“Where is the emotional Stroop effect in depression?”

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Abstract

Scope

The literature remains inconsistent regarding a negative attentional bias in depression, as shown on the emotional Stroop task. This study used a non-clinical undergraduate sample to investigate how depression severity influences performance on the emotional Stroop task compared to a new task that enforced emotional processing. Different calculations of the emotional Stroop effect (ESE) were also compared to determine the influence of depression at different stages of emotional processing.

Purpose

To examine alternative explanations for the ESE and how this relates to theories of depression beyond a negative attentional bias. By comparing the emotional Stroop task to a novel forced-processing task (forced task), this study aimed to test whether emotional processing is a mandatory outcome in the emotional Stroop task, as assumed by studies searching for an automatic attentional bias. The ESE was deconstructed into both a fast effect, where interference results from the current emotional word, and a slow effect, where interference carries over from the previous emotional word. Isolating these two effects within the context of depression allows for an investigation of whether depression increases an immediate attentional bias, the fast effect, or whether depression instead involves a difficulty in inhibiting the effect of previous emotional words, the slow effect. Both positive and negative words were included as emotional stimuli to test whether the ESE is due to interference from emotion generally, or a valence-specific bias.

Methodology

Fourteen participants completed the Beck Depression Inventory II (BDI-II) as a measure of depression severity, and the Depression Anxiety Stress Scales (DASS-21) to measure possible
confounding variables of anxiety and stress. Participants performed in two tasks: the emotional Stroop task and the forced task. In the emotional Stroop task, participants were asked to classify the print colour of emotional (positive and negative) words and non-emotional (neutral) words by pressing the corresponding coloured key. In the forced task, participants were asked to classify the colour of the words only if the word was emotional and to press a different key if the word was neutral, therefore participant responses were contingent on understanding the word meaning and emotional processing was mandatory.

Results

Six out of 14 participants scored in the depression range on the BDI-II. The ESE was significantly larger in the forced task, beyond the expected difficulty of the task. Participants demonstrated equivalent interference to positive and negative words, while interference from emotional words was significantly greater than neutral words. The ESE was therefore identified as the effect of emotion generally. Only the fast effect was significant in the forced task, while there was a significant positive correlation between depression severity (on both measures) and the slow effect across both tasks.

Conclusions and implications

The results suggest that emotional processing can be voluntary on the emotional Stroop task, which has implications for the use of the task to investigate automatic attentional processes. Studies focusing on the fast effect have often failed to find evidence of an ESE in depression. Few studies have investigated a slow ESE, and this study found that the slow effect was significantly related to depression severity. This finding suggests that a bias in depression exists in a later stage of processing with a difficulty in disengaging from the impact of emotion once processed. This difficulty may relate to other maladaptive emotion regulation
mechanisms in depression, such as rumination.

*Key words*

Depression, emotional Stroop task, emotional Stroop effect, emotional processing, attentional bias
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Critical Literature Review

In his foundational cognitive theory, Beck (1967; 1976) proposed that an attentional bias towards negative emotion is one of the main contributing and maintaining factors in depression. For decades, this cognitive conceptualization of depression has guided clinical practice through the success of Cognitive Behavioural Therapy (CBT) in treating depression (Scott, 2001). The emotional Stroop task was developed as a variant to the Stroop task, the ‘gold standard’ in assessing selective attention (MacLeod, 1992). Countless studies have used the emotional Stroop task to investigate a bias in attention in people with depression, however, the proposed attentional bias has not been consistently found. There are at least two possibilities to explain this discrepancy between theory and findings: a gap in our understanding of depression, or limitations in the methodology and interpretation of the emotional Stroop task.

This literature review will explore the discrepancy by discussing theories of depression with different foci, as well as alternative explanations for the emotional Stroop effect (ESE). Stemming from the debate in the literature, the Emotion Context Insensitivity hypothesis draws on an evolutionary understanding of depression as a ‘blunted’ response to emotion (Rottenberg & Gotlib, 2004). Depression can also be understood as involving a difficulty in regulating emotion, exemplified by the maladaptive rumination strategy that inevitably maintains a low mood (Nolen-Hoeksema, 2000).

Meanwhile, the ESE has been reinterpreted by some researchers (Algom, Chajut & Lev, 2004) and deconstructed into two separate effects by others (McKenna & Sharma, 2004; Frings, Englert, Wentura & Bermeitinger, 2010). The emotional Stroop task has been used to demonstrate an automatic process of attentional bias, thereby assuming that the emotional words in the task are processed involuntarily, causing emotional interference. However, findings of a previous study that used the original Stroop task (Eidels, Ryan & Algom, 2010) may extend to question this assumption of mandatory processing in the emotional Stroop task. Discussion of these alternative perspectives to depression and the ESE may allow for more room in understanding the lack if consistent findings
for an attentional bias in depression.

**Depression**

The term ‘depression’ is used to describe a wide range of experiences from a low mood to a severe disorder requiring hospitalization. This paper will review studies including both clinically diagnosed and sub-clinical depression. The DSM-IV-TR defines Major Depressive Disorder (MDD) as a depressed mood, with or without a loss of interest in activities, lasting for at least two weeks (American Psychiatric Association, 2002). Symptoms of MDD can include anhedonia, suicidal thoughts, fatigue, appetite and weight changes, disrupted sleep, and difficulties with concentration and memory (APA, 2002).

Depression is an alarmingly prevalent and costly disorder. As the most prevalent lifetime DSM disorder, 16.6% of people are affected by depression at some point in their lives (Kessler, Berglund, Demler, Jin & Walters, 2005). Although not fully meeting diagnostic criteria, sub-clinical depression affects the quality of life for an even greater number of people (Barrett, Barrett, Oxman & Gerber, 1988). To the individual, depression can lead to death from suicide, or disability demonstrated by work impairment, poor social functioning, loss of quality of life and utilization of health services (Department of Health and Ageing, 2012). The risk of relapse to a depressive episode is high: greater than 80% of those diagnosed will experience another depressive episode, with an average of 4 episodes in a lifetime (Judd, 1997). Such high relapse rates reflect the need for continued improvement in our understanding of the factors maintaining the disorder. Considering its high prevalence and cost, depression is viewed an important area to research and the initial focus of the National Health Priority Action Council (Australian Institute of Health and Welfare, 2011).

**Attentional bias in the emotional Stroop task**

The Stroop task (Stroop, 1935) is one of psychology’s most replicated instruments. In the congruent condition, names of colours are printed in ink of the same colour, for example, the word
“RED” printed in red. In the incongruent condition, colour names are printed in ink of a different colour, for example, the word “RED” printed in blue. Participants are asked to name the colour of the ink and ignore the semantic content of the word. Slower response latencies have reliably been found on incongruent trials, described as the effect of interference as the person has presumably read the word instead of named the ink colour. Interference is now generally agreed to demonstrate our difficulty in suppressing the automatic power of reading. The emotional Stroop task is one of the many variants of the Stroop task, with emotional words replacing the colour names. The ESE is interpreted as the emotional content of the word interfering with attention to the task. The emotional Stroop task is frequently used in research for a wide range of psychological disorders, including depression and anxiety (Chajut, Mama, Levy & Algom, 2010).

Studies using the emotional Stroop task to investigate attentional biases in psychological disorders draw upon Beck’s (1967; 1976) cognitive theory. Beck proposed that, from early life experiences, a person can develop negative schemas that lead to biases in information processing. This includes a biased attention, interpretation and memory for negative and schema-congruent information. People with depression are said to selectively filter out incongruent positive information and perceive neutral information as more negative than it objectively is. These cognitive biases are proposed to contribute to the development and maintenance of depression.

A meta-analysis of the emotional Stroop task literature found that generally, depressed groups tend to have slower latencies in response to negative words and no significant difference in responding to positive and neutral words (Epp, Dobson, Dozois & Frewen, 2012). This is explained as negative emotion capturing the attention of those with depression. In contrast, non-depressed people displayed a similar response time (RT) across all stimulus valence types. Higher depression scores have also been associated with a greater degree of negative interference on the emotional Stroop task (Williams & Nulty, 1987). Findings of this direction have been interpreted as evidence of Beck’s (1967, 1976) theory of a negative attentional bias in depression.

As a recent review of the literature in question, the meta-analysis by Epp et al (2012)
requires some close examination. Firstly, it is pertinent to consider the conclusions of the meta-analysis to be a summary of the literature’s findings, as many studies have not found an ESE for depression (e.g., Gotlib & Cane, 1987). On inspection of the meta-analysis results, the depressed groups displayed similarly large effect sizes (between .81 and .98) across the negative, positive, neutral and original Stroop stimuli. When comparing the RT between negative and neutral stimuli, the depressed groups experienced significant but small interference effects that did not meet Rosenthal’s (1991) tolerance level for robustness. The depressed groups also demonstrated high interference on the original Stroop task, which was significantly different from the non-depressed control groups. It is unclear why depressed participants also displayed interference on a task without emotional stimuli. The authors proposed that cognitive deficits resulting from depression could explain this finding (Epp et al, 2012). Although people with depression demonstrate impairment on several neuropsychological tests, performance on the original Stroop task is typically spared and found to be similar to controls (Austin et al, 1999). Qualitative studies were not included in the meta-analysis, although Epp et al acknowledged that qualitative reviews have shown inconsistent findings for depression (e.g., Gotlib, Roberts & Gilboa, 1996).

A strength of the meta-analysis is its effort to overcome the common ‘file drawer problem’, where the inclusion of published studies leads to an exaggeration of significant effects and neglect of unpublished null findings (Schwarzer, 1991). This is pertinent to finding evidence as to whether depressed people show an attentional bias or not. To address this problem, Epp et al (2012) included unpublished dissertations and conducted an analysis for publication bias. A bias was found but it was not a significant moderator for the results. Interestingly, the authors concluded against the theory of a negative attentional bias in depression and in favour of a general emotional bias for both negative and positive (Epp et al, 2012).

The Emotion Context Insensitivity hypothesis

In response to the inconsistent findings of a negative attentional bias in depression, Gotlib
and colleagues initiated a new research path and different conceptualization of the disorder. Using the emotional Stroop task, they found no significant difference in RT between negative and positive words (Gotlib & Cane, 1987; Gotlib & McCann, 1984) and no negative attention bias (McCabe & Gotlib, 1995; Mogg, Bradley, Williams & Matthews, 1993) in depressed populations. When free to allocate attention, depressed participants were found to respond similarly to positive, neutral and negative words (Gotlib, MacLachlan & Katz, 1988; MacLeod, Mathews & Tata, 1986). To explain this apparent ‘even-handed’ approach to emotions, Rottenberg and Gotlib (2004) put forward the Emotion Context Insensitivity: depressed individuals are proposed to have a reduced reactivity and ‘blunting’ towards emotion in their environment. The Emotion Context Insensitivity hypothesis stemmed from evolutionary theories of depression as an adaptive defense mechanism allowing for disengagement from futile goals and the conserving of resources when the environment is unpropitious (Klinger, 1975; Nesse, 2000). However, reacting to the environment with emotions is considered important in order to direct adaptive behaviour and adjust to change (Smith & Lazarus, 1990).

Support for the Emotion Context Insensitivity hypothesis has been found in several studies: people with depression showed less differential neural responses to emotionally-valenced faces (Gotlib, Sivers, Canli, Kasch & Gabrielli, 2001), and an equivalent neurophysiological response to negative and positive words (McNeely, Lau, Christensen & Alain, 2008). The proposed emotional blunting also fits with naturalistic observations of depressed patients as presenting a flat affect (Andreasen, 1987; Rottenberg & Gotlib, 2004).

A difficulty in regulating emotion

Emotion regulation difficulties in depression are characterized by an inability to shift the symptomatic low mood state. Emotion regulation is a broad concept said to range from emotion-generation to overt behaviour regulation strategies, such as rumination. In a maladaptive attempt to cope with negative emotions and problem-solve, individuals with depression often engage in
rumination. This behaviour is defined as a repetitive thought pattern focused on one’s negative emotional state and the causes and consequences of that state (Nolen-Hoeksema, 1991). Rumination is found to be related to a difficulty in manipulating emotional information in working memory (Nolen-Hoeksema, 2000), and the holding of negative content in working memory is predicted to alter one’s mood (Gross, 2002). Indeed, rumination is a maintaining factor that worsens and extends a depressive mood, risks a future depressive episode and predicts a poor prognosis (Nolen-Hoeksema, 1991; 2000).

One study provided an interesting link between rumination and a proposed later attentional bias in depression (Donaldson, Lam & Mathews, 2007). In this experiment, a dot-probe task was used to examine emotional interference and negative emotional stimuli were processed prior to the test trials. The researchers found that the participants with depression demonstrated interference from the previously processed emotional stimuli. They also found that the ESE is dependent on the duration of stimulus exposure. The researchers concluded that depression involves an attentional bias, but only when the negative emotional information has reached the later disengagement stage of attentional processing, which is fostered by longer exposure times (Donaldson et al, 2007). This contrasts to the assumption that a bias in depression involves the earlier process of an automatic shifting of attention towards negative emotion. Rumination was also induced in this study through self-referent questions. The participants who engaged in more rumination also displayed a stronger difficulty in disengaging from the previously processed negative emotion, impacting on their performance in the test trials. The finding by Donaldson et al allows an attentional bias and a difficulty in regulating emotion to be within the same model of depression.

Turning to a physiological mechanism of emotion regulation, the function of crying is also compromised in people with depression. In a study where a sad film provoked crying, non-depressed participants showed an increase in the vagal control of heart rate, associated with regulating emotion. Conversely, the depressed participants did not display this self-regulatory mechanism, even while they were crying (Rottenberg, Gross, Wilhelm, Najmi & Gotlib, 2002).
Therefore, depressed people do not experience the homeostatic function of crying that non-depressed people benefit from.

Medication and neurological studies illustrate that people with depression process emotion in a maladaptive way. A study found that anti-depressants increased the processing of positive information, but notably, non-depressed participants were used (Kemp, Gray, Silberstein, Armstrong & Nathan, 2004). Another study using depressed participants found that Selective Serotonin Reuptake Inhibitors (SSRI’s) increased responses to pleasant stimuli and suppressed responses to unpleasant information (Fu et al, 2007). In neurological studies, depressed individuals show a greater activation in the right lateral prefrontal cortex in response to negative stimuli, an area associated with negative affect and withdrawn behaviour. In contrast, non-depressed individuals show a left lateral prefrontal activity when appraising negative stimuli, associated with positive affect and approach behaviour (Johnstone, van Reekum, Urry, Kalin & Davidson, 2007). These findings reflect that people with depression process emotion in a counterproductive way, and this is likely to affect their ability to regulate emotion effectively and thus sustain their low mood state.

On the other hand, non-depressed people show an attentional bias towards positive information, which is lacking in those with depression (Deldin, Keller, Gergen & Miller, 2001; Gotlib, MacLachlan & Katz, 1988; McCabe & Gotlib, 1995). If people with depression attend to less positive information, then less positive input represented and elaborated upon in working memory, lowering the likelihood of it improving their low mood (Levens & Gotlib, 2009). The differentially greater processing of positive information in non-depressed people may have an adaptive role in offsetting negative emotions and regulating mood.

Re-interpreting the emotional Stroop effect

An interesting pattern was identified in the emotional Stroop task literature that led some researchers to question how the ESE is interpreted. The ESE is significant in studies that use a
blocked design of the stimuli, where each block of trials contains either emotional or neutral words. A study directly compared the blocked design to a mixed design, where emotional and neutral stimuli are mixed randomly within the same block, and found that the ESE disappeared in the mixed design (Algom et al, 2004). Other studies have shown that the ESE is influenced by the valence of previous trials (McKenna & Sharma, 2004; Kunde & Mauer, 2008). With the ESE only found in the blocked design, Algom et al argued that the ESE is the result of interference from previous emotional words carrying over and influencing the processing of subsequent words. The ESE therefore disappears in the mixed design because this carry-over effect is not possible. From this finding, it appears that the ESE does not result from the immediate interference of the current emotional word.

The study by Algom et al (2004) provided a challenge to the generally accepted interpretation of the ESE. In explaining their findings, Algom et al reframed the ESE as a generic slowing of activity, as attentional resources are re-allocated from the task and towards the perceived threat of emotions. In support, people are found prioritize attention towards evolutionary-relevant emotional stimuli at the expense of task performance (Öhman, Flykt & Esteves, 2001).

Although the study by Algom et al (2004) employed only negative stimuli, interpreting the ESE as a slowdown to the threat of emotion implies that all types of emotion can be considered threatening. Research has found that interference is related to the level of arousal generated by emotional stimuli, independent of their emotional valence (Lang et al, 1993; Schimmack, 2005). Skin conductance, a physiological sign of arousal, is also related to interference on the emotional Stroop task (Gronau, Cohen & Ben-Shakhar, 2003). So far, arousal has not typically been controlled in studies that found a negative attentional bias in depression (e.g., Williams & Nulty, 1986). Together, these findings point to the importance of including both negative and positive stimuli when using the emotional Stroop task to holistically investigate the impact of emotion on attention.
Fast and slow emotional Stroop effects

The ESE has been deconstructed into two effects, the fast effect and the slow effect, with different underlying processes involved (Frings et al, 2010; McKenna & Sharma, 2004). The fast effect is assumed to result from the interference of the current emotional word and is mostly used in the literature as the ESE (e.g., Williams, Mathews & MacLeod, 1996). It is interpreted as an automatic re-allocation of attention towards negative information, the negative attentional bias (Frings et al, 2010). The slow effect is said to result from the valence of the previous emotional word continuing to impact performance in subsequent trials, in line with the slow-down to threat proposed (Algom et al, 2004). In comparing the fast and slow effects, McKenna and Sharma (2004) only found evidence for a slow effect. This study is limited in its design, however, as the negative stimuli usually followed the neutral stimuli and vice versa. Participants could have then learnt and expected this pattern, therefore counteracting the fast effect (Frings et al, 2010). In the study by Frings et al (2010), the stimuli were uncorrelated in random order and the two effects calculated separately. In this study, the fast effect only included trials that followed neutral trials, controlling for the possible effect of the previous trial. Similarly, the slow effect only included trials prior to neutral trials, controlling for the current trial. Using this design, Frings et al found evidence for both the fast and slow effects.

These finding demonstrates the importance of isolating the fast and slow effects using a mixed design with random stimulus presentation, otherwise the two effects cannot be disentangled. The majority of the literature focuses on the fast effect (e.g., Williams, Mathews & MacLeod, 1996). It is pertinent to note that the Frings et al (2004) study included only negative words as the emotional stimuli.

Assumptions of the emotional Stroop task

As a variant of the original Stroop task, the emotional version is used with the same assumption that the reading and processing of words is involuntary, causing interference to one’s
attention to the task. This assumption is reflected in the calculation of the ESE, as the difference in mean RT between the conditions (emotional and non-emotional). But if means are used, how can we definitely know that each and every emotional word has been processed? Using means, the same ESE can be calculated for two participants for different reasons. One participant may read and process every emotional word and demonstrate a small amount of emotional interference, and receive the same ESE as another participant who only read some of the emotional words but experienced more interference from each emotional word. Therefore, interpretation of the mean RT as a Stroop effect is ambiguous.

To test the assumption that word-reading is automatic in the original Stroop task, Eidels et al (2010) developed a new task: the forced-processing Stroop task. Participants were asked to respond only if the word was a colour name, and to otherwise withhold responding. With responses now relying on comprehension of the word content, it could be identified if participants had read each word. If reading is automatic as assumed, then the Stroop effect should be analogous in the original and forced-processing tasks. To the contrary, a significant difference was found with an exponentially higher Stroop effect in the forced task. The Stroop effect is typically proportional to the absolute RT of a task, and with the additional aspect of decision-making, a larger RT is expected in the forced task. Despite this, the Stroop effect increased disproportionately to the absolute RT in the forced task. By comparison, the significantly smaller Stroop effect in the original task revealed that participants did not read each word in every trial. The authors concluded that reading is not a truly automatic process (Eidels et al, 2010).

Another assumption held for the emotional Stroop task is that it involves the same phenomenon of selective attention in the original task. A principal difference between the tasks lies in the relationship between the stimuli. The colour-name RED written in the colour blue are directly competing stimuli with two different representations of the same concept, colour. Meanwhile, the word HOPELESS written in blue are two different concepts, emotion and colour, and as non-complementary stimuli they cannot create the same conflict of attention. The two tasks are therefore
said to be qualitatively different, involving different cognitive mechanisms that require separate interpretations (Algom et al., 2004). Another question to consider is how an automatic attentional bias could be demonstrated on the emotional Stroop task if one needs to first attend to and read the word to recognize it as emotional.

The present study

The aims of this study are drawn from research that has forged new paths in the conceptualization of depression and interpretation of the ESE. Participants will be scored on a depression measure and their performance compared between the emotional Stroop task and a novel task that will be piloted: a forced-processing task, now named the forced task for simplicity. The two tasks will be identical in presentation, except for one important difference: the design of the forced task will require participants to process the emotional content of each word in order to respond, which contrasts to the emotional Stroop task where participants are asked to ignore the meaning of the word. The forced task is designed so that emotional processing is mandatory, which by comparison, may reveal whether emotional processing can be voluntary on the emotional Stroop task when participants are not required to process the word content.

Contrasting how participants perform on the two tasks can also illustrate the influence of depression when emotional processing is and is not required. This comparison allows for a novel investigation of different conceptualizations of depression: the Emotion Context Insensitivity Hypothesis proposes that individuals depression can ‘blunt’ responding to emotion, while other models of depression characterize a difficulty in disengaging from and regulating emotion once processed.

The design of the present study will allow for investigation of several alternative explanations for the ESE: as a slowdown towards the threat of emotion, using both positive and negative emotional stimuli, and by separately calculating fast and slow effects. Individual analysis of these two effects may shed light on whether depression involves an automatic shifting of attention
towards negative information (the negative attentional bias) as shown by a fast effect, or a difficulty in disengaging from previously processed emotional information, reflected in a slow effect.

**Clinical Implications**

The way in which depression is conceptualized in theory can guide research that, together, informs clinical practice. Beck’s (1967; 1976) cognitive theory provides the foundation to the CBT intervention for depression. The National Institute of Mental Health (NIMH) landmark study for the treatment of depression found that CBT was effective and recommended it for mild to moderate depression. However, CBT was not found to be effective for those severely depressed, who instead benefited from anti-depressant medication combined with clinical management (Elkin et al, 1989). Therefore, there is a gap in efficacious treatment for individuals with severe depression. This is a crucial gap to fill considering the high costs of the disorder, including the individual’s life, and that 20% of those with depression suffer from a persistent and treatment-resistant form (Watkins et al, 2011).

Understanding how or if depression is related to the ESE, through a fast or slow effect, has implications on whether the disorder is conceptualized as involving an attentional bias or a difficulty in disengaging from and regulating emotional information. Finally, investigation of alternative explanations of the ESE within the context of depression may have implications on how the emotional Stroop task is used in research on depression.
A multitude of studies have employed the emotional Stroop task, and its emotional Stroop effect (ESE), to find the attentional bias proposed to be one of the main factors in Beck’s Cognitive Theory of depression (1967; 1976). Nevertheless, the literature has remained inconsistent. This study aimed to investigate alternative accounts for both the ESE and depression. Fourteen participants were measured on depression severity and their response times to classifying the colour of positive, negative and neutral words compared across two tasks: the emotional Stroop task, where they were asked to ignore the word content, and a novel forced-processing task, where participants were required to process the content of each emotional word. There was a significant difference between when participants were required and not required to process emotion, suggesting that emotional processing is voluntary on the emotional Stroop task, and thus challenging the use of the task to investigate an automatic process such as attention. Rather than a specific negative bias, emotional interference was found from both positive and negative stimuli, and thus the ESE was identified as the difference between emotional and neutral conditions. The ESE was also deconstructed into the fast effect, interference from the current emotional word, and the slow effect, interference from the previously presented emotional word. Although the fast effect is typically used in the literature to identify an automatic attentional bias, it was the slow effect that was significantly related to depression severity in this study.

With the support of other studies, a bias in depression is suggested to occur in a later disengagement stage of attentional processing rather than during the initial shifting of attention that is assumed in the fast effect. An inability to disengage from interfering emotional information is linked to rumination and a difficulty in regulating emotion in depression. The findings suggest the importance of focusing treatment on strategies to disengage from unhelpful emotional information, and have implications for how the ESE is used in research on depression.
1. Introduction

The Cognitive Theory of depression (Beck, 1967; 1976) is prominent in research and practice, stimulating decades of research and providing the theoretical framework to the evidence-based use of Cognitive Behavioural Therapy (CBT) for depression. An attentional bias towards negative information is one of the core features of Beck’s conceptualization of depression. Myriad studies have investigated this attentional bias in depression through the competing demands on selective attention in the emotional Stroop task (Epp et al, 2012). Despite the substantial amount of research conducted, a negative attentional bias has not been consistently demonstrated in the emotional Stroop task literature for depressed populations. The question remains as to where the inconsistency lies: is our understanding of depression incomplete, or is something missing in the methodology and interpretation of the emotional Stroop task? Alternative possibilities will be reviewed, of both different conceptualizations of depression and other explanations for the emotional Stroop effect (ESE).

1.1 Depression

‘Depression’ is used to describe a lengthy continuum from a low mood to severe impairment from a long-lasting mood disorder. The DSM-IV-TR defines Major Depressive Disorder (MDD) as a depressed mood lasting for at least two weeks, with some symptoms including anhedonia, fatigue and suicidal ideation (American Psychiatric Association, 2002). The statistics for depression are staggering. As the most prevalent lifetime DSM disorder, 16.6% of people are affected by depression during their life (Kessler, Berglund, Demler, Jin & Walters, 2005). Sub-clinical depression affects an even greater number (Barrett, Barrett, Oxman & Gerber, 1988). Depression is costly, leading to death from suicide for some, and disability for others through work impairment and utilization of health services (Department of Health and Ageing, 2012). The risk of relapse is great: more than 80% of those diagnosed will experience another depressive episode (Judd, 1997).
Beck’s (1967, 1976) pivotal cognitive theory of depression has prevailed in the research and treatment of the disorder for decades. He proposed that from early life experiences, negative schemas can develop about the self, the world and the future. Information processing is then biased as the person attends to and remembers information congruent with these negative schemas. Incongruent positive information is filtered out, and neutral information interpreted as more negative than it objectively is. This cognitive bias in attention, interpretation and memory is then said to influence the development and maintenance of depression. To examine attentional bias, the emotional Stroop task is said to be the most frequently employed tool for a range of psychological disorders, including depression (Williams, Mathews & MacLeod, 1996).

1.2 The Stroop and emotional Stroop tasks

The Stroop effect is considered a ‘gold standard’ in assessing selective attention (MacLeod, 1992). In the Stroop task (Stroop, 1935), colour names are printed in ink of the same colour in the congruent condition (for example, the word RED printed in red colour) and in a different colour in the incongruent condition (e.g., RED in green). When asked to name the ink colour and ignore the word meaning, participants reliably show slower response times (RT) on incongruent trials. The asymmetrical difference in RTs between incongruent and congruent conditions is titled the Stroop effect and is often explained as our inability to suppress the overwhelmingly automatic nature of reading (MacLeod, 1991). This kind of explanation, of course, assumes that the participants are reading each word. As a variant, the emotional Stroop task was developed, where participants are asked to name the ink colour of disorder-relevant emotional words.

As a measure of selective attention, the emotional Stroop task has been utilized in multitudes of studies in an attempt to demonstrate a negative attentional bias in depression. In a recent meta-analysis of the emotional Stroop literature Epp, Dobson, Dozois and Frewen, (2012) found that, on average, people with depression demonstrate slower RTs for negative words, and
faster RTs to positive and neutral words (approximately equally fast for the latter two). It is argued that this pattern shows a bias towards negative stimuli capturing attention and interfering with task performance. In comparison, non-depressed groups exhibited equivalent RTs across all of the stimuli.

On examining the results of the above mentioned meta-analysis by Epp et al (2012), there were only small differences between the differently valenced stimuli for the depressed groups. A slight gradient can be seen from the effect sizes of neutral words (0.81), followed by positive (0.87) and then negative words (0.98). The interference effect for negative words was significant but small in the depressed samples, and did not meet Rosenthal’s (1991) tolerance level for robustness. The authors proposed that people with depression show a general emotional bias on the emotional Stroop task, for both positive and negative emotions, challenging Beck’s model. If the meta-analysis was unable to identify a specific negative attentional bias, then perhaps a different theory of depression can more suitably the general emotional interference that was found.

1.3 Alternative conceptualizations of depression

1.3.1 The Emotion Context Insensitivity hypothesis

As reflected in the findings of the meta-analysis, studies have found no difference in how depressed participants respond to positive, neutral and negative emotional words in the emotional Stroop task (Gotlib et al, 2004; Gotlib, MacLachlan & Katz, 1988; Grant & Beck, 2006). To explain this apparently ‘even-handed’ approach to emotions, a new theory of depression was developed: The Emotion Context Insensitivity hypothesis proposes that depressed people have a diminished reactivity or a ‘blunting’ to emotion in their environment (Rottenberg & Gotlib, 2004). Such an emotional blunting concurs with clinical observations of people with depression presenting with a flat affect (Andreasen, 1987).

The Emotion Context Insensitivity hypothesis is based on evolutionary conceptualizations of depression as an adaptive reaction to loss: disengaging from fruitless goals, dangerous situations
and when resources are lacking (Klinger, 1975; Nesse, 2000). The symptoms of reduced motivation, anhedonia, fatigue and social withdrawal may therefore be advantageous in inhibiting futile action. Although understandable as a defense mechanism, depression is clearly maladaptive for the individual and results in a costly illness. The authors of the ECI hypothesis predict that such restricted emotional processing is a key maintaining factor for depression (Rottenberg & Gotlib, 2004).

1.3.2 Emotion regulation difficulties

Emotion regulation is a broad concept said to range from emotion-generation to biological regulation, and behavioural strategies such as rumination. Difficulty in manipulating emotional information in working memory is related to rumination, a potent risk and maintaining factor for depression. Rumination is a repetitive negative thought pattern focused on one’s negative mood state without active problem solving (Nolen-Hoeksema, 2000). This leads to negative content being held in working memory, which can contribute to a low mood (Gross, 2002). Indeed, rumination worsens and extends a depressive mood, and predicts a depressive episode as well as a poor prognosis (Nolen-Hoeksema, 1991; 2000).

A difficulty in disengaging from negative emotion has been proposed to explain interference on the emotional Stroop task for individuals with depression. One study found that previously processed negative information resulted in an increase in emotional interference for depressed participants, and this interference was directly related to the extent the participants engaged in rumination (Donaldson, Lam & Mathews, 2007). Mogg and Bradley (2005) posited that extended processing of negative stimuli in the emotional Stroop task could activate negative schemas and trigger ruminative behaviours for participants with depression, interfering with their task performance and leading to a larger ESE.

Biologically oriented studies show that people with depression process emotion maladaptively, which in turn influences their ability to regulate their mood effectively. Research has
found that anti-depressant medication increases the processing of positive information (e.g., Kemp, Gray, Silberstein, Armstrong & Nathan, 2004). In a neurological study with negative stimuli, depressed individuals showed greater activation in the right lateral prefrontal cortex, associated with negative affect and withdrawn behaviour, while non-depressed individuals displayed left lateral prefrontal activity associated with positive affect and approach behaviour (Johnstone, van Reekum, Urry, Kalin & Davidson, 2007). Turning to a physiological mechanism of regulation, depressed people are shown to not experience the homeostatic function of crying that non-depressed people benefit from (Rottenberg, Wilhelm, Gross & Gotlib, 2003).

1.4 Alternative explanations for the emotional Stroop effect

1.4.1 Slowdown to threat

The role of previously processed emotional stimuli in the ESE was emphasized by Algom et al (2004). The authors contrasted the effects of when the stimuli are presented in blocked designs compared to mixed designs. In a blocked design, each block of trials only contains either emotional or neutral words, whereas in a mixed design, both emotional and neutral stimuli are mixed within the same block. The majority of studies employing the emotional Stroop task use the blocked design, and when the ESE is found, the blocked format is used. Interestingly, when Algom et al incorporated the mixed design, the ESE was found to disappear. The authors proposed that interference from an emotional word could extend to affect the processing of subsequent words, including non-emotional words. This suggests that the ESE can be carried over from previous emotional words and not reflect true interference from the currently presented word. For example, if the word “LATELY” in the colour green is preceded by the word “LONELY” in red, it is possible that a slow colour-classification response to the word “LATELY” actually reflects a carry-over emotional effect of the word “LONELY”. Of course, in a blocked design, it is practically impossible to disentangle the effects of currently and previously presented emotional words.

From finding an effect of ongoing emotional interference, Algom et al (2004) proposed that
the ESE is the result of a generic slowdown to the threat of emotion. Emotional stimuli are predicted to trigger a general slowing of activity as attention is reallocated towards threat. This further suggests that all emotional words could be interpreted as threatening. Indeed, humans show a prioritizing of attention resources towards evolutionary-relevant emotional stimuli, to the detriment of the current activity (Öhman, Flykt & Esteves, 2001).

Although the ESE is proposed to be the result of a slowdown to threat, only negative words were included as the emotional stimuli in the study by Algom et al (2004). This reflects the emotional Stroop task literature, where most studies compare only negative and neutral stimuli (Epp et al, 2012), presumably in the aim of investigating a negative attentional bias in depression. However, the meta-analysis found that emotion generally, both positive and negative, produced interference for both depressed and non-depressed individuals (Epp et al, 2012). There are also robust findings from studies using pictorial and word stimuli that it is the arousal generated by the emotional stimuli causes the interference, independent of emotional valence (Lang et al, 1993; Schimmack, 2005). Physiological measures of arousal are also related to interference effects on the emotional Stroop task (Gronau, Cohen & Ben-Shakhar, 2003). Interestingly, arousal is not typically controlled in studies that have supported a negative bias in depression (e.g., Williams & Nulty, 1986).

1.4.2 Fast and slow effects

The literature has predominantly focused on the ESE as a fast effect, where interference results from the immediately presented emotional word. Using the example above, this would occur if the negative word LONELY caused slower colour-naming only for this word. Focusing on the fast effect, the ESE has been commonly interpreted as the outcome of an automatic re-allocation of attention towards negative information, the negative attentional bias (Frings, Englert, Wentura & Bermeitinger, 2010). The ESE has since been re-interpreted as a slow effect by Algom et al (2004), where the effect of the previous trial continues to influence performance on the current trial (Algom
et al, 2004). Again using the example above, the slow effect would occur if the previous negative word LONELY caused emotional interference that continued to slow down colour-naming for the subsequent word LATELY, despite this word being neutral.

A small number of studies have included both fast and slow effects in a mixed design (McKenna & Sharma, 2004; Frings et al, 2010). The design of the study by McKenna and Sharma was criticized as creating a strong contingency between the presentation of neutral and emotional words, which may have influenced their finding of a null fast effect as participants could have predicted the following word (Frings et al). In contrast, Frings et al separately calculated the two effects by controlling for the other: the fast effect included only trials that followed neutral trials, controlling for the possible effect of the previous trial, and the slow effect included only neutral trials, controlling for the effect of the current trial. Interestingly, and despite unique explanations for each, evidence was found for both fast and slow emotional Stroop effects.

1.4.3 Voluntary emotional processing

The emotional Stroop task is used with the same underlying assumption of the original Stroop task: that reading is automatic, producing the famous Stroop effect. The processing of emotional words is thought to be even more powerfully automatic (McKenna & Sharma, 1995). Yet a point to consider is that the ESE is calculated as the difference between the mean RT of the conditions: emotional and neutral. By using means, how can we know if every word is actually read and the emotion processed? For example, two participants can receive the same calculated ESE for two different reasons: one participant may read and process every word and achieve the same ESE as the other participant who only read some words but experienced greater interference from the words read.

A recent study tested the mandatory nature of reading in the original task (Eidels, Ryan & Algom, 2010). The authors developed a novel, forced-reading Stroop task where participants were asked to respond only if the word was the name of a colour, and to withhold responding if it was not
a colour name. As their responses relied on understanding the word content, it could be identified if the participants had read each word. If reading is automatic then the Stroop effect should be comparable in both the original and forced-reading Stroop tasks. But, the difference was significant: the Stroop effect was much larger in the forced task, beyond what would be expected from the increased difficulty of the new task. By comparison, the smaller Stroop effect in the classic task reflects that participants could not have read each word in every trial, as would be expected if reading were mandatory. Extending this finding to the emotional Stroop task would suggest that the processing of emotional information may not necessarily be automatic.

An attentional bias is typically described as an automatic process (Williams, Mathews & MacLeod, 1996), and thus the use of the emotional Stroop task to demonstrate such a bias relies on the assumption that emotional processing is mandatory. Donaldson, Lam and Mathews (2007) found that attentional biases are critically dependent on the length of the exposure of the stimulus, with greater emotional Stroop effects found in studies that use longer stimulus exposure. The authors suggest that increased stimulus exposure allows the emotional information to eventually come into attentional focus and be processed more extensively, even if the information has not been automatically captured. Therefore studies that use smaller exposure lengths can discourage participants to process the emotional information. If the processing of emotional information is voluntary and participants can ignore emotional information on some trials, then differences between experimental designs may account for the apparent lack of an ESE in some studies and the inconsistency in the literature.

1.5 The present study

The present study aims to concurrently investigate two possibilities for the lack of consistent findings of a negative attentional bias in depression using the emotional Stroop task: the need for a broader understanding of depression, and methodological issues in the emotional Stroop task. These possibilities have been discussed in two separate categories of alternative conceptualizations of
depression and explanations for the ESE, although they are inevitably interlinked.

Participants will be measured on depression severity and their performance compared between the emotional Stroop task and a new task, a forced-processing task. The two tasks will be identical except for one difference. In the emotional Stroop task, participants are instructed to press the key corresponding to the colour of the word and ignore reading the word. In the forced task, participants will be instructed to press the corresponding colour key if the word is an emotional word, but press a different key if the word is neutral (non-emotional). Participant responses will therefore be contingent on the word content. The new forced task is designed so that the reading and processing of the emotional words is mandatory, as participants are required to understand the word meaning on 100% of trials. If emotional processing is mandatory, as assumed by the use of the emotional Stroop task to investigate an automatic attentional bias, then performance should be analogous on the two tasks: participants should process every word to the same extent, whether instructed to or not. If emotional processing is voluntary, then we can expect participants to experience less interference on the emotional Stroop task compared to when they are required to process every word on the forced task. Such a finding would refute the expectation that emotional processing is mandatory and suggest that participants are able to limit their processing of emotional words when not forced to.

Comparing performance on these two tasks with depression severity provides a novel investigation of the influence of depression when emotional processing can be voluntary. When asked to not read emotional words, can individuals with depression avoid the processing emotion to a greater or lesser extent than individuals without depression? The Emotion Context Insensitivity hypothesis proposes that people with depression can ‘blunt’ their response to emotions, and thus less interference would be expected for participants higher in depression on the emotional Stroop task. Meanwhile, once required to process emotional information in the forced task, the emotion regulation difficulties in depression are expected to result in substantially greater emotional interference for those with higher depression scores.
To further investigate the alternative explanation of the ESE as a slowdown towards the threat of emotion (Algol et al, 2004), both negative and positive words will be included as the emotional stimuli. The positive and negative stimuli will be collapsed into an ‘emotional’ condition to be compared with the neutral condition as an Emotional-Neutral ESE (EN-ESE). RTs to the positive and negative conditions will also be directly compared as a Positive-Negative ESE (PN-ESE) to determine whether there is a valence-specific emotional threat. This analysis provides a broader investigation of whether the ESE is due to the threat of emotion generally by involving stimuli from both ends of the valence continuum.

Both fast and slow emotional Stroop effects will be calculated as other explanations for the ESE. A mixed design, including both emotional and neutral stimuli within a block, and random presentation of stimuli, will allow for comparison of the effects of currently-presented and previously-presented emotional words. Identifying both fast and slow effects is critical considering they are thought to have unique meanings for depression. The fast effect is interpreted as an attentional bias in the literature, and supports the cognitive bias theory of depression. Conversely, a slow effect from the previously processed emotional stimuli supports a difficulty in disengaging from and regulating emotion for individuals with depression (Donaldson et al, 2007).

Regarding some other aspects of this study’s design, a non-clinical undergraduate population was chosen in order to pilot the new forced task. This population is also considered relevant with a substantial number of people affected by sub-clinical depression. In light of findings of a well-replicated attentional bias in anxiety, and a high co-morbidity between anxiety and depression (Gotlib, Roberts & Gilboa, 1996), anxiety level will be examined as a possible confounding variable.

2. Method

2.1 Participants

There were fourteen participants recruited from two separate advertisements, one requesting people who often experience a depressed mood, and another targeted towards people who rarely, if
ever, feel depressed. The advertisements were placed on the online SONA system for undergraduate psychology students at the University of Newcastle, who received course credit for participation. Further advertisements were posted around the University of Newcastle campus, and those recruited received $15 remuneration per experiment session. The inclusion criteria were listed as: native English language, intact colour vision, and corrected to normal vision. Thirteen of the participants responded to the advertisement about a depressed mood, despite having a range of high and low depression scores. The participants included ten females and four males, ranging from 19 to 28 years old with a mean age of 21.21 (SD = 2.69). The Beck Depression Inventory-II (BDI-II) was used as the main depression measure (BDI-II). Three participants scored as moderately depressed (score between 20-27), and 3 as mildly depressed (score between 14-16). This sample demonstrated a similar mean score on the BDI-II to other non-clinical undergraduate populations (e.g., Dugas et al, 2005). Each of the participants completed both tasks in the study on separate days, in a counterbalanced order.

2.2 Design

A 2 x 3 within-subject design was used, with factors Task (classic emotional Stroop and forced-processing) and Condition (neutral, negative, and positive). This design allows 2 x 3 ANOVA, as well as a subsequent 2 x 2 ANOVA, where the negative and positive trials are collapsed to form a single condition, emotional, to be contrasted against neutral (non-emotional) words. RT and accuracy were the dependent variables. Level of depression, anxiety and stress were also measured.

2.3 Measures

2.3.1 Beck Depression Inventory

The BDI-II (Beck, Steer & Brown, 1996) is a 21-item self-report measure of the severity of depression symptoms. Each item consists of four self-evaluative statements scored on a 4-point scale with increasing depression symptoms. For example, from “I do not feel sad” (0) to “I am so
sad or unhappy that I can’t stand it” (4). Higher scores reflect greater depression severity in an overall range from 0 to 63. The BDI-II is found to have high internal consistency and construct validity (Dozois, Dobson & Ahnberg, 1998) and factorial validity (Whisman, Perez & Ramel, 2000) in undergraduate samples.

2.3.2 Depression, Anxiety and Stress Scales

The Depression Anxiety Stress Scales (DASS-21; Lovibond & Lovibond, 1995) were used to measure symptoms of broader emotional distress. The trait version was used, where participants responded regarding the extent to which they generally experience the negative affect symptoms described in the items. Items are scored on a 4-point scale from did not apply to me at all (0) to applied to me very much, or most of the time (3). Each scale has 7 questions with higher scores indicating greater distress. The DASS-21 is known to have good convergent and discriminant validity, high internal consistency and a stable factor structure (Szabo, 2010).

2.4 Stimulus

Words of positive and negative emotional valence were drawn from past research on the emotional Stroop task (Denny & Hunt, 1992; Grant & Beck, 2006). Word frequency was controlled by selecting words with a close written language frequency rate (Davis, 2005). The N-watch computer program (Davis, 2005) was used to find word frequency and orthographic neighbours, words with similar spelling that differ in only one letter. Sets of positive, neutral and negative words were created and matched on orthographic similarity, word frequency and length. For example, for the negative word “Sad”, positive word “Glad” and neutral words “Sat” and “Pad”. As shown by this example, the position of the different letter varied for each word, so that participants needed to read the word in full in order to respond, and did not rely on local cues. Finally, the stimulus also appeared at different positions around the centre of the screen, to reduce local cue responding. The words were printed in uppercase Arial font, bold, size 30, which, in a sitting distance of 60 cm subtended a maximum width of less than 3 degrees of visual angle. The coloured words displays were generated in Presentation software that also recorded response times to 1ms.
The colour red was defined by RGB values of 220, 0, 0, and green by RGB values of 0, 170, 0. Stimuli were presented on a grey background on a 17” CTR computer monitor screen.

In a pilot phase, a survey was used to confirm whether the positive, neutral and negative words were actually perceived as such by a random group of naive participants. Ten people were presented with the list of 24 words, ordered alphabetically, and were asked to rate the stimuli as negative, positive, or neutral in valence. Another group of six people rated the words as emotional or neutral. All the words in the list achieved a total consensus on emotionality and valence and could thus be included in the study. The survey was repeated at the end of the experiment, this time with the participants who had completed both tasks, to confirm that the stimuli were being appropriately classified during the experiment. Out of 336 total ratings (twelve participants classifying 24 words each), only 2 words were misclassified. Every word in the emotional category was correctly classified as emotional, and two of the neutral words were rated as emotional words (one for Participant 8, and one for Participant 11). These errors comprise a negligible 0.4% of the total amount of deviance possible.

2.5 Procedure

The sequence of each trial was as follows: a fixation cross appeared in the centre of the screen for 500ms, followed by a blank screen for 500ms, and then the presentation of the word stimulus for up to 500ms. The stimulus was either terminated by the participant’s response or the next trial started after 400ms. Each word valence type (6 positive, 6 negative and 12 neutral) appeared printed in each ink colour (red and green) 8 times, creating 48 trials for each word valence type. Each block contained 2 sets of trials, resulting in 96 trials. 8 blocks of these trial sets were conducted, so that each participant performed in 768 trials for both tasks. The order of stimulus presentation was random and the valence type was randomly mixed within each block. Blocks were separated by a break of 1 minute. The order of tasks was also counterbalanced across participants.

Participants were tested individually in a dimly lit cubicle. Each of the participants performed the two tasks, on separate days with no more than seven days between tasks. The
two tasks were identical in the presentation of stimuli and instructions: participants were asked to respond as quickly and as accurately as possible by pressing a green-coloured key if the print colour was green and a red-coloured key if the colour was red on a Cedrus pad. The one difference is that for the forced-processing task, participants were asked to press the key corresponding to the print colour only if the word was an ‘emotional’ word, and to press a different “X” key if the word was ‘neutral’. The keys were counterbalanced for colour and the right/left side of the pad. Before each task, there were two practice sessions with 20 trials each, one with and one without feedback.

3. Results

3.1 Data excluded

Extreme response times were excluded from the analysis (< 200ms and > 1500ms, which roughly represent 2 standard deviations from the mean). Overall, 0.05% of trials were excluded based on these criteria. Participant 5 did not return for the second task, and his data was therefore excluded from the analysis.

3.2 Hypotheses tests

3.2.1. Emotional Stroop effect as Emotional-Neutral

A 2 (Task: emotional Stroop, emotional forced-task) x 2 (Condition: emotional, neutral) repeated measures ANOVA found a significant main effect for task, $F(1,13) = 44.67, \ p < .000$, where participants demonstrated slower RT on the forced task, $M = 619.73 \ (SD = 40.23)$, compared to the emotional Stroop task, $M = 356.30 \ (SD = 1.59)$. There was also a significant main effect for condition $F(1,13) = 5.36, \ p = .038$, where participants showed slower RT to emotional words, $M = 501.68 \ (SD = 207.18)$, compared to non-emotional words, $M = 474.36 \ (SD = 165.36)$. The latter difference marks the ESE. There was also a significant interaction of task and condition, $F(1,13) = 5.70, \ p = .033$.

Paired samples t-tests were conducted to examine the ESE within each of the tasks. There was a non-significant ESE in the emotional Stroop task, $t(13) = -.94, \ p = .363$, with similar RTs in the emotional condition ($M = 355.18, \ SD = 28.17$) and neutral condition ($M = 357.43, \ SD = 33.04$).
However, in the forced task, there was a significant ESE $t(13)=2.36$, $p=.034$, between the emotional ($M = 648.18, SD = 11.75$) and neutral ($M = 591.29, SD = 129.36$) conditions. This finding supports the interpretation of the interaction. As illustrated by Figure 1 below, the vertical discrepancy between the two lines represents the difference in mean RT between emotional and neutral words, the ESE, which was significantly greater in the forced task.

![Figure 1. Emotional Stroop effect in each task](image)

*Figures 1. Emotional Stroop effect in each task*

A between-subjects t-test was used to determine the ESE at the individual level. Only two of the participants displayed a significant ESE in the emotional Stroop task, while eight participants showed a significant ESE in the forced task. For these eight participants, the interaction between task and condition was retained as significant. Table 1 below illustrates the mean RT across each condition and the ESE, as Emotion-Neutral and Positive-Negative, for each participant.
Table 1.  
Mean individual RT (ms) for each condition, and emotional Stroop effects as Emotional-Neutral and Positive-Negative

<table>
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<th>Participant</th>
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*p<0.5, **p<0.01, ***p<0.000
It is acknowledged that the forced task is more difficult with participants required to make decisions on the word content, thus naturally increasing the RT. Studies have also found that with increasing absolute RT, the Stroop effect tends to also increase (Melara & Algom, 2003; Shalev & Algom, 2000). Therefore, the significantly slower RT in the forced task may merely reflect a proportional slowdown due to the heightened difficulty of this task. To investigate this possibility, the analysis was repeated on a logarithmic transformation of RTs. The significant results of the 2x2 repeated measures ANOVA survived the log transformation with a main effect for task, \( F(1,13) = 62.71, p<.000 \), and condition, \( F(1,13) = 4.45, p = .055 \), as well as a sustained significant interaction, \( F(1,13) = 4.93, p=0.045 \).

3.2.2 Emotional Stroop effect as Positive-Negative

A paired samples t-test was used, separately for each task, to investigate whether there was an ESE comparing positive and negative conditions (PN-ESE). In the emotional Stroop task, the mean RTs were almost equivalent for the positive condition, \( M = 353.64 \ (SD = 28.20) \), and for the negative condition, \( M = 356.86 \ (SD = 29.02) \). The similar RTs are reflected in the non-significant PN-ESE for the emotional Stroop task, \( t(13)=-1.264, p=.228 \). The mean RTs were also similar in the forced task across the positive condition, \( M = 645.07 \ (SD = 185.21) \), and the negative condition, \( 651.36 \ (SD = 193.90) \). Again, this is reflected in the non-significant PN-ESE for the forced task, \( t(13)=-.647, p=.529 \).

3.2.3. Depression and the emotional Stroop effect (Emotional-Neutral)

As described above, there was no difference in participant responses between the positive and negative conditions, a negligible PN-ESE, for both tasks. In contrast, a significant ESE was found when comparing the emotional and neutral conditions in the forced task, illustrating that there was an effect of emotion generally when participants were forced to process each word. The EN-ESE was therefore chosen for further analysis. Pearson’s product moment linear correlation between depression score and ESE revealed a small positive but non-significant relationship in the
forced task, \( r(12) = 0.23 \), with higher depression scores related to a greater ESE. A weak, non-significant negative relationship was found in the emotional Stroop task, \( r(12) = -0.176 \).

### 3.2.4 Fast and slow effects

The EN-ESE was deconstructed into two effects, fast and slow, which were separately calculated from the mean RTs of the emotional and neutral conditions. The fast effect was calculated by including only the emotional words where the previous word was a neutral word, which controlled for a possible slow effect. In a similar vein, the slow effect was calculated by including only neutral words where the prior word was an emotional word, which controlled for a possible fast effect.

A 2 x 2 ANOVA of current trial valence (emotional, neutral) and last trial valence (emotional, neutral) was conducted separately for each task. This analysis provides a test of the ESE from the currently presented word and the ESE due to the previously presented word, and their potential interaction. For the emotional Stroop task, a non-significant main effect was found for current trial valence, \( F(1,14) = 3.188, p = .096 \), and a non-significant main effect for last trial word valence \( F(1,14) = 1.826, p = .198 \).

The same 2 x 2 ANOVA was repeated for the forced task and found a significant main effect of the current trial valence, \( F(1,13) = 5.516, p = .035 \), where participants responded slower when the current trial was emotional (M = 657.12, SD = 174.05) compared to when the current trial was neutral (M = 604.66, SD = 124.20). A fast effect was therefore identified on the forced task. The main effect of the previous trial valence was non-significant, \( p = 0.74 \), thus no evidence of a slow effect was found across all participants.

### 3.2.5 Fast and slow effects with depression

Individual fast effects were calculated by subtracting each participant’s mean RT when the current trial was emotional and when the current trial was neutral. Likewise, for individual slow effects, the mean RT when the previous trial was emotional and when the previous trial was neutral
was subtracted for each participant. Individual fast and slow effects were then correlated with depression scores on the BDI-II measure.

For the emotional Stroop task, the fast ESE was not found to be significantly correlated with depression scores, $r(12) = -0.357, p = .105$. A positive and significant correlation was found between individual slow ESE and depression severity, $r(12) = 0.566, p = 0.017$. This finding suggests that with higher levels of depression, a greater ESE is experienced as the result of previous emotional words slowing current performance.

The same analysis was conducted for the forced task. There was a non-significant relationship between individual fast ESE and depression scores on the BDI-II, $r(12) = 0.073, p = .402$. There was a positive and significant relationship between individual slow ESE and depression severity on the BDI-II, $r(12) = 0.659, p = 0.005$. This is supported by a significant correlation between individual slow ESE and depression scores on the DASS-21 measure, $r(12) = 0.511, p = 0.037$. These significant relationships suggest that the slow effect increased with greater depression severity.

A post-hoc analysis was used to investigate whether depression was related to a slow PN-ESE. Individual slow ESEs were calculated as the difference between mean RT on previous positive and previous negative trials. No significant correlation was found between this slow ESE and depression scores, $r(12) = .093, p = .376$

### 3.3 Confounding variables

Anxiety was found to be significantly correlated with the ESE in the emotional Stroop task, $p=0.039$, but not the forced task. Participant level of stress significantly correlated with the ESE in the forced task, $p=0.014$, but not the emotional Stroop task.

### 3.4 Accuracy

The RT-accuracy trade off was calculated, which considers that some participants may show
a slower RT in order to be more accurate in their responses. Error rates were found to be
significantly larger in the forced task, \( M = 0.146 \) (SE = 0.028), than the emotional Stroop task, \( M = 0.054 \) (SE = 0.007), \( F = 14.29, p = 0.002 \). Error in the emotional condition was also significantly
greater, \( M = 0.116 \) (SE = 0.017), than error in the neutral condition, \( M = 0.084 \) (SE = 0.016), \( F = 16.69, p = 0.01 \). This was qualified by a significant interaction between task and condition, \( F = 6.11, p = 0.028 \). These results are in the expected direction, therefore slower RTs were explained by
the predicted more difficult task and condition, suggesting that there was no RT-accuracy trade-off.

4. Discussion

4.1 Findings

4.1.1 Summary of the findings

In this study, the time taken for participants to classify the print colour of emotional and
neutral words was compared across two tasks. In the emotional Stroop task, participants were
instructed to ignore the word content and select the print colour, whereas in the forced task,
participants were asked to respond to the colour only if the word was an emotional word, thereby
forcing participants to process the emotional content of the word on each and every trial. As
expected, RTs were significantly slower on the forced task. Importantly, the time taken to respond
to the colour of positive and negative words was equivalent, while RTs to the general emotion
condition were longer than the neutral condition. This was qualified by a significant interaction of
task and condition (emotional and neutral). The EN-ESE was therefore identified for further
investigation, and found to be significant in the forced task. Fast and slow effects were separately
calculated, and only the fast effect was found to be significant, in the forced task. Interestingly, a
significant and positive correlation was found between the slow effect and depression severity for
both measures of depression and on both tasks.

4.1.2 Voluntary emotional processing

Participant RTs were found to be significantly different between the two tasks. The
emotional Stroop task is widely used with the assumption that the processing of emotional words is mandatory, and if this were the case, we would expect participants to take the same amount of time to classify the word-colour when they are and are not required to process the word content. To the contrary, when participants were forced to process every word, the ESE accentuated disproportionately to the increased difficulty of the task. By comparison, this implies that not every emotional word was processed and produced interference in the emotional Stroop task. This finding suggests that the processing of emotional words in the emotional Stroop task may not be mandatory, as previously assumed.¹ This outcome poses a challenge to research using the emotional Stroop task to probe automatic processes such as attentional bias in psychological disorders.

4.1.3 Emotion-Neutral emotional Stroop effect

In this study, the ESE was found to be the difference between emotional, both positive and negative, and neutral stimuli, the EN-ESE. Indeed, no difference was found between participant’s responses to positive and negative conditions, on either task. By including both positive and negative emotional stimuli, the results of this study provide further support that emotion generally is an evolutionary threat that causes interference on the emotional Stroop task (Algom et al, 2004). The findings also suggest the importance of including positive emotional information in future research using the emotional Stroop task.

4.1.4 Fast and slow effects

The design of this study allowed for both the fast and slow emotional Stroop effects to be examined within the same data and participants. After separately calculating each effect while controlling for the other, only a fast effect was identified in the forced task, across all participants.

¹ A further interpretation is that emotional processing may occur at different levels, where emotion is processed at a deeper level on some trials and at a more shallow level on other trials. This perspective also departs from the assumption that emotional processing is mandatory and occurs on each and every trial to the same extent.
This outcome can be expected as participants were required to process every emotional word in the forced task, and RTs were significantly slower in the emotional condition. A fast effect was not found in the emotional Stroop task, which is not in line with the findings of Frings et al (2010). Indeed, the fast effect has not been consistently found in the literature. A possible explanation for the lack of a fast effect in this study may be the duration of stimulus exposure (500ms). Across the literature, studies using this exposure length have typically failed to find a fast effect, while longer durations of 1000ms have demonstrated the effect. Indeed, the fast effect is found to be critically dependent on the stimulus exposure duration (Donaldson et al, 2007).

4.1.5. Fast and slow effects with depression

Although a slow effect was not found across all participants on either task, significant correlations were found between the slow effect and depression scores on both tasks. This relationship suggests that higher depression severity was related to a greater interference from previously processed emotional words on task performance. These results also suggest that the slow effect was not as relevant for the participants with lower scores that did not reach the threshold for depression.

In comparison, the significant relationship between depression and the slow effect suggests that the participants higher in depression may have had difficulty in disengaging from the previous emotional stimuli. In support, Donaldson et al (2007) found that the prior processing of negative information resulted in an increase in the baseline interference for depressed participants. As described above, stimulus exposure duration is directly linked to finding an ESE. Donaldson et al proposed that a negative bias exists in depression, but only when the emotional information has reached the later disengagement stage of attention. This stage is beyond the initial and automatic attentional shifting that has been presumed previously. In support, another study found differentially higher emotional interference in the later stages of information processing for people with depression compared to those without depression (Gotlib et al, 1998).

A longer exposure time supports more extensive elaboration of the information (Donaldson et al,
which can also be expected from the forced task in this study where participants were required to process the emotional content of each word. Indeed, the slow effect in the forced task was correlated with both depression measures. Mogg and Bradley (2005) proposed that the extended processing of negative stimuli could activate negative schemas and ruminative processes in individuals with depression that further interfere with their task performance. Again, this reflects a bias in later cognitive processes. In support, Donaldson et al (2007) found that interference from negative information was higher in participants who engaged in rumination more often. Rumination is related to a difficulty in regulating emotion in working memory, and can perpetuate and predict severe depression (Nolen-Hoeksema, 2000). The role of working memory has been implicated in depression (Levens & Gotlib, 2009), and is supported by an inpatient trial found that anti-depressant treatment improved patients’ measured verbal working memory (Douglas, Porter, Knight & Maruff, 2011). Therefore, the slow effect experienced by participants higher in depression in this study may have been contributed to by a difficulty in disengaging from and regulating emotional information once it was processed.

A fast effect is thought to reflect an automatic shifting of attention towards emotional stimuli. There was a lack of a significant correlation between depression severity and the fast effect, when interference results from the current emotional word, aligning with many other studies failing to find an ESE in depression through the fast effect (e.g, Gotlib et al, 2004; Grant & Beck, 2006). This finding suggests that emotional interference is less related to the initial stages of automatic selective attention for people with depression. With many studies not finding a fast ESE in depressed populations, it appears that emotional processing can be avoided in these individuals. These null findings could be taken as support for the Emotion Context Insensitivity hypothesis, where responding to emotion is blunted in depression. But after calculating the slow effect, this study found that participants higher in depression did show a significant difference in how they responded to emotional and neutral words, both when required (forced task) and not required (emotional Stroop task) to process the content of the words. This finding is contrary to the expectations of the Emotion Context Insensitivity hypothesis and suggests that the emotional
interference experienced by depressed participants was hidden in analyses focusing on the fast effect.

Although much of the literature focuses on a negative bias in depression, whether early or later in attentional processes, this study found a relationship between depression and interference from emotion generally, with slower performance following both positive and negative words. There was no relationship between depression severity and the slow effect when positive and negative conditions were compared (PN-ESE), reflecting that those higher in depression did not respond any differently towards the positive and negative words, even when forced to process the emotional content. This finding connects with the similarly large effect sizes found for positive and negative words in the meta-analysis, which concluded that depressed individuals show a general emotional bias rather than one that is valence-specific (Epp et al, 2012).

4.1.6. Anxiety and stress

There was a significant relationship between the fast ESE on the emotional Stroop task and anxiety, but this relationship was not found for depression. The same outcome was found in another study where anxious but not depressed participants demonstrated interference on the emotional Stroop task (Mogg, Bradley, Williams & Mathews, 1993). The robust relationship between anxiety and the ESE has been well replicated (e.g., Williams, Mathews & MacLeod, 1996), and it is even suggested that an ESE in depressed participants is the result of co-morbid anxiety (Mogg et al, 2003). Importantly, all of these studies have calculated the ESE as a fast effect. Considering the results of this study, it is possible that studies that have failed to find an ESE in depression have missed a possible slow effect.

The fast ESE may make sense for anxiety, considering that the evolutionary function of anxiety is to detect and respond to threat in the environment (Mathews & McLeod, 2002). The relationship with anxiety and the fast effect in this study illustrates that although the negative words were depression-relevant, they were also considered threatening to participants high in anxiety. In support of the theory that all types of emotion can be perceived as threatening, the anxious
participants displayed a characteristic hypervigilant response to threat. Researchers have suggested that anxiety and depression influence emotional processing at different stages. While anxiety evolved as a biased shifting of attention towards threat, depression appears to be characterized by a bias in the elaboration (Williams, Watts, MacLeod & Mathews, 1997) and memory (Mathews & MacLeod, 1994) stages of processing. Other authors have put forward rumination as an internally self-focused negative bias in depression (Mogg & Bradley, 2005).

There could be several possibilities for the unexpected relationship between stress level and the ESE (the fast effect) in the forced task. If emotion is perceived as an evolutionary-relevant threat, then the forced processing of emotion is likely to increase stress, particularly for participants with high levels of trait stress. Participants may have experienced an increase in arousal level when forced to process emotion, as arousal has previously been related to interference effects on the emotional Stroop task (Gronau et al, 2003). The increased difficulty of the forced task and its demand on cognitive resources may also account for the significant relationship with participants who have high trait stress levels.

4.2. Limitations and future research

The current experimental design, combining the emotional Stroop task with the newly developed forced processing task, entails several advantages. It allows a comparison regarding when emotional processing is required and when it can be voluntary. The introduction of negative, neutral, and positive words mixed with each block allows for a direct comparison between two kinds of ESE, the EN-ESE, and the PN-ESE. Moreover, employing a mixed rather than a blocked design allows for calculation of both fast and slow effects from the same data. However, there are also limitations to this design. In the forced task, the required response was different for each condition. For the neutral condition, participants made one decision: when the word was non-emotional, press the “X” key. For the emotional condition, participants made two decisions: whether the word was emotional and then whether the colour of the word was green or red in order
to press the corresponding key. Responses were found to be faster to neutral words in this task, and this may have been contributed to by the fact that one less decision was required. Future research employing the forced task should attempt to reduce excess variance by creating equal response processes for emotional and neutral words.

Future research may extend the sample size, yet also maintain the pertinent within-subject design. In the current study, 14 participants were divided into two groups (depressed and non-depressed). Some studies in the emotional Stroop task literature have used larger sample sizes, for example, 48 participants in Gotlib and Cane (1987). However, the forced-processing task in the current study mandates that the same participants return to complete multi-session experiments (the two tasks must be carried out on separate days), which limits the capacity for a larger sample size. Yet, the smaller sample size is mitigated by the within-subject design that results in reduced individual variance across the tasks and conditions. Studies using a within-subjects analysis often employ smaller samples for a large number of trials per participant. For example, Eidels, Ryan and Algom (2010) collected data from 20 participants in their forced-reading task, and in another Stroop task study by Eidels, Townsend and Algom (2010), a smaller sample of 5 participants completed many trials across several sessions.

Although a non-clinical sample was used, some participants met the threshold for clinically significant depression. Drawn from an undergraduate first-year psychology population, this sample may therefore not be representative of the general non-clinical population. Participants were of a similar age and the inclusion criteria required native English, thus the sample is limited in generalizing the results to older age groups and other cultures with different native languages. Gender was not controlled and there were disproportionately more female participants. Nevertheless, a meta-analysis of the emotional Stroop task literature did not find gender to be a significant moderator (Epp et al, 2012).

With respect to the selection of stimuli, although a survey was used to check the consensus of the words as either emotional or non-emotional, some of the emotional words chosen carry a higher emotional valence than others. For example, the word “Merry” may carry more positive
emotion than the word “Better”, which can have other connotations of competence and comparison. The different degree of emotionality likely added excess variation to the results by evoking different levels of emotional interference. As arousal is related to emotional interference (Gronau et al, 2003), a stronger emotional word may have evoked greater arousal in participants that led to a larger ESE. The positive, neutral, and negative words used in this study were matched for frequency, word length and orthographic similarity, although it is practically impossible to find words that perfectly match on all these factors (see Appendix 1). A review of the literature found that emotional words were significantly lower in frequency, longer in length and had smaller orthographic neighbourhoods, which could contribute to the ESE through simply slower word recognition (Larsen, Mercer & Balota, 2006). In this study, these differences were approximately balanced across the emotional and non-emotional words.

In this study, emotions were induced via the presentation of emotionally charged words. Other studies have induced emotion via other means, for example, by using pictures of facial expressions and scenes with different emotional themes (Walla & Panksepp, 2013). Nevertheless, the vast literature on the ESE demonstrates prima facie that emotional words can generate emotions in participants.

Additional comprehensive assessment tools are suggested for future research. Self-report questionnaires were used to measure depression and anxiety in this study. These measures are limited in being subject to bias from demand effects, noncompliance and social desirability. Self-report measures of depression are criticized as providing a surface level assessment and may be insensitive to fluctuations in depression (Boyle, 2011). A diagnostic clinical interview could provide a more accurate assessment of depression severity. Other measures could be used to more precisely investigate emotional processing in depression, such as physiological recordings of arousal level and tests of working memory function after exposure to emotion.

There have been several criticisms of the emotional Stroop task throughout the literature. In the original task, the Stroop effect is generated from the difference in RT to congruent and incongruent colour words. However, emotional words cannot be congruent or incongruent with
colour in the same way that colour names are in the original task (Algom, Chajut & Lev, 2004). For example, the word “hopeless” written in blue does not create the same conflict of attention as directly competing stimuli, such as the colour word “RED” written in the colour blue. The two tasks are therefore qualitatively different, with separate cognitive mechanisms underlying the interference effects requiring distinct interpretations.

With a strong relationship found between the slow ESE and depression, it is suggested that future research focus on what can be further understood from the impact of previously processed emotion. As emotion generally was found to cause the ESE in this study, but depression is characterized by a pervasive low mood, future research may disentangle whether negative and positive emotions are processed and regulated differently.

### 4.3 Clinical implications and conclusions

The findings of this study carry implications for both clinical practice and research. Firstly, the results suggest that emotional processing can be voluntary on the emotional Stroop task, challenging the use of the task to investigate automatic attentional processes in depression. Secondly, the ESE was found as the difference between responses to emotional and neutral conditions, the EN-ESE, supporting that both positive and negative emotions produce interference that may result from a general threat of emotion. Research focusing on the fast effect has failed to consistently find an attentional bias in depression. The present study found that depression severity relates to emotional interference through the slow effect. This finding is in support of other studies where depressed individuals demonstrate interference from previously processed emotional information, suggested as evidence that a bias exists during the later disengagement stage of attentional processing (Donaldson et al, 2007).

A bias in the disengagement stage of processing links to two related characteristics of depression that are important to focus treatment: rumination and a difficulty in regulating a low mood. Rumination is a potent risk and maintaining factor, related to difficulty in regulating emotion.
in working memory, and predicts a poor prognosis (Nolen-Hoeksema, 1991; 2000). Twenty percent of depression cases become chronic and treatment resistant (Watkins et al, 2011). Therefore focusing intervention on the maintaining factors, such as rumination, is vital to treating persistent depression. Rumination-focused CBT specifically targets ruminative behaviours for individuals no longer benefiting from standard CBT, and is found to significantly improve residual symptoms and remission rates for chronic depression (Watkins et al, 2011). Mindfulness is another intervention found to decrease rumination through training attention away from dysfunctional thought patterns (Ramel, Goldin, Carmona & McQuaid, 2004). Considering the results of this study, both these interventions for are recommended to treating depression as they importantly focus on identifying and disengaging from unhelpful emotional information that can perpetuate a low mood or trigger a relapse to a depressive episode.
4. References


References


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### Appendix 1. Statistics of the matched emotional and non-emotional stimuli

<table>
<thead>
<tr>
<th>Word</th>
<th>Category (Negative, Positive, Neutral)</th>
<th>Celex frequency*</th>
<th>Log frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sad</td>
<td>Negative</td>
<td>42.60</td>
<td>1.67</td>
</tr>
<tr>
<td>Glad</td>
<td>Positive</td>
<td>64.02</td>
<td>1.81</td>
</tr>
<tr>
<td>Sat</td>
<td>Neutral</td>
<td>228.04</td>
<td>2.36</td>
</tr>
<tr>
<td>Pad</td>
<td>Neutral</td>
<td>11.79</td>
<td>1.07</td>
</tr>
<tr>
<td>Bitter</td>
<td>Negative</td>
<td>35.87</td>
<td>1.57</td>
</tr>
<tr>
<td>Better</td>
<td>Positive</td>
<td>452.46</td>
<td>2.66</td>
</tr>
<tr>
<td>Butter</td>
<td>Neutral</td>
<td>27.37</td>
<td>1.45</td>
</tr>
<tr>
<td>Letter</td>
<td>Neutral</td>
<td>121.01</td>
<td>2.09</td>
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<tr>
<td>Depressed</td>
<td>Negative</td>
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</tr>
<tr>
<td>Impressed</td>
<td>Positive</td>
<td>28.88</td>
<td>1.48</td>
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<tr>
<td>Addressed</td>
<td>Neutral</td>
<td>18.60</td>
<td>1.29</td>
</tr>
<tr>
<td>Depicted</td>
<td>Neutral</td>
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<td>0.86</td>
</tr>
<tr>
<td>Lonely</td>
<td>Negative</td>
<td>27.82</td>
<td>1.46</td>
</tr>
<tr>
<td>Lovely</td>
<td>Positive</td>
<td>60.11</td>
<td>1.79</td>
</tr>
<tr>
<td>Lately</td>
<td>Neutral</td>
<td>12.40</td>
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<tr>
<td>Daily</td>
<td>Neutral</td>
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<td>Failure</td>
<td>Negative</td>
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<td>1.83</td>
</tr>
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<td>Pleasure</td>
<td>Positive</td>
<td>83.52</td>
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<td>Neutral</td>
<td>28.99</td>
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</tr>
<tr>
<td>Paint</td>
<td>Neutral</td>
<td>40.39</td>
<td>1.62</td>
</tr>
<tr>
<td>Merry</td>
<td>Positive</td>
<td>8.10</td>
<td>0.96</td>
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<td>Misery</td>
<td>Negative</td>
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<td>Neutral</td>
<td>31.06</td>
<td>1.51</td>
</tr>
<tr>
<td>Ferry</td>
<td>Neutral</td>
<td>7.60</td>
<td>0.93</td>
</tr>
</tbody>
</table>

* Celex is the total word frequency in both written and spoken English
Appendix 2. Manuscript submission

Scope of the journal

‘Emotion’ was chosen as the preferred journal to submit the manuscript. A description of the journal, taken from the journal’s website (APA, 2013), is provided below:

*Emotion*® publishes significant contributions to the study of emotion from a wide range of theoretical traditions and research domains. The journal includes articles that advance knowledge and theory about all aspects of emotional processes, including reports of substantial empirical studies, scholarly reviews, and major theoretical articles. Submissions from all domains of emotion research are encouraged, including studies focusing on cultural, social, temperament and personality, cognitive, developmental, health, or biological variables that affect or are affected by emotional functioning. Both laboratory and field studies are appropriate for the journal, as are neuroimaging studies of emotional processes. Studies of psychopathology contributing to the understanding of the role of emotional processes in affective and behavioral disorders are also welcome. Reports of work at the animal and molecular levels will be considered if they help to elucidate fundamental mechanisms of emotion.

Most of the articles published in *Emotion* will be reports of original research, but other types of articles are acceptable:

- Case studies from either a clinical setting or a laboratory will be considered if they raise or illustrate important questions that go beyond the single case and have heuristic value.
- Articles that present or discuss theoretical formulations of emotion and related affective phenomena, or that evaluate competing theoretical perspectives on the basis of published data, may also be accepted.
- Comprehensive reviews of the empirical literature in an area of study are acceptable if they contain a meta-analysis and/or present novel theoretical or methodological perspectives.
- Comments on articles published in the journal will be considered.
Notes to contributors

The instructions to authors specific for submitting manuscripts to the Emotion journal are provided below (APA, 2013):

Submission

Submit manuscripts electronically through the Manuscript Submission Portal in Word Document format (.doc).

All tables and figures should be included in the manuscript file.

Correspondence:

David DeSteno
Northeastern University
Boston, MA 02115

General correspondence may be directed to the Editor's Office.

Masked Review Policy

Masked reviews are optional, and authors who wish masked reviews must specifically request them when they submit their manuscripts. For masked reviews, the manuscript must include a separate title page with the authors' names and affiliations, and these ought not to appear anywhere else in the manuscript. Footnotes that identify the authors must be typed on a separate page. Authors are to make every effort to see that the manuscript itself contains no clues to their identities. If your manuscript was mask reviewed, please ensure that the final version for production includes a byline and full author note for typesetting.

Manuscript Submission Guidelines

In addition to addresses and phone numbers, authors should supply email addresses and fax numbers for use by the editorial office and later by the production office. The majority of
correspondence between the editorial office and authors is handled by email, so a valid email address is important to the timely flow of communication during the editorial process. Authors should provide email addresses in their cover letters and should keep a copy of the manuscript to guard against loss. Manuscripts are not returned. Manuscripts for Emotion® can vary in length; typically they will range from 10 to 40 double-spaced manuscript pages. Manuscripts should be of sufficient length to ensure theoretical and methodological competence.

Most of the articles published in Emotion will be reports of original research, but other types of articles are acceptable.

- Case studies from either a clinical setting or a laboratory will be considered if they raise or illustrate important questions that go beyond the single case and have heuristic value.
- Articles that present or discuss theoretical formulations of emotion and related affective phenomena that evaluate competing theoretical perspectives, or that offer innovative commentary or analysis on timely topics of inquiry may also be accepted.
- Comprehensive reviews of the empirical literature in an area of study are acceptable if they contain a meta-analysis and/or present novel theoretical or methodological perspectives.
- Comments on articles published in the journal will be considered.

**Brief Reports**

Emotion also publishes brief reports. Manuscripts submitted as Brief Reports should not exceed 2,500 words, exclusive of references and figure captions. There should be no more than 2 figures or tables and no more than 30 references.

The journal ‘Emotion’ is published by the American Psychological Association (APA; 2001), and therefore a submitted manuscripts must follow the APA Journals Manuscript Submission Instructions for All Authors. A copy of these instructions is provided below.
Manuscript preparation

Prepare manuscripts according to the Publication Manual of the American Psychological Association (6th edition). Manuscripts may be copyedited for bias-free language (see Chapter 3 of the Publication Manual). Double-space all copy. Other formatting instructions, as well as instructions on preparing tables, figures, references, metrics, and abstracts, appear in the Manual. Below are additional instructions regarding the preparation of display equations and tables.

Display equations

We strongly encourage you to use MathType (third-party software) or Equation Editor 3.0 (built into pre-2007 versions of Word) to construct your equations, rather than the equation support that is built into Word 2007 and Word 2010. Equations composed with the built-in Word 2007/Word 2010 equation support are converted to low-resolution graphics when they enter the production process and must be rekeyed by the typesetter, which may introduce errors.

To construct your equations with MathType or Equation Editor 3.0:

- Go to the Text section of the Insert tab and select Object.
- Select MathType or Equation Editor 3.0 in the drop-down menu.

If you have an equation that has already been produced using Microsoft Word 2007 or 2010 and you have access to the full version of MathType 6.5 or later, you can convert this equation to MathType by clicking on MathType Insert Equation. Copy the equation from Microsoft Word and paste it into the MathType box. Verify that your equation is correct, click File, and then click Update. Your equation has now been inserted into your Word file as a MathType Equation.

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