. Brain areas activated when processing emotional ambiguous sentences modulated by the severity of past Minor Depressive episode

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
R, Inferior frontal gyrus (47)	28 32 -8	3.96	0.918	387	0.596	0.025°
L, Cerebrum	-6 22 2	3.31	1.000	31	1.000	0.503
R, Cingulate gyrus (24)	10 -10 28	3.30	1.000	59	1.000	0.348
R, Superior parietal lobe (7)	32 -64 62	3.27	1.000	44	1.000	0.419
L, Superior temporal gyrus (42)	-64 -28 16	3.27	1.000	87	1.000	0.254
L, Superior temporal gyrus	68 -30 6	3.17	1.000	150	0.994	0.140
R, Superior frontal gyrus (8)	16 46 40	3.13	1.000	79	1.000	0.277
R, Superior frontal gyrus (22)	58 -2 4	3.05	1.000	105	1.000	0.212
R, Anterior cingulate (32)	20 42 8	3.01	1.000	33	1.000	0.488
R, Medial frontal gyrus (25)	12 26 -16	2.95	1.000	28	1.000	0.526
R, Posterior lobe	46 -54 -22	2.86	1.000	17	1.000	0.631
R, Middle temporal gyrus (21)	60 6 -22	2.85	1.000	29	1.000	0.518
L, Superior frontal gyrus (10)	-24 66 18	2.83	1.000	45	1.000	0.414
R, Medial frontal gyrus (8)	2 42 38	2.83	1.000	17	1.000	0.631
R, Middle temporal gyrus (21)	46 8 -36	2.83	1.000	27	1.000	0.534
L, Superior frontal gyrus (6)	-2 26 58	2.72	1.000	14	1.000	0.667
R, Precentral gyrus (4)	62 -10 28	2.70	1.000	6	1.000	0.794
L, Medial frontal gyrus	-10 50 14	2.70	1.000	10	1.000	0.723

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
(10)						
L, Anterior cingulate (32)	-16 44 -2	2.70	1.000	10	1.000	0.723
R, Superior frontal gyrus (9)	32 46 32	2.66	1.000	7	1.000	0.775
R, Inferior parietal lobe (40)	48 -42 60	2.65	1.000	27	1.000	0.534
L, Cerebrum	-20 24 14	2.64	1.000	4	1.000	0.839
L, Middle frontal gyrus (9)	-32 34 34	2.63	1.000	7	1.000	0.775
R, Anterior lobe	36 -46 -20	2.53	1.000	3	1.000	0.865
L, Inferior temporal gyrus (20)	-64 -6 -22	2.51	1.000	1	1.000	0.933
L, Superior temporal gyrus (22)	-58 12 -4	2.51	1.000	1	1.000	0.933

Note. HEM=hemisphere; L=left; R=right; BA=Brodmann's area; *k*=cluster extent (in 2 x 2 x 2 mm voxels). Clusters were *a priori* defined at *p=0.01*. The fitted model (contrast ambiguous vs. neutral) included the DSQ, ADS and WBSI scores as regressors. ° reported region that reached significance either on a voxel (corr.) or a cluster (corr./uncorr.) level.

Table 14.1. Brain areas activated when processing emotional ambiguous sentences modulated by the current depressive state

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
L, Parahippocampal gyrus (36)	-30 -32 -22	3.58	0.996	278	0.848	0.051°
L, Superior temporal gyrus	-66 -44 14	3.43	0.999	116	0.999	0.190
R, Middle temporal gyrus (37)	56 -66 6	3.33	1.000	95	1.000	0.234
R, Corpus Callosum	14 30 0	3.29	1.000	57	1.000	0.356

HEM (BA)	Coordinates x y z (MNI)	t	Voxel-level p (FWE)	k (vol.)	Cluster-level p (corr.)	p (uncorr.)
R, Precentral gyrus	52 2 50	3.28	1.000	36	1.000	0.468
R, Anterior lobe	40 -52 -22	3.21	1.000	58	1.000	0.352
R, Inferior frontal gyrus	54 34 0	3.03	1.000	161	0.991	0.127
R, Medial frontal gyrus (10)	12 52 -8	2.81	1.000	19	1.000	0.609
L, Rectal gyrus (11)	-2 36 -24	2.74	1.000	46	1.000	0.409
R, Middle temporal gyrus (39)	54 -64 22	2.71	1.000	14	1.000	0.667
L, Middle frontal gyrus (6)	-36 12 56	2.70	1.000	12	1.000	0.694
R, Fusiform gyrus (37)	28 -44 -14	2.70	1.000	11	1.000	0.708
R, Middle Temporal gyrus (21)	52 6 -36	2.69	1.000	7	1.000	0.775
R, Occipital lobe, Cuneus (18)	14 -86 24	2.68	1.000	10	1.000	0.723
L, Temporal lobe, Hippocampus	-26 -38 0	2.66	1.000	9	1.000	0.740
R, Superior temporal gyrus	52 -48 20	2.66	1.000	16	1.000	0.642
R, Middle frontal gyrus (8)	50 18 48	2.66	1.000	14	1.000	0.667
R, Temporal lobe, Fusiform gyrus, (20)	58 -40 -22	2.65	1.000	7	1.000	0.775
R, Precentral gyrus (4)	38 -22 64	2.65	1.000	5	1.000	0.816
R, Postcentral gyrus (3)	50 -14 54	2.62	1.000	3	1.000	0.865
L, Lentiform nucleus	-32 -10 -10	2.59	1.000	4	1.000	0.839
R, Superior parietal lobe (7)	30 -68 62	2.57	1.000	2	1.000	0.895
R, Superior occipital gyrus (19)	38 -84 24	2.56	1.000	12	1.000	0.694
R, Occipital lobe, Lingual gyrus	24 -86 -4	2.54	1.000	3	1.000	0.865
R, Caudate	16 18 10	2.51	1.000	2	1.000	0.895

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
L, Superior temporal gyrus (38)	-32 2 -18	2.49	1.000	3	1.000	0.865
R, Occipital lobe, Lingual gyrus (17)	8 -94 0	2.45	1.000	1	1.000	0.933

Note. HEM=hemisphere; L=left; R=right; BA=Brodmann's area; *k*=cluster extent (in 2 x 2 x 2 mm voxels). Clusters were *a priori* defined at *p=0.01*. The fitted model (contrast ambiguous vs. neutral) included DSQ, ADS and WBSI scores as regressors. ° reported region that reached significance either on a voxel (corr.) or a cluster (corr./uncorr.) level.

Table 14.2. Brain areas activated when processing emotional ambiguous sentences modulated by habitual thought suppression

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
L, Postcentral gyrus (7)	-14 -52 72	3.68	0.989	104	1.000	0.214
R, Inferior parietal lobe (40)	56 -28 24	3.66	0.991	115	0.999	0.192
R, Inferior temporal gyrus	66 -18 -18	3.38	1.000	38	1.000	0.455
R, Insula (13)	38 -28 22	3.35	1.000	74	1.000	0.293
R, Limbic lobe, Anterior cingulate (32)	4 48 4	3.09	1.000	27	1.000	0.534
L, Precentral gyrus (4)	-30 -22 58	3.01	1.000	31	1.000	0.503
R, Midbrain	20 -18 -2	2.83	1.000	16	1.000	0.642
R, Inferior frontal gyrus (45)	62 18 6	2.82	1.000	27	1.000	0.534
L, Frontal lobe	-20 2 44	2.80	1.000	14	1.000	0.667
R, Parietal lobe (7)	10 -64 62	2.66	1.000	13	1.000	0.680
R, Middle temporal gyrus (21)	56 -6 -12	2.57	1.000	5	1.000	0.816
R, Superior temporal gyrus (22)	46 -24 -2	2.54	1.000	2	1.000	0.895

HEM (BA)	Coordinates x y z (MNI)	*t*	*Voxel-level* *p* (FWE)	*k* (vol.)	*Cluster-level* *p* (corr.)	*p* (uncorr.)
R, Precentral gyrus (6)	26 -12 48	2.53	1.000	2	1.000	0.895
L, Medial frontal gyrus (9)	-4 54 34	2.52	1.000	2	1.000	0.895
L, Medial frontal gyrus (10)	-4 52 -6	2.52	1.000	5	1.000	0.816
R, Cerebrum	22 -32 24	2.52	1.000	2	1.000	0.895
R, Temporal lobe	32 -14 -10	2.49	1.000	4	1.000	0.839
L, Cingulate gyrus (24)	-12 -2 46	2.47	1.000	3	1.000	0.865

Note. HEM=hemisphere; L=left; R=right; BA=Brodmann's area; *k*=cluster extent (in 2 x 2 x 2 mm voxels). Clusters were *a priori* defined at $p=0.01$. The fitted model (contrast ambiguous vs. neutral) included DSQ, ADS and WBSI scores as regressors.

4. Discussion

The present study used an implicit task to assess negative bias in the information processing in a group at mild risk and in a group with no risk for depression. CBF during active and resting state was also assessed to investigate brain activation associated with processing of emotional ambiguous material.

4.1. Behaviour results

A negative bias in information processing is seen as a cognitive vulnerability factor for depression. Because research has found inconsistent results when measuring directly negative cognitions in subjects at risk for depression, one explanation derived from ironic process theory of thought suppression (Wegner, 1994) suggesting that vulnerable subjects suppress their negative thoughts. This process of mental control fails when under stress or cognitive load. In other words, a mental load would lead to a manifestation of negative thoughts. This paradoxical effect was supported by several studies that compared groups who remitted from a Major Depressive episode with groups that never experienced a depressive episode before, using the SST (e.g., Hedlund & Rude, 1995; Wenzlaff & Bates, 1998; van der Does, 2005). The present study compared subjects vulnerable for depression, i.e. who suffered a Minor Depressive episode before, with subjects at no risk for depression. The behavioural results showed that subjects at mild risk – relative to healthy subjects - built more negative sentences overall. This effect was enhanced when under an explicit cognitive load like keeping a nine-digit-number in mind. That is, subjects at mild risk for a depressive relapse built more negative sentences when under a mental load. Hence, the results are in line with previous studies. Furthermore, the new finding in present study is that even subjects with only a mild risk for depression show the negative bias in information processing.

This result is well in line with the cognitive theory of depression. According to Beck (1967), negative cognitive schemata develop early in life and might play a crucial role in the development of depression. Research has found evidence that these negative cognitive schemata exist before the first onset of a depressive episode. For example, children at risk for depression were examined for evidence of more negative cognitions about themselves. They were found to have more negative self-concept, less positive self-schemata and more negative attributional style (Jaenicke et al., 1987) compared to healthy counterparts. Dearing and Gotlib (2009) found cognitive negative biases in girls at risk for depression when asked to interpret ambiguous material in two information-processing tasks. Therefore, it is in line with cognitive theory and empirical evidence that the subjects at mild risk for depression in the present study also showed a cognitive negative bias in information processing that could be made assessable with the SST.

The findings of Dearing and Gotlib (2009) are also in line with the result that remitted Minor depressed subjects showed a greater amount of negative sentences independent of a cognitive load, since these investigators did not use a cognitive load condition. However, this effect disappeared when controlling for sex, WBSI and ADS. The data indicate stronger effects of gender and ADS than for WBSI, although the high correlation between ADS and WBSI suggest that both might share the same variance. Nevertheless, the higher the actual depression score, the more negative sentences were built (independently of a cognitive load). The ADS assesses the existence of depressive symptoms like depressed mood, sadness and feelings of worthlessness. Therefore, the ADS score is supposed to be correlated with a current mood state. As many studies have shown, negative mood reactivates and enhances dysfunctional cognitions (e.g., Miranda, Gross, Petersons & Hahn, 1998; Miranda & Persons, 1988; van der Does, 2005; for a review, see Ingram et al., 1998). Hence, the higher the ADS score, the more negative the actual mood respectively, the more negative sentences were built. But importantly, there were no effects of ADS on the cognitive load condition.

The significant interaction between cognitive load and gender resulted from the fact that males in the present study built more negative sentences under load than females. Also, men built more negative sentences overall. This is somewhat surprising because Wegner and Zanakos (1994), Blumberg (2000) and Rassin (2003) found gender differences on the WBSI with women exhibiting significantly higher thought suppression scores than men. However, a similar gender effect was reported by Rude, Wenzlaff, Gibbs, Vane and Whitney (2002) who found that men unscrambled more negative sentences under load than females. The difference to present investigation is that in Rude, Wenzlaff, Gibbs, Vane and Whitney's (2002) investigation men self-reported lower WBSI scores than women. The investigators' interpretation of discrepant self-report measures and SST scores was the reflection of different self-presentation strategies used by men and women. Men may have a higher threshold than women for describing their experiences in negative terms on self-report measures; yet their experiences or perceptions, as reflected by processing measures (like the SST score) may be as negative or more negative than women, in contrast to the self-report measurements (Rude, Wenzlaff, Gibbs, Vane & Whitney, 2002). Self-report inventories require respondents to quantify their experience and hence are subject to anchoring and estimation biases. This may also be true in the present study. Although men reported higher WBSI scores than women, male unscrambled more negative sentences overall, this effect was much more enhanced when under cognitive load, independently of their WBSI scores. This suggests that male indeed may have a higher threshold for describing their experiences on self-report measures. A second possible interpretation of the discrepant self-report and processing measures (SST) is the reflection of different emotion regulation strategies used by men and women. Men may use more thought suppression, while women are more expressive in their negative emotions. Western norms suggest that men use suppression to a greater degree than women. Although norms differ somewhat across specific emotions, expressing emotions is generally “viewed as unmanly” (Brody, 2000, p.26; cf. Gross & John, 2003); parents report teaching sons greater emotional control than daughters, and boys report that they are expected to inhibit their emotional expressions to a greater extent than girls (Underwood, Coie & Herbsman, 1992; cf. Gross & John, 2003). These gender differences emphasize the importance to use tests like the SST that measure process variables, in contrast to questionnaires and self-report measures that might be biased by social desirability and different self-presentations.

In contrast to other studies using the SST (Hedlund & Rude, 1995; Wenzlaff & Bates, 1998, van der Does, 2005), WBSI as a covariate neither explained nor correlated with the increase of negative sentences under load. Further exploration revealed that the subjects vulnerable for depression built more negative sentences during the scanning procedure. This effect was independent of gender but this time WBSI as a covariate showed an effect. However, the effect of WBSI vanished when ADS were included in the model, supporting the notion that WBSI and ADS might overlap in their factorial structure. Given that WBSI only correlated with mSSTscore, but not with SSTscore, the question arises whether the circumstances of the tasks before and during scanning are comparable. The highly significant correlation of both indices supports the fact that both conditions, SST before and during scanning, are related to each other. That is, the higher the increase of negative sentences under mental load before scanning, the more negative sentences were unscrambled during the scanning procedure. Hence, the modification of the SST to investigate brain activity during the unscrambling of emotional ambiguous sentences was successful.

Overall, the effect of WBSI seems to be difficult to interpret. The high correlation between ADS and WBSI (that might explain a large part of the same variance) and the significant interaction between WBSI and gender (men scored higher on the self-report measure) might be responsible for the inconsistent findings. However, the WBSI has been criticised because it does not only seem to measure suppression attempts, but also failing suppression (a combination of suppression attempts and the experience of intrusive thoughts) (e.g., Blumberg, 2000, Robichaud, Dugas & Conway, 2002; Rassin, 2003). Given that intrusions can be thought of as a result of failing cognitive control, it can be argued that the WBSI focuses on the negative side of thought suppression which might also be a depressogenic experience. Furthermore, the scale suffers from a conceptual overlap with questionnaires measuring intrusion-related complaints, and thus its correlations with such scales may be artificially high (see Rassin, 2003). Rassin (2003) proposed an alternative questionnaire that contains items construing a subscale explicitly referring to successful suppression. Rassin (2003) found also sex differences with men judging themselves to be more successful suppressors than did women in his version of measuring thought suppression. In his study, women engaged more frequently in suppression, but experience their suppression attempts as less successful. Future studies could use the modified version of the WBSI (see Rassin, 2003) to control for less overlap between WBSI and other psychopathology measurements (like ADS) and to assure a more valid thought suppression assessment, not only the failure of suppression attempts.

Another difference to other studies using SST (Hedlund & Rude, 1995; Wenzlaff & Bates, 1998, Van der Does, 2005) is a methodological one. In the present study, cognitive load is considered as within-subject-factor whereas other studies used this variable as between-subject factor. In the present study, the cognitive load procedure was used in the second block of sentences administered to each participant (similar to Rude, Wenzlaff, Gibbs, Vane & Whitney, 2002) while the subjects of other studies performed a set of sentences either with load or without load. However, a within-subject-factor design has the advantage that it is less susceptible to intersubject variability.

Overall, it is important to note that the number of subjects in the present study is not high enough to interpret the behavioural results validly. Future studies should assure to assess a greater number of healthy and vulnerable individuals and to counterbalance gender and age.

In summary, this is the first study that found that even subjects at mild risk for depression, i.e. who suffered a Minor Depressive episode in the past, built more negative sentences in the SST when under a cognitive load. This suggests that thought suppression as a cognitive vulnerability factor for depression – measured with the SST - is not only present in remitted Major depressed but also in remitted Minor depressed individuals. However, this increase could not be explained by the subjective rating of habitual thought suppression. Furthermore, effects of gender and ADS seem to be stronger. A conceptual overlap between ADS and WBSI appeared to make this questionnaire an inappropriate instrument to measure a habitual thought suppression. A modified version of WBSI was suggested for future studies. Finally, the significant interaction between cognitive load and gender hint to the fact that male built more negative sentences under mental load than their female counterparts.

4.2. Neuroimaging results

The first model of interest regarded the neural correlates of the processing of emotional ambiguous sentences. The results suggest that when emotional ambiguous verbal material – relative to neutral material - has to be unscrambled, the right vACC (BA 32), the right putamen, and the left parietal lobe (BA 3) were greater activated concomitant to a decrease in bilateral DLPFC (BA 6) and in left superior parietal lobe (BA 7). The initial hypothesis of the expected regions is only partly supported. An activation in ACC is well in line with neuroimaging studies using paradigms when cognitive control is required (e.g., Milham et al., 2001). Specifically, the vACC is often reported when emotional information has to be processed (Bush, Luu & Posner, 2000). An increased putamen along with an increased insula activation during the high-stress relative to a low-stress task have often been reported (e.g., Davidson & Irwin, 1999; Phan, Wager, Taylor & Liberzon, 2001). For example, Wang et al. (2005a) confronted healthy subjects with an unexpected math task to induce stress. They found an increased putamen and insula activation that was associated to higher stress and negative emotions. However, a decrease in DLPFC when processing ambiguous relative to neutral sentences is somewhat surprising. DLPFC regions have often been reported to be involved in top-down biasing toward task-relevant information and away from task-irrelevant information whether the information to-be-ignored is emotional or non-emotional (for a review, see Banich et al., 2009). They suggested that the dorsal ACC is involved in late-stage selection, which is influenced by how well DLPFC is able to implement attentional control. However, in the present study, relative to a baseline condition, DLPFC was increased when processing emotional ambiguous material but this activation was even more enhanced when processing neutral sentences.

The question arises what the decreased DLPFC activation might reflect. Tomasi, Ernst, Caparelli and Chang (2006) suggested two potential mechanisms underlying deactivation. Model 1: local reduction of rCBF in less active brain regions to compensate for rCBF increases in activated brain regions, without central involvement ("blood stealing") and Model 2: stimulus-correlated, centrally mediated inhibition of neural processes in task-irrelevant brain regions. Potentially, because the task was cognitively not demanding to present individuals, there was no need for a recruitment of a cognitive control entitiy like the DLPFC. The neural pattern showed that during the unscrambling of emotional ambiguous sentences regions are activated that involve emotional processing (vACC; BA 32) and negative emotions (putamen), while regions involved in cognitive control (DLPFC; BA 6), somatosensory (BA 3) and visual (BA 7) processes were not needed and therefore the rCBF was decreased. In the absence of emotional ambiguous material, the blood flow in somatosensory and visual as well as in cognitive control regions seems to increase. An explicit instruction to unscramble only positive or only negative sentences (e.g., Wenzlaff & Bates, 1998) may enhance the need for cognitive control. This would be in line with those neuroimaging studies that used an explicit thought suppression instruction (Wyland et al., 2003; Andersen et al., 2004; Mitchell et al., 2007) and that found a DLPFC involvement when trying to suppress a thought. This assumption is preliminary and requires empirical support. Additionally, the need for cognitive control and greater effort might be more enhanced in a current Major Depressive epsiode, but not in a vulnerable state of depression as in the present study.

The second model included the SSTscore (before scanning) and mSSTscore (during scanning) as regressors. A conjoint positive association of both scores included mainly the left TPJ (BA 40). While the SSTscore was not significantly associated to other regions, the mSSTscore showed additional associations to the insula (BA 13), the right OFC (BA 10) and the right occipital lobe (BA 18). The TPJ has been found to be recruited in various studies using a cognitive task where conflicts or interference has to be processed simultaneously. For example, a recent study by Fales et al. (2008) used an emotional conflict task. They reported a significantly reduced activation (greater deactivation) in left inferior parietal lobe (BA 40) in the low-anxious group in the default brain network. Corbetta and Shulman (2002) reviewed that the TPJ is strongly activated by target detection. When targets occur at an unexpected location, the activity in this area is further enhanced and even more lateralized to the right hemisphere. Areas that are centred on the right supramarginal and superior temporal gyrus (TPJ) and on the inferior frontal gyrus are most active when stimuli are presented at unattended locations and subjects reorient towards them. A TPJ activation has also been found in other experiments that involved reorienting of attention to unattended locations (Corbetta & Shulman, 2007), supporting representations of a potential response in a flanker task (Hazeltine, Poldrack & Gabrieli, 2000), in processes of distinguishing one's own from others' perspectives in the domain of perception, emotion or knowledge (D'Argembeau et al., 2007), and even in a study investigating the neural correlates of theory of mind and mentalizing task (Frith & Frith, 2003) where the authors concluded an association between TPJ and retrieving scripts that are built up through experience and record the particular goals and activities that take place in a particular setting at a particular time. Hence, a function of TPJ might be the initialization of greater effort of attention. It can be concluded that the processing of emotional ambiguous material require more attentional effort in situation when a negative sentence was built (mSSTscore) and when more negative sentences under mental load were unscrambled (SSTscore).

The OFC has been found to play a role in controlling emotional responses. A study by Johnson et al. (2005, Exp. 6) showed in a refreshing paradigm an activation in OFC (BA 10) when an emotional word had to be refreshed. There, subjects saw words on the screen that they must say out loud. In the refresh condition, an asterisk appears afterwards and the individual must say the previously presented word. In the repeat condition, which acts as a control, the word is simply shown on the screen and the word must be repeated. The effect of emotional context in this paradigm was investigated by showing three words simultaneously, two neutral and one emotional. The neural systems engaged by refreshing a neutral word as compared to an emotional one were identical, except for the activation in anterior OFC. The authors suggested that orbitofrontal regions might play a role in controlling emotional responses that might interfere with on-going processing of the neutral word.

In summary, the neural correlates of the SSTscore, that is the increase of negative sentences under a cognitive load, was expected to be more pronounced in brain regions that are associated to emotional processing. This assumption was not supported in the present study. Overall, the analyses of the second model, i.e. the results for both scores (SSTscore and mSSTscore) indicate that a greater effort of attentional orienting or distinguishing one’s own from other’s perspective is required when confronted with emotional ambiguous material compared to a neutral condition. Also, the mSSTscore - that is when negative sentences has been built during the scanning procedure - activated brain regions that are associated to the processing of emotional material, like the insula and the OFC. Similar to the scores derived from questionnaires, the effect of SSTscore was small. The lack of significantly associated brain areas to the SSTscore might be due to the fact that the SSTscore was not performed during the scanning procedure, i.e. is not a directly assessed score. Furthermore, the modified SST during scanning was performed without a cognitive load condition. A further modification of the SST would be needed that could be used during the fMRI procedure in order to get reliable data about the neural correlates of the processing of emotional ambiguous material when under cognitive load.

The third model focused on the modulation of the activated brain regions by the individual differences. They were the severity of a remitted Minor Depressive episode, scores of actual depression and habitual thought suppression. ADS, the score reflecting the current state of depressiveness was associated to the left parahippocampus (BA 36). Bremner et al. (2003) found in a baseline metabolism study increased activity in parahippocampal gyrus as well as the limbic regions predicting vulnerability for depressive symptoms in severely depressed patients. A recent default-mode-network study by Sheline et al. (2009) also reported an increased left parahippocampus activity in depressed subjects compared to controls in response to negative as compared with neutral pictures. The parahippocampus, the hippocampus and the amygdala are part of a limbic network that has been shown to be decreased in activity during cognitive tasks (Shulman et al., 1997). Studies have shown that decreases in activity during focused attention reflect a dynamic interaction between cognitive demands and the person's emotional state (Drevets & Raichle, 1998; Simpson, Drevets, Snyder, Gusnard & Raichle, 2001; Bush, Luu & Posner, 2000; Ochsner & Gross, 2005; Dolcos & McCarthy, 2006). In depression, it has been hypothesized that heightened limbic responses to negative affect-eliciting stimuli may provide a bottom-up source of input that can serve to dysregulate cognitive control systems that might normally suppress such affective responses (Drevets & Raichle, 1998; Mayberg, 1997; Costafreda, Brammer, David & Fu, 2008). This is supported by studies of cognitive task performance in depression that have revealed a failure to reduce activity in medial prefrontal regions in response to increased cognitive demand (Wagner et al., 2006) or during an emotional conflict task (Fales et al., 2008). As such, the failure of depressed patients to appropriately decrease activity in medial prefrontal regions suggests an impaired ability to suppress attention to internal emotional states. In the present study, the higher the depressive mood the more negative sentences were unscrambled overall. In line with the ironic process theory (Wegner & Wenzlaff, 1996), this can be interpreted in that way that a depressive mood state might be associated to an impaired ability to suppress not only the attention to internal emotional states but also to suppress an upcoming negative bias while processing emotional ambiguous material.

Like in the behaviour results, WBSI did not show strong effects on neuronal level when unscrambling emotional ambiguous sentences. As it has been previously discussed, the WBSI might overlap conceptually with ADS and is therefore not appropriate to measure habitual thought suppression. Other measurements of habitual thought suppression might be useful for future studies.

As expected, the severity of remitted Minor Depressive episode was associated to an activation in right VLPFC (BA 47) when confronted with emotional ambiguous material. Usually, studies found the VLPFC activated rather by cognitive than by emotional processes (e.g., Alexander et al., 1990; cf. Steele & Lawrie, 2004). However, the previously reported study by Fales et al. (2008) showed the right VLPFC (BA 47) interacting with anxiety and task difficulty in an emotional conflict task. In addition, the VLPFC has been suggested to be a useful vulnerability marker in depression in a verbal emotional memory task (Wolfensberger et al., 2008) They found increased left VLPFC activation by negative words in high-risk subjects, most prominently during recognition. This strengthens the assumption that a remitted Minor Depressive episode represents a vulnerability to depression. In the present study, the more severe the remitted Minor Depressive episode was the stronger the association to the right VLPFC (BA 47). It might be conceivable that the subjects vulnerable to depression are susceptible for depressive or anxious mood that could be provocated by the task. Future studies could focus on mood fluctuations that might modulate the neural activation. A right PFC activation has also been shown to be recruited when people are trying to reappraise by distancing oneself from a self-threatening stimuli by adopting a detached, third-person perspective (for a review, see Ochsner & Gross, 2008). This is supposed to be a form of an effective cognitive emotion regulation strategy. Possibly, the vulnerable subjects in the present study attempted to use a reappraisal strategy to cognitively regulate their emotions. Naturally, this assumption needs to be proven in future studies.

Overall, the individual differences showed less associations to the DLPFC or the dACC, those regions responsible for executive functions. Assuming that the process of thought suppression requires increased attentional and conflict monitoring efforts – as it has been demonstrated by studies that used an explicit thought suppression instruction (Wyland et al., 2003; Andersen et al., 2004; Mitchell et al., 2007) - it seems that there is no or few association between an increased vulnerability to depression and an increased effort to control cognitive processes. Furthermore, a mild risk for depression was associated to regions that have been found to interact with depression and anxiety. In summary, the results do not support the hypothesis that subjects vulnerable for depression require more cognitive control processes that are associated to DLPFC and dACC to suppress negative sentences. However, there might be other entities or concepts that might influence the processing of emotional ambiguous material when vulnerable to depression.

An important concept might be the working memory (WM) capacity. Because an individual's WM capacity indicates the capability to control attention, especially in contexts in which there are competing demands, individual differences in WM capacity should influence how well the accessibility of representations is managed and behavioural expressions are controlled in situations that are novel or that involve some time pressure. WM capacity also detemines having more or less attentional resources or regulating better or worse one's own attentional focus (Feldman Barrett, Tugade & Engle, 2004). As Braver, Gray and Burgess (2007) assumed, control processes are a critical component of WM function. The SST might involve control processes that require WM capacity. In line with this notion, some set of internal mechanisms must be responsible for (1) selecting information for active maintenance in WM, (2) ensuring that it can be stored for an appropriate length of time, (3) protecting it against sources of interference, (4) updating it at appropriate junctures, and (5) using it to influence other cognitive systems (i.e. perception, attention, memory and action) (Braver, Gray & Burgess, 2007). From this point of view, it is assumed that the SST is processed the more efficiently the better the working memory capacity of an individual. This notion is supported by Brewin and Beaton (2002) who investigated the modulation of individual differences in WM capacity and intelligence to the ability to intentionally suppress thoughts (measured with the White Bear paradigm). Their results indicated that more effective thought suppression was related to higher WM capacity and greater fluid intelligence. In addition, a diminished working memory capacity in depressed patients has often been reported (e.g., Harvey et al., 2004). Following this line of argument, the theory of Wegner (1994) can be refined in that way that the ability to unscramble positive sentences depends also on the individual WM capacity. Depression (as well as schizophrenia, frontal lobe damage, alcohol, fatigue etc.) is thought to reduce attentional resources and also to reduce the capacity for controlled processing (Feldman Barrett, Tugade & Engle, 2004). But because the WM capacity of Major depressed subjects who are in remission has also been found to be impaired (e.g., Weiland-Fiedler et al., 2004), i.e. the capacity for controlled processing is diminished, the negative bias in their information processing becomes manifest when the capacity is taxed by an additional cognitive load. This association might be less pronounced in remitted Minor depressed subjects, assuming that they perform at normal levels. In other words, a high WM capacity represents a protective factor for controlled processing in the vulnerability for depression. Naturally, further exploration is needed to answer the question whether vulnerable subjects show an impaired WM capacity and whether the individual WM capacity is associated to an increase of negative sentences under mental load or not.

In continuing the concept of WM, Braver, Gray and Burgess (2007) proposed an interesting theory that is strikingly similar to the ironic process theory. They suggested that cognitive control operates via two distinct operating modes: reactive and proactive control. A central hypothesis of their approach is that the core of WM is controlled processing: the ability to flexibly adapt behaviour to particular task demands, favouring the processing of task-relevant information over competing sources of information and emphasizing goal-compatible behaviour over habitual or otherwise dominant responses. In fact, people who are relatively successful in WM span tests are also relatively successful in resolving interference of various types (Jonides & Nee, 2006).

The distinction between proactive and reactive control would be comparable to a distinction between early selection and late correction (Braver, Gray & Burgess, 2007). Reactive control is engaged after - rather than before - the occurrence of some imperative event. Prior to this event, the system remains relatively unbiased, and so is more influenced by bottom-up inputs. Furthermore, reactive control mechanisms are engaged only as needed, on a “just-in-time” basis and in advance of critical events. When control depends on the use of context information, the activation of such information by reactive mechanisms occurs transiently rather than in a sustained fashion, and also decays away quickly. The usefulness of proactive control is that plans and behaviours can be continually adjusted to facilitate optimal completion of the goal. In contrast, with a reactive control strategy the goal would only be transiently activated at the time of intention, and then need to be reactivated again by an appropriate trigger event. Because of this need for repeated reactivation, there is greater dependence on the trigger events themselves, since if these are insufficiently salient or discriminative they will not drive reactivation. A brain system that might be critical for reactive control is the ACC (Braver, Gray & Burgess, 2007). This brain region indicates the demand for cognitive control by detecting the presence of response conflict or uncertainty due to interference, the activation of an erroneous response, or the likelihood of making an erroneous response. Under proactive control conditions, PFC activity should be present reliably across events, and not just on those in which it is most needed. The theory posits that these two forms of cognitive control are used by virtually all people at different times. Right VLPFC has been linked to response inhibition and the resolution of proactive interference (e.g., Aron, Robbins & Poldrack, 2004; Badre & Wagner, 2005) and more specifically to greater activation during retrieval of non-targets versus targets. The VLPFC might also be in order to manage, or perhaps prevent cognitive interference (Badre & Wagner, 2005). The concept of proactive interference as it has been proposed by Braver, Burgess and Gray (2007) would be well in line with the present study that has shown an increased right VLPFC (BA 47) in vulnerable subjects when unscrambling emotional ambiguous sentences. This would reflect their need for response inhibition and interference resolution. From this point of view, the attempt to suppress negative thoughts in subjects who are vulnerable for depression would be associated to a control of proactive interference. Future studies are needed in order to test the assumption of an association of WM capacity, the theory of proactive and reactive control with the processing of emotional ambiguous material in the SST.

There are some limitations of the present study that should be discussed shortly. One is the effect of learning and habituation. After two blocks of unscrambling sentences the subjects might get used to the task and might have learnt a strategy to control their internal emotional states provoked by the emotional ambiguous sentences. To minimize this effect, the SST before and during scanning has to be counterbalanced in future studies.

It should also be pointed out that the method of fMRI in general suffers disadvantages. For instance, fMRI cannot isolate brain regions that are critical for a specific function, but only identify those regions that may play a role. This method also can not determine whether signals reflect activation in a particular brain region or feedback/feedforward connections from other regions (for a recent review of these issues, see Logothetis, 2008; cf. Banich et al., 2009). Other neuroimaging techniques should be investigated in the future to shed more light on the information processing in individuals vulnerable for depression.

In summary, the behavioural results were well in line with the previously reported studies using the SST. Subjects vulnerable for depression showed an increase in the amount of negative sentences when under a cognitive load. The new finding is that the present subjects were only at mild risk for depression. However, an association between habitual thought suppression and the increase under a cognitive load have not been found. But this effect might be due to the assessment of habitual thought suppression. The WBSI might not be an approriate questionnaire since it assesses not only the attempt to suppress a thought but also the failure of such an attempt, which can be experienced as depressogenic. On a neuroimaging level, the processing of emotional ambiguous sentences showed an association to an increased vACC and putamen, concomitant to a decreased DLPFC activation. This emphasizes two points. First, the processing of emotional ambiguous material recruits regions that are associated with the control for emotional internal states (vACC) as well as negative emotions (putamen) and second, the SST without explicit instruction might not constitute a demanding task that would require the need for a cognitive control entitiy like the DLPFC in present subjects. Furthermore, when negative sentences were unscrambled, an increased activation was seen mainly in TPJ and OFC, suggesting more effort of attentional orienting and controlled emotional processes. The increase under mental load before the scanning procedure as well as depression, habitual thought suppression and the severity of a past Minor Depressive episode showed only marginally significant effects. There was a trend, that those subjects vulnerable for depression showed an increased activation in the right VLPFC (BA 47) when unscrambling emotional ambiguous relative to neutral sentences. This region has already been reported as a useful vulnerability marker for high-risk groups of depression, as well as when attempting to regulate one's own emotions by distancing from a stimuli. Initially, it was expected that if the vulnerable sujects would suppress their negative thoughts when processing emotional ambiguous sentences (as it is postulated by the ironic process theory) and that this would entail an aberrant activation in brain regions responsible for cognitive control and monitoring, like the DLPFC or the dACC. This initial hypothesis was not supported. But interestingly, an increased right VLPFC activation has been reported in line of the theory of reactive and proactive control. An increased right VLPFC activation would indicate the need for control of proactive interference in vulnerable subjects. Therefore, future studies should investigate the SST from the point of view of the theory of proactive and reactive control and try to integrate it to the ironic process theory. Additionally, there might be other influencing factors that have not been the focus in the present study, like the concept of working memory. This could represent a protective cognitive factor in the face of vulnerability for depression. Second, the conceptual overlap of WBSI and ADS makes it difficult to interpret the fitted models and hence, could not explain much of the variance at behavioural and neuroimaging levels. Third, the subjects who suffered a Minor Depressive episode in lifetime might function widely at a normal level. Further studies should include remitted Major Depressed subjects as an additional comparison group.

5. Summary

A negative cognitive bias in information processing is seen as a vulnerability factor for the development of depression. Previous research has shown that the Scrambled Sentences Task (SST) is an appropriate implicit test to measure the negative bias in information processing in remitted Major depressed individuals. A cognitive negative bias can not be seen in remitted depressed people – a high-risk group – when processing emotional ambiguous material in the SST. Only when put under mental load, the remitted depressed subjects show a negative cognitive bias. The ironic process theory of thought suppression explains these results with a suppression of negative thoughts in remitted depressed. This process of mental control would be disturbed by the additional cognitive load task.

One aim of the present study was to answer the question whether people at only mild risk for depression (i.e. who suffered a Minor Depressive episode in lifetime) also show this negative cognitive bias in their information processing or not. The fMRI helped to investigate the neural correlates that were associated with the processing of emotional ambiguous material in the SST. Different individual processes that might play a role were discussed.

The behavioural results suggest that even people at mild risk show an increase of negative sentences when under mental load. However, this increase was not associated to WBSI, a measurement of habitual thought suppression. When processing emotional ambiguous relative to neutral material, the neuroimaging data showed an association to an increase in vACC and putamen, indicating an involvement of higher stress and negative emotions, as well as a concomitant decreased DLPFC activation, indicating a less demanding task for present subjects. When negative sentences were unscrambled, activations in TPJ, OFC and insula were observable, that seem to reflect a greater effort for attentional orienting and controlling emotional responses. The experience of a Minor Depressive episode in lifetime was associated to the right VLPFC. This replicates other studies suggesting that this region might be a vulnerability marker for depression and anxiety. Furthermore, this region supports the notion that subjects vulnerable for depression would need more control for proactive interference than their healthy counterparts. The habitual thought suppression showed only marginal effects at behavioural and neural levels. This suggests that the processes might involve other influencing factors that has not been the focus in present work. The working memory capacity as a protective cognitive factor for normal functioning will be discussed.

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Appendix

Contents of appendix

A1: Depression Screening Questionnaire (DSQ)

Die folgenden Fragen beziehen sich auf eine momentane oder frühere Phase in Ihrem Leben, in der Sie sich besonders schlecht gefühlt haben und die **mindestens zwei Wochen** angedauert hat.

Wie lange hat diese Phase etwa gedauert? .... Wochen
Kreuzen Sie bitte für jede Beschreibung zuerst die Zahl an, die angibt, **wie zutreffend** die Beschreibung für Sie ist. Bei einem Zeitraum von mehr als 2 Wochen, beziehen Sie sich bitte auf die 2 schwierigsten Wochen.

		nein	manchmal	Fast täglich
	Haben Sie sich da die meiste Zeit des Tages über traurig, niedergeschlagen oder deprimiert gefühlt?			
	Haben Sie Ihr Interesse an fast allem verloren, oder konnten Sie sich nicht mehr über Dinge freuen, die Ihnen sonst Freude bereiteten?			
	Haben Sie sich müde, erschöpft oder ohne Energie gefühlt, auch wenn Sie nicht hart gearbeitet haben?			
	Haben Sie Ihren Appetit verloren oder erheblich an Gewicht verloren?			
	Oder hatten Sie mehr Appetit, so dass Sie zugenommen haben?			
	Hatten Sie Schwierigkeiten einzuschlafen, durchzuschlafen oder sind Sie zu früh aufgewacht?			
	Haben Sie langsamer gesprochen oder sich langsamer bewegt als gewöhnlich?			
	Mussten Sie sich die ganze Zeit bewegen, auf- und abgehen und konnten Sie nicht stillsitzen?			
	War Ihr sexuelles Interesse geringer oder hatten Sie gar kein sexuelles Interesse mehr?			
	Haben Sie Ihr Selbstvertrauen verloren, sich wertlos oder schuldig gefühlt oder machten Sie sich gar unbegründete Selbstvorwürfe?			
	Hatten Sie Schwierigkeiten sich zu konzentrieren (z.B. beim Lesen oder Fernsehen), oder alltägliche Entscheidungen zu treffen?			
	Haben Sie viel über den Tod nachgedacht oder dachten Sie daran, sich das Leben zu nehmen?			

A2: White Bear Suppression Inventory (WBSI)

In diesem Fragebogen geht es um Gedanken. Es gibt **keine richtige oder falsche Antwort**, bitte beantworten Sie die untenstehenden Fragen **wahrheitsgemäß,** wie es für Sie am ehesten zutrifft. Achten Sie darauf, dass Sie **jede einzelne Frage** beantworten, indem Sie die passende Antwort ankreuzen.

	Stimmt über-haupt nicht	**Stimmt eher nicht**	**Neutral / weiß ich nicht**	**Stimmt teil-weise**	**Stimmt voll-kommen**
1. Es gibt Dinge, über welche ich lieber nicht nachdenke.	❒	❒	❒	❒	❒
2. Manchmal frage ich mich, warum ich gerade diese Gedanken habe, die mir durch den Kopf gehen.	❒	❒	❒	❒	❒
3. Manche Gedanken kann ich nicht stoppen.	❒	❒	❒	❒	❒
4. Manchmal kommen mir Bilder in den Sinn, die ich nicht auslöschen kann.	❒	❒	❒	❒	❒
5. Meine Gedanken kreisen immer wieder um ein Thema.	❒	❒	❒	❒	❒
6. Ich wünschte, ich könnte aufhören, über bestimmte Dinge nachzudenken.	❒	❒	❒	❒	❒
7. Manchmal rasen mir Gedanken so schnell durch den Kopf, dass ich wünschte, ich könnte sie stoppen.	❒	❒	❒	❒	❒
8. Ich versuche immer, mir Probleme aus dem Sinn zu halten.	❒	❒	❒	❒	❒
9. Es gibt Gedanken, die sich immer wieder plötzlich aufdrängen.	❒	❒	❒	❒	❒
10. Es gibt Dinge, über die ich versuche nicht nachzudenken.	❒	❒	❒	❒	❒
11. Manchmal würde ich am liebsten einfach aufhören zu denken.	❒	❒	❒	❒	❒
12. Oft mache ich etwas, um mich von meinen Gedanken abzulenken.	❒	❒	❒	❒	❒
13. Es gibt Gedanken, die ich versuche zu vermeiden.	❒	❒	❒	❒	❒
14. Viele meiner Gedanken erzähle ich niemanden.	❒	❒	❒	❒	❒

	Stimmt über-haupt nicht	Stimmt eher nicht	Neutral / weiß ich nicht	Stimmt teil-weise	Stimmt voll-kommen
15. Manchmal halte ich mich mit etwas beschäftigt, damit sich keine Gedanken aufdrängen.	❐	❐	❐	❐	❐

A3: Allgemeine Depressionsskala (ADS)

Im Folgenden geht es um Ihre Stimmung in der letzten Woche. Bitte kreuzen Sie bei allen folgenden Aussagen jeweils die Antwort an, die Ihrem Befinden **während der letzten Woche** am besten entspricht/entsprochen hat.

Mögliche Antworten:			
	0	selten oder überhaupt nicht	(weniger als 1 Tag)
	1	manchmal	(1 bis 2 Tage lang)
	2	öfters	(3 bis 4 Tage lang)
	3	meistens, die ganze Zeit	(5 bis 7 Tage lang)

	Während der letzten Woche...	selten 0	manch-mal 1	öfters 2	meistens 3
1.	…haben mich Dinge beunruhigt, die mir sonst nichts ausmachen.	o	o	o	o
2.	…hatte ich kaum Appetit.	o	o	o	o
3.	…konnte ich meine trübsinnige Laune nicht loswerden, obwohl meine Freunde oder Familie versuchten, mich aufzumuntern.	o	o	o	o
4.	…kam ich mir genauso gut vor wie andere.	o	o	o	o
5.	…hatte ich Mühe, mich zu konzentrieren.	o	o	o	o
6.	…war ich deprimiert/niedergeschlagen.	o	o	o	o
7.	…war alles anstrengend für mich.	o	o	o	o
8.	…dachte ich voller Hoffnung an die Zukunft.	o	o	o	o
9.	…dachte ich, mein Leben ist ein einziger Fehlschlag.	o	o	o	o
10.	…hatte ich Angst.	o	o	o	o
11.	…habe ich schlecht geschlafen.	o	o	o	o
12.	…war ich fröhlich gestimmt.	o	o	o	o
13.	…habe ich weniger als sonst geredet.	o	o	o	o
14.	…fühlte ich mich einsam.	o	o	o	o
15.	…waren die Leute unfreundlich zu mir.	o	o	o	o

	Während der letzten Woche...	selten 0	manch-mal 1	öfters 2	meistens 3
16.	...habe ich das Leben genossen.	o	o	o	o
17.	...musste ich weinen.	o	o	o	o
18.	...war ich traurig.	o	o	o	o
19.	...hatte ich das Gefühl, dass mich die Leute nicht leiden können.	o	o	o	o
20.	...konnte ich mich zu nichts aufraffen.	o	o	o	o
21.	...war ich ungewöhnlich glücklich, erregt oder überdreht.	o	o	o	o
22.	...rasten meine Gedanken.	o	o	o	o
23.	...war ich sehr reizbar.	o	o	o	o
24.	...war ich extrem aktiv und mit vielen Dingen beschäftigt.	o	o	o	o
25.	...war ich sehr leicht ablenkbar und verlor ständig den Faden.	o	o	o	o
26.	...brauchte ich kaum Schlaf und hatte kein Schlafbedürfnis.	o	o	o	o
27.	...redete ich deutlich mehr oder schneller.	o	o	o	o
28.	...glaubte ich, ganz besondere Fähigkeiten/Kräfte zu haben.	o	o	o	o
29.	...konnte ich nicht still sitzen und fühlte mich getrieben.	o	o	o	o

A4: Oldfield Handedness scale

Vor Ihnen liegt eine Liste mit Tätigkeiten. Bitte geben Sie an, welche Hand Sie für diese Tätigkeit bevorzugen, indem Sie ein Kreuz (x) in die entsprechende Spalte machen. Wenn Sie in einem Fall keine Hand bevorzugen, tragen Sie bitte ein Kreuz in beide Spalten ein.

Versuchen Sie bitte, alle Fragen zu beantworten. Lassen Sie nur dann eine Lücke, wenn Sie mit einer Aufgabe überhaupt keine Erfahrung haben.

	links	rechts
1. schreiben		
2. zeichnen		
3. werfen		
4. schneiden		
5. Zahnbürste		
6. Messer (ohne Gabel)		
7. Löffel		
8. Besen (obere Hand)		
9. Streichholz anzünden (Streichholz)		
10. Schachtel aufmachen (Deckel)		
11. Welchen Fuß bevorzugen Sie zum Kicken?		
12. Welches Auge bevorzugen Sie, wenn sie photographieren?		

13. Besitzen Sie linkshändige Angehörige und in welchem Verwandtschaftsgrad?

A5: Participants’ instruction of the Scrambled Sentences Task (SST)

Sie werden gleich aufgefordert, Sätze zu bilden. Jeder der durcheinander gewürfelten Sätze bestehen aus sechs Wörtern. Lesen Sie bitte alle sechs Wörter aufmerksam durch bevor Sie einen Satz bilden und ihn niederschreiben. Jeder gebildete Satz sollte aus fünf Wörtern bestehen.

Z.B.:
hat grüne Kind das Augen blaue
Notiert:
Das Kind hat grüne Augen.

Bilden Sie bitte grammatikalisch richtige Sätze und keine Fragen. Sie können die Sätze so bilden, wie sie Ihnen zuerst in den Sinn kommen. Rechtschreibfehler sind nicht wichtig. Arbeiten sie so zügig wie möglich, da die Zeit pro Satz limitiert ist. Antworten Sie so spontan wie möglich und denken Sie nicht zu viel nach. Es gibt keine richtigen oder falschen Antworten.

A6: Scrambled Sentences in the SST

Block 1:

„das ist schön sehr Leben traurig“
„sterben Blumen die wachsen schnell meisten“
„Soldaten Ende am kämpften die siegten“
„sieht die Zukunft rosig düster aus“
„unsinnig Studium sinnvoll ein heutzutage ist“
„Hoffnungen das Paar keine hatte groß“
„Kopf mein ist sehr klar vernebelt“
„interessant Leben mein langweilig eher ist“
„beschwerlich Leben mir erscheint leicht das“
„ist sehr Leben mein stressig entspannt“
„Prüfung ich habe bestanden die verhauen“
„ist unmöglich zu Glück möglich erlangen“
„finde unsympathisch Person nett ich diese“
„Erwartungen erfülle die ich nicht schon“
„wahrscheinlich werde glücklich ich sein unglücklich“
„Problemen wachse ich an verzweifle meinen“
„gut mich Leute über schlecht denken die“
„ein dieser Kinofilm war Flop Hit“
„körperliches Aussehen mein akzeptabel ist schlecht“
„Leben das ist zu mir grausam gut“

Block 2:

“mich Leute verstehen missverstehen diese”
„viele mein Professor wenige Hausaufgaben vergibt“
„Pflanze meine ist langsam verblüht gewachsen“
„ist meines Lachen ansteckend Freundes das schrill“
„einmal ich versagen noch werde bestehen“
„Zukunft mir Sorgen die bereitet Freude“
„wertvolle ich wertlose bin eine Person“
„gewöhnlich mögen Leute verachten mich die“
„schwer die letzte war leicht Pfüfung“
„alles okay mir bei ist nichts“
„fühle gerade mich energievoll ich müde“
„vergeht Zeit schnell die langsam meistens“
„ist meine besser Konzentration momentan schlechter“
„traurig meine größtenteils Erinnerungen positiv sind“
„fällen ist schwer Entscheidungen zu leicht“
„nichts habe geben zu ich viel“
„heim ich möchte gerne weg gehen“
„nicht ich glaube an mich häufig“
„Zuneigung ich anderer verdiene die vermeide“
„habe ich viele Freunde verloren gefunden“

A7: Scrambled Sentences in the mSST

<u>Ambiguous sentences</u>

Block 1:

„langweilig andere ich sei denken interessant“
„ich verschwende Leben genieße mein momentan“
„für sind Leute gegen mich diese“

„ich von abgelehnt anderen werde akzeptiert“
„Probleme oft geschaffen ich gelöst habe“
„Misserfolg ich für gewöhnlich habe Erfolg“
„denke klug ich dumm ich bin“
„Person eine bin unzulängliche ich wertvolle“
„viele ich wenige genutzt habe Möglichkeiten“
„werde Ziele ich verfehlen erreichen meine“
„abschließen gut kann ich schlecht Dinge“
„geborener ich Versager ein Gewinner bin“
„mich unfähig ich fähig halte für“
„glücklich traurig zu werden ich erwarte“
„unzufrieden ich mit zufrieden bin mir“
„ewig könnte schlafen ich leben heute“
„kann gut nicht ich leiden mich“
„geschehen schlechte es werden gute Dinge“
„selbstbewusst fühle ich mich minderwertig häufig“
„allen kann ich wenigen Ansprüchen genügen“
„ich habe wenig bieten habe viel zu“
„Freunde habe viele wenige ich gute“
„ist heute Tag kein guter ein“
„besonders ich heute bin ich fröhlich unruhig“
„ich schlecht häufig gelaunt bin gut“

Block 2:

„bringt Zukunft viel die Gutes wenig”
„Tage sehr vergehen die schnell langsam“
„verschwende ich meine nutze häufig Zeit“
„fühle gut ich schlecht heute mich“
„voller Überraschungen Leben das steckt Trauer“
„immer ich enttäusche mich überrasche wieder“
„Zeit schlimm die letzte schön war“
„macht Arbeit mich die fertig glücklich“
„krank macht sehr das fröhlich bin sehr“
„erzählt alles sie gelassen sehr aufgeregt“
„bin sehr ich wohl empfindlich nicht“
„gereizt manchmal ich fröhlich bin sehr“
„Verzweiflung oft Freude fließen aus Tränen“
„Menschen Glück andere mehr haben Pech“
„gestern fühlte wohl einsam mich ich“
„bin mit unzufrieden mir zufrieden ich“
„das siegt Ende Gute Böse am“
„schwierige meide Situation diese meistere ich“
„leicht bin ich begeistern zu verunsichern“
„optimistisch häufig pessimistisch eher ich bin“
„zurückhaltend bin gegenüber ich anderen offen“
„an der schon fing Tag gut schlecht“
„Momente vermeide stets diese geniesse ich“
„ich gut ablenken kann schlecht mich“
„weniges um sorge vieles mich ich“

Neutral sentences

Block 1:

„der Hunger Mann keinen Durst hat"
„Zoo im viele tier sind exotische"
„der braun Bär weiß ist große"
„man oft das gehört hat gesehen"
„sie Tee trinken Morgen Kaffee jeden"
„Computer der alt ist neu sehr"
„das Wetter kühl warm geworden ist"
„sie abends Theater gingen Kino ins"
„Silvester vor feierten Kurzem Weihnachten wir"
„Cello Instrument ist altes ein großes"
„lebt Ulm er in seit langem kurzem"
„Süden ziehen Vögel fliegen die nach"
„Freizeit der in malt sie liest"
„Informationen Internet viele bietet das Möglichkeiten"
„spielen Kinder im die Schnee Sand"
„Kind Kreide malt Buntstiftem mit das"
„fährt großes ein teures sie Auto"
„Frau blonde diese Haare schwarze hat"
„dick Buch sehr das dünn ist"
„die groß klein Häuser recht sind"
„Sommer geht oft sie im baden schwimmen
„brennt die sehr hell Kerze lang"
„der bald Frühling schon beginnt Tag"
„steht gut passt das ihr Kleid"
„Süden ziehen Vögel fliegen die nach"

Block 2:

„war Abend organisiert der ungewöhnlich sehr"
„Winter fährt im Schlitten er Snowboard"
„den er Stuhl setzt Hocker sich auf"
„Bus fährt sie Fahrrad den mit"
„ein das neuer Kollege ist Student"
„laden Geburtstag sie Abendessen ein zum"
„weiß Fußball er viel Basketball über"
„sie wieder erkannt uns er hat"
„Wasser angenehm ist warm das kühl"
„Park Kinder im spielen Hunde die"
„schließt sie Tür ab die auf"
„nützliche er viele erhält Informationen neue"
„Hose neue die ist blau schwarz"
„verschmust die verspielt sehr Katze ist"
„ist Wohnung die eingerichtet gemütlich schön"
„Blumen Garten im wachsen die blühen"
„Sonne gerade die geht auf unter"
„ist sehr das Sofa bequem groß"
„Zeit es zu essen ist gehen"
„Geburtstag hat Frühling Sommer er im"
„Obst man Gemüse täglich essen sollte"
„an sie Nordsee fuhren die Ostsee"
„suchen sie Haus ein Auto neues"
„gestern heute als wärmer ist kälter"
„spazieren am einkaufen Wochenende sie gehen"

A8: Manipulation check of the mSST during fMRI session

Probandencode: ______________

Manipulation check 1: alternatives_amb_1

1 (pos)		2 (neg)		3 (pos)		4 (neg)		5 (pos/miss)		6 (neg)		Code
Ich habe andere oft zufriedengestellt		Ich habe andere oft enttäuscht		Oft zufriedengestellt habe ich andere		Oft enttäuscht habe ich andere		Zufriedengestellt habe ich andere oft		Enttäuscht habe ich andere oft		amb_01
Andere denken ich sei interessant		Andere denken ich sei langweilig		Ich sei interessant denken andere		Ich sei langweilig denken andere		Ich weiß nicht mehr				amb_02
Ich genieße mein Leben momentan		Ich verschwende mein Leben momentan		Momentan genieße ich mein Leben		Momentan verschwende ich mein Leben		Mein Leben genieße ich momentan		Mein Leben verschwende ich momentan		amb_03
Diese Leute sind für mich		Diese Leute sind gegen mich		Für mich sind diese Leute		Gegen mich sind diese Leute		Ich weiß nicht mehr				amb_04
Ich werde von anderen akzeptiert		Ich werde von anderen abgelehnt		Von anderen werde ich akzeptiert		Von anderen werde ich abgelehnt		Ich weiß nicht mehr				amb_05
Ich habe oft Probleme gelöst		Ich habe oft Probleme geschaffen		Oft habe ich Probleme gelöst		Oft habe ich Probleme geschaffen		Probleme habe ich oft gelöst		Probleme habe ich oft geschaffen		amb_06
Ich habe für gewöhnlich Erfolg		Ich habe für gewöhnlich Misserfolg		Für gewöhnlich habe ich Erfolg		Für gewöhnlich habe ich Misserfolg		Erfolg habe ich für gewöhnlich		Misserfolg habe ich für gewöhnlich		amb_07
Ich denke ich bin klug		Ich denke ich bin dumm		Ich bin klug denke ich		Ich bin dumm denke ich		Klug bin ich denke ich		Dumm bin ich denke ich		amb_08
Ich bin eine wertvolle Person		Ich bin eine unzulängliche Person		Eine wertvolle Person bin ich		Eine unzulängliche Person bin ich		Ich weiß nicht mehr				amb_09
Ich habe viele Möglichkeiten genutzt		Ich habe wenige Möglichkeiten genutzt		Viele Möglichkeiten habe ich genutzt		Wenige Möglichkeiten habe ich genutzt		Genutzt habe ich viele Möglichkeiten		Genutzt habe ich wenige Möglichkeiten		amb_10
Ich werde meine Ziele erreichen		Ich werde meine Ziele verfehlen		Meine Ziele werde ich erreichen		Meine Ziele werde ich verfehlen		Erreichen werde ich meine Ziele		Verfehlen werde ich meine Ziele		amb_11

Pos_ges: __________ Neg_ges : __________ Miss : ___________

Manipulation check 2: alternatives_ntrl_1

1		2		3		4		5		6		Code
Der Baum trägt viele Früchte		Der Baum trägt reife Früchte		Viele Früchte trägt der Baum		Reife Früchte trägt der Baum		Ich weiß nicht mehr				ntrl_01
Der Mann hat keinen Durst		Der Mann hat keinen Hunger		Keinen Durst hat der Mann		Keinen Hunger hat der Mann		Durst hat der Mann keinen		Hunger hat der Mann keinen		ntrl_02
Im Zoo sind viele Tiere		Im Zoo sind exotische Tiere		Viele Tiere sind im Zoo		Exotische Tiere sind im Zoo		Ich weiß nicht mehr				ntrl_03
Der große Bär ist weiß		Der große Bär ist braun		Weiß ist der große Bär		Braun ist der große Bär		Ich weiß nicht mehr				ntrl_04
Das hat man oft gehört		Das hat man oft gesehen		Oft gehört hat man das		Oft gesehen hat man das		Ich weiß nicht mehr				ntrl_05
Sie trinken jeden Morgen Tee		Sie trinken jeden Morgen Kaffee		Jeden Morgen trinken sie Tee		Jeden Morgen trinken sie Kaffee		Tee trinken sie jeden Morgen		Kaffee trinken sie jeden Morgen		ntrl_06
Der Computer ist sehr alt		Der Computer ist sehr neu		Sehr alt ist der Computer		Sehr neu ist der Computer		Ich weiß nicht mehr				ntrl_07
Das Wetter ist kühl geworden		Das Wetter ist warm geworden		Kühl ist das Wetter geworden		Warm ist das Wetter geworden		Ich weiß nicht mehr				ntrl_08
Sie gingen abends ins Theater		Sie gingen abends ins Kino		Abends gingen sie ins Theater		Abends gingen sie ins Kino		Ins Theater gingen sie abends		Ins Kino gingen sie abends		ntrl_09
Vor kurzem feierten wir Silvester		Vor kurzem feierten wir Weihnachten		Wir feierten vor kurzem Silvester		Wir feierten vor kurzem Weihnachten		Silvester feierten wir vor kurzem		Weihnachten feierten wir vor kurzem		ntrl_10
Cello ist ein altes Instrument		Cello ist ein großes Instrument		Ein altes Instrument ist Cello		Ein großes Instrument ist Cello		Ich weiß nicht mehr				ntrl_11

Miss : ___________

Manipulation check 3: alternatives_ntrl_2

1		2		3		4		5		6		Code
Sie kann sehr gut tanzen		Sie kann sehr gut jonglieren		Tanzen kann sie sehr gut		Jonglieren kann sie sehr gut		Sehr gut tanzen kann sie		Sehr gut jonglieren kann sie		ntrl_23
Der Abend war sehr organisiert		Der Abend war sehr ungewöhnlich		Sehr organisiert war der Abend		Sehr ungewöhnlich war der Abend		Ich weiß nicht mehr				ntrl_24
Im Winter fährt er Schlitten		Im Winter fährt er Snowboard		Er fährt im Winter Schlitten		Er fährt im Winter Snowboard		Schlitten fährt er im Winter		Snowboard fährt er im Winter		ntrl_25
Er setzt sich auf den Stuhl		Er setzt sich auf den Hocker		Auf den Stuhl setzt er sich		Auf den Hocker setzt er sich		Ich weiß nicht mehr				ntrl_26
Sie fährt mit dem Fahrrad		Sie fährt mit dem Bus		Mit dem Fahrrad fährt sie		Mit dem Bus fährt sie		Ich weiß nicht mehr				ntrl_27
Das ist ein neuer Kollege		Das ist ein neuer Student		Ein neuer Kollege ist das		Ein neuer Student ist das		Ich weiß nicht mehr				ntrl_28
Sie laden zum Geburtstag ein		Sie laden zum Abendessen ein		Zum Geburtstag laden sie ein		Zum Abendessen laden sie ein		Ich weiß nicht mehr				ntrl_29
Er weiß viel über Fußball		Er weiß viel über Basketball		Viel über Fußball weiß er		Viel über Basketball weiß er		Über Fußball weiß er viel		Über Basketball weiß er viel		ntrl_30
Er hat sie wieder erkannt		Er hat uns wieder erkannt		Sie hat er wieder erkannt		Uns hat er wieder erkannt		Wieder erkannt hat er sie		Wieder erkannt hat er uns		ntrl_31
Das Wasser ist angenehm warm		Das Wasser ist angenehm kühl		Angenehm warm ist das Wasser		Angenehm kühl ist das Wasser		Ich weiß nicht mehr				ntrl_32
Die Kinder spielen im Park		Die Hunde spielen im Park		Im Park spielen die Kinder		Im Park spielen die Hunde		Ich weiß nicht mehr				ntrl_33

Miss : ___________

Manipulation check 4: alternatives_amb_2

1 (pos)		2 (neg)		3 (pos)		4 (neg)		5 (pos)		6 (neg)		Code
Ich mache mir wenige Sorgen		Ich mache mir viele Sorgen		Wenige Sorgen mache ich mir		Viele Sorgen mache ich mir		Ich weiß nicht mehr				amb_23
Die Zukunft bringt viel Gutes		Die Zukunft bringt wenig Gutes		Viel Gutes bringt die Zukunft		Wenig Gutes bringt die Zukunft		Gutes bringt die Zukunft viel		Gutes bringt die Zukunft wenig		amb_24
Die Tage vergehen sehr schnell		Die Tage vergehen sehr langsam		Sehr schnell vergehen die Tage		Sehr langsam vergehen die Tage		Ich weiß nicht mehr				amb_25
Ich nutze häufig meine Zeit		Ich verschwende häufig meine Zeit		Meine Zeit nutze ich häufig		Meine Zeit verschwende ich häufig		Häufig nutze ich meine Zeit		Häufig verschwende ich meine Zeit		amb_26
Ich fühle mich heute gut		Ich fühle mich heute schlecht		Heute fühle ich mich gut		Heute fühle ich mich schlecht		Gut fühle ich mich heute		Schlecht fühle mich heute		amb_27
Das Leben steckt voller Überraschungen		Das Leben steckt voller Trauer		Voller Überraschungen steckt das Leben		Voller Trauer steckt das Leben		Ich weiß nicht mehr				amb_28
Ich überrasche mich immer wieder		Ich enttäusche mich immer wieder		Immer wieder überrasche ich mich		Immer wieder enttäusche ich mich		Ich weiß nicht mehr				amb_29
Die letzte Zeit war schön		Die letzte Zeit war schlimm		Schön war die letzte Zeit		Schlimm war die letzte Zeit		Ich weiß nicht mehr				amb_30
Die Arbeit macht mich glücklich		Die Arbeit macht mich fertig		Glücklich macht mich die Arbeit		Fertig macht mich die Arbeit		Ich weiß nicht mehr				amb_31
Das macht mich sehr fröhlich		Das macht mich sehr krank		Sehr fröhlich macht mich das		Sehr lustig macht mich das		Ich weiß nicht mehr				amb_32
Sie erzählt alles sehr gelassen		Sie erzählt alles sehr aufgeregt		Alles erzählt sie sehr gelassen		Alles erzählt sie sehr aufgeregt		Sehr gelassen erzählt sie alles		Sehr aufgeregt erzählt sie alles		amb_33

Pos_ges: ___________ **Neg_ges :** ____________ **Miss :** ___________

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