

## **A Review of Cognitive Inhibition in Adults with Unipolar Depression**

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### **ABSTRACT**

Although it is generally accepted that systematic processing biases are associated with depressive episodes, what is less well understood are the mechanisms responsible for such negative cognitive biases. Overall, empirical evidence has suggested that cognitive inhibitory deficits of emotional processing may play a central role in the onset and maintenance of depression. Thus, research has begun to investigate cognitive inhibition, a mechanism proposed to be fundamental to the negative cognitive biases evidenced within depression. These investigations may help to fill these gaps in the literature. The aim of the current paper was to provide a comprehensive review of the literature related to cognitive inhibition and investigate the evidence supporting the role of cognitive inhibition in the development and maintenance of major depressive disorder. Relevant research is reviewed and the current methods for examining cognitive inhibition are discussed. Furthermore, the implications of these results for research examining selective attention within depression are considered.

*Key words:* depression, cognitive inhibition, information processing, cognitive vulnerability.

### ***Novelty and Significance***

*What is already known about the topic?*

- Research largely suggests that depressed patients exhibit an inability to inhibit neutral information access to working memory, restrain and delete irrelevant information. This cognitive inhibition deficit could explain cognitive processing issues in depression.

*What this paper adds?*

- Cognitive inhibition is a key factor in important models of depression and the current manuscript provides both a brief review of the research on cognitive inhibition and depression, as well as considering future directions.
- The current manuscript considers the issue from the viewpoint of multiple methodologies for accessing inhibition. This allows the reader to compare and contrast the results from multiple tasks.

The various mood disorders, including depression, are considered among the most prevalent and serious of all psychological illnesses. Major depressive disorder is one of the leading causes of disability worldwide (World Health Organization, 2008). In fact, some studies suggest that as many as 25% of women and 12% of men will experience depression sometime during their lifetimes (American Psychiatric Association, 2000). A current depressive episode is often associated with anhedonia, persistent sadness and disturbances of normal sleep, appetite, and cognitive functioning. Therefore, it is clear that this disorder is a serious issue for both the medical and mental health fields. The investigation of dysfunctional processes that are theorized to underlie and maintain depression after its onset can increase our understanding of risk and causality, the disorder itself, and potentially help us develop more effective intervention strategies.

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Overall, empirical evidence suggests that individuals with depression tend to evidence a systematic negative processing bias during depressive episodes (Haaga, Dyck, & Ernst, 1991; Ingram & Holle, 1992). For example, depressed individuals have been found to selectively encode negative information (Ingram & Holle, 1992). Individuals with depression have also been found to recall considerably more negative information than positive information (Matt, Vazquez, & Campbell, 1992). It has also long been suggested that these individuals selectively attend to negative information and tend to interpret neutral information as being more negative than it truly is (Beck, 1976). Therefore, a number of prominent theories propose that these negative biases likely play a central role in the onset and maintenance of depression (Beck, 1976; Clark, Beck, & Alford, 1999; Mathews & MacLeod, 2005).

Research on depression has only recently begun to examine the processes responsible for these negative cognitive biases. Thus, although the evidence generally supports these systematic negative biases in information processing during depression, what is less well understood are the mechanisms related to these biases. Therefore, the goal of the current paper is to provide a comprehensive review of the literature surrounding cognitive inhibition, a mechanism proposed to be fundamental to the processes of negative cognitive biases.

#### **RELATIONSHIP TO EMOTION REGULATION**

Some theories have suggested that depressed persons do not respond differently to negative stimuli than do individuals who are non-depressed. Instead, it may be that those who are depressed have a harder time recovering from the experience of negative emotions (Teasdale, 1988; Rottenberg, 2007). Thus, this implies that depression is not a problem related to one's initial response to negative events, but is actually a problem with the subsequent emotion regulation.

Emotion regulation refers to the cognitive processes that individuals use in order to control the influence of emotionally arousing stimuli or information. It has previously been argued that cognitive inhibition plays a central role in the regulation of emotion (Joormann, Yoon, & Zetsche, 2007; Joormann, 2010). Maladaptive emotion regulation strategies have been implicated as being a key mechanism in contributing to depression. Some go so far as to suggest that the disorder should be conceptualized as a result of impaired emotion regulation (Campbell-Sills & Barlow, 2006). Therefore, this idea highlights the importance of cognitive inhibition as an emotion regulation strategy in relation to depression.

Although cognitive inhibition is a complex mechanism of executive control involving numerous components, it can be described as the process of restricting or disregarding irrelevant information, preventing the activation of unnecessary information and updating the content of working memory (Hasher, Zacks, & May, 1999; Friedman, & Miyake, 2004). In the context of depression, it has been suggested that depressed individuals may have a hard time ignoring or inhibiting the processing of negatively valenced information (Joormann, 2010), meaning that selective attention and cognitive biases for negative information may result from impaired inhibitory processes. The same may be

true for individuals who are vulnerable to the development of depression. Furthermore, deficits in inhibition processes are thought to bring about depressed individuals' biased recall and memory for negative information, which consequently exacerbates negative affectivity. Thus, it is theorized that deficits in cognitive inhibition may play a central role in the onset and maintenance of depressive psychopathology.

### SYSTEMATIC REVIEW

The aim of the current paper was to provide a comprehensive review of the literature related to cognitive inhibition and investigate the evidence supporting the role of cognitive inhibition in the development and maintenance of major depressive disorder.

#### *Literature Search*

Relevant studies were identified through thorough searches of several online databases, including PsycINFO, PubMed, and MEDLINE through April 2012. Keyword searches were employed using combinations of the terms *cognitive inhibition*, *inhibition*, *inhibit*, *inhibitory deficits*, *negative information* and *negative stimuli* paired with *depression*, *dysphoria* and *major depressive disorder*. Abstracts of all articles were read to determine whether the studies met the inclusion criteria. In instances where there was some doubt, the full text of the article was also read. The author also examined the reference sections of studies meeting inclusion criteria for any additional relevant studies.

#### *Inclusion and Exclusion Criteria for Included Studies*

The current review included studies that met the following criteria. To refine the search, it was required that articles were written in English and were designed to specifically address the issue of cognitive inhibition in relation to unipolar depression. Only studies including a majority of participants who were identified as having a current or past history of major depressive disorder were included. In order to address this issue within an adult sample, studies investigating children, adolescents or elderly populations were excluded. In addition, in order to provide a unitary review, studies were excluded if the depressed participants had co-occurring suicidal ideations or psychotic symptoms or if they met criteria for bipolar disorder, substance abuse disorders or had any other serious psychological issue.

### RESULTS

The presentation of results will be organized according to the type of experimental paradigms and methods which were employed in the various studies.

#### *Cognitive Inhibition and the Negative Affective Priming (NAP) task*

The negative affective priming (NAP) task consists of trials involving a prime trial followed by a test trial. In both trials individuals are simultaneously presented

with two stimuli, a target and a distractor, and instructed to respond to the target while ignoring the distractor. The NAP paradigm uses emotionally valent stimuli as the targets and distractors. In experimental conditions, the valence of the distractor in the prime trial is related to the target of the test trial. In control conditions, there is no relationship between the distractors and targets. Alternative designs employ the same precise stimuli, rather than relating the stimuli on valence, meaning that the distractor becomes the target on the subsequent test trial. The act of ignoring the distractor in the prime trial is what serves as the inhibition. The extent to which the distractor is still inhibited during the consecutive test trial relates to the delay in responses. This delayed response is referred to as the negative priming effect and is considered to be a valid measure of the inhibitory processing of emotional information.

As expected, Wentura (1999) found that participants instructed to ignore distractors during the prime trials demonstrated a slower response during the test trials when the target matched the valence of the prime distractor, as compared to control conditions. Although the original design was developed by Wentura (1999), it was Joormann (2004) who proposed this improved version of this paradigm to study the processes of selective attention within individuals with depression. Furthermore, it was theorized that individuals with depression would not demonstrate this NAP effect with negatively valenced information due to the proposed deficits of cognitive inhibition.

A great deal of research investigating this topic has used this method in order to study cognitive inhibition. For example, Joormann and Gotlib (2010) used this NAP task to assess inhibition in clinically depressed, formerly depressed, and never-depressed participants. They found that depressed participants exhibited less effective inhibition when processing negative words. It is also worth noting, that inhibition functioning was unaffected for positive words. This finding was consistent with an earlier NAP study in which individuals were instructed to evaluate the target as being either negative or positive. This study found that depressed individuals demonstrated a reduced negative affective priming effect which indicates that these individuals are inadequately inhibiting negative information (Joormann, 2004). Furthermore, previously depressed individuals also failed to evidence a delayed response in the priming condition, as compared to the control condition, when presented with negative target words.

In addition, Goeleven, DeRaedt, Baert, & Koster (2006) used this design with pictures of happy and sad emotional faces as the stimuli to study inhibition in hospitalized patients diagnosed with major depressive disorder, participants with a former history of depression and never-depressed control participants. Individuals experiencing a current depressive episode evidenced an inability to sufficiently inhibit the negative information and formerly depressed individuals still demonstrated a decreased inhibition.

Frings, Wentura, & Holtz (2007) again confirmed this pattern of results, finding that negative priming effects were directly related to participants' depressive symptomatology as measured by the Beck Depressive Inventory (BDI). For individuals obtaining lower scores on the BDI (average score of 3), or nondysphorics, they found significant priming effects for negative information, but no effect for positive information. Whereas, for individuals obtaining high scores on the BDI (average score of 12), they found a significant priming effect for positive information, but no effect for negative

information. In addition, these results demonstrated that BDI scores were highly correlated with negative priming effects. Therefore, the authors interpreted this as meaning that dysphoric status acts to mediate negative priming effects for negative information.

Finally, Yao, Liu, Liu, Hu, Yi, & Huang (2010) replicated these results using the NAP task and electroencephalogram (EEG) recordings among patients with unipolar depression and control participants. The results revealed that control participants demonstrated the expected negative priming effect, whereas individuals with depression demonstrated faster reaction times in the experimental condition during negative trials, meaning that the prime distractor matched the valence of the test target. Analyses of event-related potentials (ERPs) also showed these results. Depressed patients displayed smaller P2 amplitudes for negative trials in the experimental condition, as compared to the control condition. Furthermore, these patients also demonstrated reduced late positive component (LPC) amplitudes for negative trials in the experimental condition. Thus, both the behavioral measures and the ERP results support the theory that depressed individuals possess reduced cognitive inhibition abilities when it comes to negative information.

Overall, the results from NAP studies show that individuals without depression exhibit negative affective priming effects for negative words, whereas depressed individuals do not exhibit this effect. This lack of effect is believed to be caused by an inability to ignore negative prime distractors. Therefore, these studies provide evidence which suggests that depression may be characterized by an inability to ignore or disengage attention from negative information even if that information is irrelevant.

#### *Cognitive Inhibition and the Prose Distraction Task (PDT)*

In the Prose Distraction Task (PDT; Connelly, Hasher & Zacks, 1991) participants are presented with printed stories containing distractor words irrelevant to the story which are printed in italics. Participants are then required to read the story aloud while ignoring any distracting material. This design has been used to study individual abilities to inhibit negative material and has therefore been employed with those suffering from depression.

In an attempt to determine whether cognitive inhibition is specific to emotionally valent material, Gohier *et al.* (2009) used neutral stimuli in combination with the PDT for control participants and patients diagnosed with major depressive disorder. The results showed that individuals with depression performed worse than controls, reading significantly slower and making more errors. This suggests the presence of great difficulties in disregarding the irrelevant material, which indicates an impairment in inhibition processes.

Lau, Christensen, Hawley, Gemar, & Segal (2007) also employed the PDT with patients diagnosed with major depressive disorder, non-depressed anxious control participants and healthy control participants. However, the italicized distractor words in this study were emotionally valenced adjectives. They found that individuals with depression read significantly slower when the stories contained negative distractor words as compared to neutral or positive distractors; whereas, both control groups read stories with positive and neutral distractors much slower than those with negative distractors.

Both studies indicate that prose reading is significantly disrupted for individuals with depression when stories contain negative distractor words. This may be due to their inability to prevent negative material from entering into their working memory which slows down their overall ability to perform the task and might also account for errors. This further supports the theory that depressed individuals possess poor inhibitory control during circumstances involving negative material.

### *Cognitive Inhibition and the Stroop Test*

The Stroop test (Stroop, 1935) is a commonly used measure that has been used to study numerous clinical issues. For instance, it can be helpful in assessing inhibition in those with depression. In the original procedure, participants are presented with a list of words describing colors and asked to name the color of the ink in which each word is written. However, the color of the ink does not correspond to the name of the color. For example, the participants may have to indicate that the word is written in blue ink despite the fact that the written word says 'red'. Gohier *et al.* (2009) utilized this version of the Stroop test and found that depressed participants took significantly longer to complete the task, again providing support for the theory of cognitive inhibition.

McNeely, Lau, Christensen, & Alain (2008) used an emotional Stroop test while collecting ERP data from participants. This design remains the same except that instead of representing the names of colors, the stimuli are now words with a pleasant, unpleasant or neutral meaning. Thus, participants were shown words of various colors and asked to identify the ink color as quickly as possible, regardless of word valence. Although it would be expected that depressed participants should respond more slowly to unpleasant words than to neutral or pleasant words this pattern was not found. However, individuals with major depressive disorder demonstrated a larger N450 wave, which is described as a negative response regulated by the proportion of congruent and incongruent stimuli, for positive and negative words. Since this component is used as an index of inhibition this may represent an inability to inhibit emotionally valent words.

Dai & Feng (2011) recruited never depressed controls, previously depressed but remitted participants and currently depressed patients to complete the emotional Stroop test during ERP data collection. As expected, patients with major depressive disorder exhibited larger interference effects for negative words than for positive words. In addition, these participants evidenced a larger interference effect for negative words than both the control and previously depressed groups. The depressed participants also evidenced reduced N1 amplitudes for negative words which correlates with slower response times and suggests reduced inhibition. These individuals also exhibited reduced P1 amplitudes for positive words, which indicates lesser attentional allocations for positive material. The N450 components also demonstrated elevated negativity for negative information. The previously depressed group also showed this enhanced negativity in their N450 results, indicating that these individuals may still have a hard time inhibiting negative information despite being in remission.

Årdal & Hammar (2011) used a longitudinal design to examine Norwegians diagnosed with unipolar depression and healthy controls of a similar demographic make-up. Participants completed the non-emotional version of the Stroop test during

the acute phase of their illness and again at both a 6-month and 10-year follow-up. Analyses revealed that individuals with depression took significantly longer to complete the Stroop test than the control group. In addition, scores for the depressed group during the initial assessment were highly correlated with their scores at the 10-year follow-up. Therefore, large inhibition deficits in the acute phase of depression are related to large deficits 10 years later, which may indicate that cognitive inhibition is a chronic problem within depression.

### *Cognitive Inhibition and Alternative Designs*

The aforementioned study by Lau *et al.* (2007) employed the stop-signal task (SST; Logan, Schachar, & Tannock, 1997) to study inhibition, in addition to the PDT. In this task, participants were instructed to indicate, as quickly as possible, whether a presented stimulus is a word or non-word. Participants were also asked to inhibit their responses when they heard a specific tone, which served as their signal to stop. However, the SST performance of participants with major depressive disorder did not significantly differ from either control group on this task.

Gohier *et al.* (2009) also used a number of other measures within their research design. Each of these tasks evaluated a different executive function related to cognitive inhibition. These assessments included the Trail Making Test (TMT), the Modified Card Sorting Test (MCST), the Rule Shift Cards (RSC), and the Hayling Sentence Completion test (HSC). They found that depressed participants completed the TMT much more slowly and took significantly longer to execute the RSC task. Furthermore, these individuals performed worse on the HSC, making significantly more errors and having a longer completion time. However, there were no differences found among groups based on the MCST.

### LIMITATIONS

Although many of these studies have found evidence supporting the theory of cognitive inhibition, there are a few problems that limit our ability to draw conclusions about the relationship between depressed mood and causal attributions of cognitive inhibition. The emotional Stroop task was used to measure this construct within a number of these studies (McNeely, Lau, Christensen, & Alain, 2008; Dai & Feng, 2011; Årdal & Hammar, 2011), which collectively demonstrate that depressed individuals take significantly longer to respond when the word intended to be ignored has negative emotional salience indicating that this causes interference. However, some have argued that it is hard to directly measure the inhibition of irrelevant information as opposed to the processing of relevant information because the design of the task requires that participants actively select one property from within a stimulus with multiple components (Mogg & Bradley, 2005).

Therefore, negative affective priming is proposed to be a more advantageous design for the study of this concept. However, the calculation of the negative affective priming effect also leaves room for ambiguous interpretation when it comes to the specific cause of any observed effects given that the design presents a confound between the distractor

valence of prime trials and NAP differences for positive and negative targets of test trials (Joormann, 2004). Thus, any interpretation of the results from separate analyses of positive and negative test target trials should be done so with caution. Furthermore, some have proposed that it is possible that the healthy controls are not responding to negative stimuli as quickly as depressed participants simply because they are more irritated by this emotional input which is what may cause the NAP effect rather than an increased ability to inhibition this information (Frings, Wentura, & Holtz, 2007).

Overall, these designs are helpful in providing us with more information, but they cannot perfectly answer the question of whether cognitive inhibition is occurring and whether or not it is a cause or a symptom of depression.

### **FUTURE DIRECTIONS**

Future research should be conducted in order to confirm the results of these research studies and to address the aforementioned limitations. In addition, new research methods may need to be designed in order to more effectively assess for cognitive inhibition deficits.

As of yet, no research has attempted to look at cognitive inhibition through the use of pupillometry techniques. Numerous studies have documented that pupil dilation provides an accurate evaluation of cognitive processing. For example, researchers have found that pupil dilation is associated with the interpretation of difficult material, increased memory usage and the use of great or prolonged attention (Beatty, 1982). Therefore, it has long been understood that information processing can be accessed via pupillometry. It could be interesting to investigate the construct of cognitive inhibition through these means. Measuring depressed individuals' pupil dilation in response to negative and positive stimuli in the context of being instructed to ignore the emotional valence of the stimuli might provide a more accurate assessment of whether they can effectively inhibit the processing of negative information. Thus, this might be an area that should be addressed by future research in order to advance knowledge on this topic and provide a more accurate picture of this issue.

### **CONCLUSIONS**

Studies using the emotional Stroop task found that when depressed individuals were asked to name the color of ink for positive and negative adjectives they took significantly longer to respond when the word intended to be ignored was emotionally negative. Furthermore, ERP analyses provided further support that there are larger interference effects for negative words than for positive words, which suggests reduced inhibition.

Research investigating cognitive inhibition through the prose distraction task indicates that prose reading is significantly disrupted for individuals with depression when stories contain negative distractor words. This also suggests the presence of great difficulties disregarding the irrelevant material, which again indicates an impairment in inhibition processes.

In addition, the results from studies employing a negative affective priming design

show that individuals without depression exhibit negative affective priming effects for negative words, whereas depressed individuals do not show this effect. This lack of effect is believed to be caused by an inability to ignore negative prime distractors. Therefore, these studies provide evidence which suggests that depression may be characterized by an inability to ignore or disengage attention from negative information even if that information is irrelevant.

It is believed that the deficits in cognitive inhibition should be particularly apparent in the individual processing of emotionally salient information. Therefore, researchers have theorized that these inhibitory deficits work in combination with the activation of mood congruent cognition within depressed individuals in order to facilitate the processing of negative information and inhibit their ability to remove this information from within their working memory. In general, these studies seem to support this theory and provide evidence for the reduction of cognitive inhibition abilities when it comes to negative information among individuals with depression.

Further studies should attempt to further explore this construct through additional methodological designs in order to provide more thorough evidence.

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