Clarifying the NAP effect and the role of dispositional factors: Behavioural and electrophysiological investigations

by

Regard Martijn Booy

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Approval

Name: Regard Martijn Booy
Degree: Master of Arts
Title: Clarifying the NAP effect and the role of dispositional factors: Behavioural and electrophysiological investigations.

Examining Committee:

Mario Liotti
Senior Supervisor
Professor

Thomas Spalek
Supervisor
Associate Professor

Rebecca Todd
External Examiner
Assistant Professor
Department of Psychology
University of British Columbia

Date Defended/Approved: May 05, 2016
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Abstract

Researchers using the negative affective priming (NAP) paradigm favour a dispositional argument for the negative ruminatory cycle in depression despite some evidence supporting an affect-based explanation. Additionally, the cognitive mechanisms underlying the task are poorly understood. To examine these questions directly, a modified version of the NAP task, that dissociates the priming effects of positive and negative words, was implemented in two experiments. The first experiment tests the contribution of disposition (as measured by the NEO-PI-R depression subscale) versus symptom severity (as measured by the BDI-II) to NAP scores. Compared to low BDI-II scorers, high BDI-II scorers showed a larger NAP effect for negative words, and a smaller NAP effect for positive words. However, there were no significant differences between high and low scorers on the NEO-PI-R depression subscale. This suggests that current severity of symptoms and not dispositional factors influence the NAP effect more strongly. The second experiment used event related potentials (ERPs) to determine the cognitive processes involved in the NAP task prior to a participant’s response. The results showed that prior presentation of irrelevant emotion words significantly affected the brain response to subsequent task-relevant emotion words. Thus, on ignored repetition (IgnRep) trials positive voltage modulations were observed both early, over frontal scalp (between 190-260ms) and late, primarily over posterior scalp (between 500-700ms). Interestingly, IgnRep trials for negative words were associated with the early frontal effects, suggesting an early, implicit attentional bias to negative material, while IgnRep trials for positive words were associated with the later positivity, indicating more conscious processing of positive material. Results are discussed in terms of current theories of the processes involved in the NAP effect.

Keywords: Negative Affective Priming; Dysphoria; Event Related Potentials; BDI-II; Late Positive Potential; Early Anterior Positivity
To my parents who taught me the value of critical thinking and hard work. To my wife who embodies the virtues of compassion and sincerity. And to my brother who inspires loyalty and creativity.
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<tr>
<td>ACC</td>
<td>Accuracy</td>
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<tr>
<td>ANEW</td>
<td>Affective Norms for English Words</td>
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<td>ANOVA</td>
<td>Analysis of Variance</td>
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<tr>
<td>AttRep</td>
<td>Attended Repetition</td>
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<tr>
<td>BDI-II</td>
<td>Beck Depression Inventory (second edition)</td>
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<tr>
<td>CES-D</td>
<td>Centre for Epidemiologic Studies Depression scale</td>
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<tr>
<td>DIA</td>
<td>Distractor Inhibition Account</td>
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<td>EAP</td>
<td>Early Anterior Positivity</td>
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<td>EEG</td>
<td>Electroencephalogram</td>
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<tr>
<td>EPN</td>
<td>Early Posterior Negativity</td>
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<tr>
<td>ERA</td>
<td>Episodic Retrieval Account</td>
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<td>ERP</td>
<td>Event-related Potential</td>
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<td>High Depression</td>
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<td>Ignored Repetition</td>
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<td>ISI</td>
<td>Inter-stimulus Interval</td>
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<td>LBDI</td>
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<td>Late Positive Complex</td>
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<td>NEO-PI-R</td>
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<td>NFC</td>
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<td>PP</td>
<td>Positive Priming</td>
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<td>RSI</td>
<td>Response Stimulus Interval</td>
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<tr>
<td>RT</td>
<td>Reaction Time</td>
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<td>WM</td>
<td>Working Memory</td>
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Chapter 1.

General Introduction

Whether depression revolves primarily around negative affect resulting in cognitive changes, or a negative thought patterns leading to a negative mood state remains undetermined. Depression is often described as a cognitive disorder characterized by negative schemas (Koster, De Lissnyder, Derakshan, & De Raedt, 2011) which causes the altered patterns in both memory and attention (Gotlib & Joormann, 2010). Under this conception, negative thought patterns, contribute to the characteristic sad mood of the disorder. For example, when receiving a poor grade on an assignment a person might think “I am terrible at this” causing them to feel negatively, especially about themselves. Continued repetition of this pattern leads to a pervasive sad mood, as well as a negative cognitive bias. However, a plausible alternative considers ineffective or insufficient emotion regulation strategies to lie at the heart of the disorder (Joormann & Gotlib, 2010; Bertram & Dickhauser, 2012). In this case, receiving a poor grade on the assignment results in negative emotions such as disappointment. If an individual does not employ the necessary compensatory mechanisms, or the emotions overwhelm the individual’s compensatory abilities, then they are unable to overcome the negative affect which contributes to negative thought patterns.

1.1. Cognitive Bias in Depression

Certainly, depressed individuals show a negative cognitive bias. Most obviously, they tend to focus on negative material, and remember negative content more readily (Dai, Feng & Koster, 2011; Gotlib & Joormann, 2010). However, a more general pattern of
altered cognition is also evident in these populations. This is best captured by the fact that they do not show the same need for cognition (NFC; Bertram & Dickhauser, 2012) relative to non-depressed individuals. NFC is the tendency to seek out and enjoy cognitive exertion (e.g. preferring demanding strategy games). Because higher NFC is related to seeking out effortful cognition, it is related to deeper processing of information and better performance on cognitive tasks. Therefore, decreased NFC in depressed individuals might explain the cognitive profile of depression. They have difficulties concentrating (Joormann, Yoon & Zetsche, 2007) which likely contributes to the over-general memories that lack detail and specificity (Rawal & Rice, 2012). And they show impairments on working memory (WM) and executive function related tasks (Gotlib & Joormann, 2010; Nixon, Liddle, Nixon & Liotti, 2013). Manipulating negative material in WM and removing negative material from WM seems to be especially difficult for depressed individuals (Gotlib & Joormann, 2010; Joormann & Gotlib, 2008). This would crowd WM capacity with negative material, and could manifest as a generalized negative world view.

Interestingly, this distinctive cognitive profile of depression is most obvious in tasks that 1) do not constrain attention 2) require more cognitive effort, and 3) where personal emotions are salient (Joormann, Yoon & Zetsche, 2007; Gotlib & Joormann, 2010; Pelosi, Slade, Blumhardt, & Sharma, 2000). For example, performance is poorer on free-recall tasks relative to recognition tasks (Gotlib & Joormann 2010) and following a period wherein rumination was possible. Thus, when dysphoric students had to wait before receiving instructions, performance was decreased (Hertel, 1998). Most likely, depressed individuals revert back to the dominant negative schema under these circumstances, allowing them to brood on the salient negative information.
1.2. Rumination in Depression

This negative bias could be explained by the negative ruminatory cycle. In the case of depression, rumination consists of recurring, intrusive thoughts fixated on the negative mood state and its associated consequences (Joormann, Yoon & Zetche, 2007; Nolen & Hoeksema, 1987). It is possible that dwelling on negative material results in a negative mood and reinforces the negative schema which originally made the negative material salient (Joormann, Yoon & Zetche, 2007; Koster, De Lissnyder, Derakshan & De Raedt, 2011). In support of this postulation, such ruminatory thought patterns are associated with more severe depressive symptomology in previously depressed individuals (Cooney, Joormann, Eugène & Gotlib 2010; Joormann & Gotlib, 2010), and indeed reduces inhibition for emotional material as measured by the negative affective priming task (Zetsche & Joormann, 2011) irrespective of depressive symptoms (Joormann, 2006). This suggests that people who are more prone to such ruminatory thought patterns, are more likely to develop a negative schema, and are potentially at higher risk of developing depression (Joormann, Yoon & Zetche, 2007).

However, while this description nicely captures the cognitive processes involved in beginning and perpetuating a depressed episode, it does not account for the origins of the ruminatory cycle. Why only certain individuals develop this thought pattern needs to be addressed (Joormann, Yoon, & Zetche, 2007). This requires one of two solutions: Firstly, one could assume that, while all aspects of the ruminatory process (negative schema, inhibitory processes, and working memory content) are continually interacting, one of the three is affected by trait factors and represents an innate vulnerability towards developing depression. For example, a person may have lower activation thresholds for negative material allowing more negative material to reach conscious awareness, and
thus building the negative schema. Alternatively, an additional factor may act on one of the components, thereby initiating the ruminatory cycle. For instance, a pervasive negative mood resulting from situational elements (e.g. losing one’s job or being bullied at school) may lead to the negative schema, which precipitates the ruminatory cycle.

1.2.1. Dispositional Argument: Inhibition and WM

Research using the Negative Affective Priming (NAP) task often claim that depression originates with a predisposition in the form of reduced inhibition for negative material. During the task, participants are presented with two objects (either two words or two faces), and are asked to ignore one while indicating the valence (positive, neutral or negative) of the other (Wentura, 1999). The ignored word is considered the distractor, while the attended word is the target (typically identified by font colour or a coloured square on each face). Reaction time (RT) to the target is analyzed based on the valence of the previous distractor. If the valence of the previous distractor is congruent with the valence of the current target, RTs are typically slower relative to trials where the previous distractor and current target valence are incongruent (Control Trials). This difference is best quantified as a NAP effect, which is calculated by subtracting the RT on control trials from the corresponding Ignored Repetition (IgnRep) trials for each word type.

Depressed individuals do not show the expected cost on IgnRep trials for negative words. That is, they are not slower when responding to a negative word after previously ignoring a negative word (Joormann & Gotlib, 2010; Joormann, 2006; Zetsche & Joormann, 2011; Dai, Feng & Koster, 2011), a robust pattern that has been replicated for sad faces (Dai & Feng, 2011; Goeleven, De Raedt, Baert & Koster, 2006; Zetsche & Joormann, 2011). Even individuals experiencing dysphoria (typically measured through BDI scores) show a similar pattern of results (Joormann, 2004; Frings, Wentura & Holtz, 2007). This reduced NAP effect for negative material is often interpreted as an inability to
inhibit negative material effectively. And it is this that is thought to drive the negative ruminatory cycle (Gotlib & Joormann, 2010). The argument generally revolves around a difficulty disengaging attention from the negative material (Owens, Koster & Derakshan, 2012; Koster, De Lissnyder, Derakshan & De Readt, 2011; Eugène, Joormann, Cooney Atlas, & Gotlib, 2010). Essentially, a fixation on negative material and subsequent failure to exercise attentional control over the content that enters WM (Joormann, Yoon & Zetche, 2007; Davis & Nolen-Hoeksema, 2000) results in abnormal amounts of negative material in WM. This primes other negative material and prevents positive material from being processed, resulting in the negative schema, the negative ruminatory thought patterns and pervasive negative affect. Hence, the reduced inhibition for negative material may constitute a dispositional vulnerability (Dai & Feng, 2011; Zetsche & Joormann, 2011) that, when aggravated by stress (Carter & Garber, 2011), leads to a depressed episode.

1.2.2. Emotion Regulation Argument: Sad Mood and Depression

However, given that the presence of negative cognitions may not predict the severity of depressive symptoms (LaGrange et al. 2011), there must be more to the story. Specifically, some evidence indicates that rumination is caused by ineffective emotion regulation strategies (Joormann & Gotlib, 2010; Bertram & Dickhauser, 2012; Gotlib & Joormann, 2010) suggesting a depressed episode might be triggered by a negative mood state rather than negative thought patterns. In other words, it is possible that the inability to overcome a negative mood state, prevents the sad mood from dissipating, which prompts the negative schema. Importantly, this failure to dispel the sad mood may be either an innate aspect of the individual (e.g. poor emotion regulation strategies), or environmental (e.g. extremely negative circumstances). Thus, the current mood state may simply be too severe or continuous to fend off, or emotion regulation strategies such as compensatory mechanisms, might be insufficient. Consequently, this sad mood begins to
pervade the individual’s life resulting in the negative schema and thought patterns that characterize the ruminatory cycle. If this is the case, then negative affect is the cause rather than the consequence of the negative rumination.

Only a few studies have pursued this line of inquiry. However, evidence does indicate that emotional state influences performance on the NAP task. Most importantly, a negative mood induction has been shown to increase inhibition for negative words and decrease inhibition for positive words; a pattern opposite that found in the neutral mood induction condition (Goeleven, De Raedt & Koster, 2007) and opposite the pattern typically observed in depressed (e.g. Joormann & Gotlib 2010) and dysphoric groups (e.g. Frings, Wentura & Holtz, 2007). This increased inhibition for negative words has also been observed in previously depressed (remitted) samples (Joormann & Gotlib, 2010; Joormann, 2004), and was explained as a subconscious over-reaction to counteract the priming bias for negative material (Joormann, Yoon, & Zetsche, 2007; Joormann, 2004).

Such an explanation is in line with the general avoidance of negative emotions shown by most individuals (Grybowski, Wyczesany & Kaiser, 2014; Koster, De Lissnyder, Derashan, & De Readt, 2011), and indicates that people naturally employ compensatory mechanisms to prevent descending into a sad mood state. Likely, the sad mood and corresponding negative thoughts conflict with a person’s tendency towards a positive self-view (Koster, De Lissnyder, Derashan, & De Readt, 2011). The resulting conflict signal initiates some compensatory mechanism that breaks the negative ruminatory cycle. The fact that this does not happen in depressed individuals could indicate that frequent and excessive negative emotions become part of a person’s self-concept and thus no conflict occurs.

Consequently, the reduced inhibition for negative words in high depressed trait groups so frequently reported, might represent an already broken system, rather than the origins of the problem. Essentially, these subjects are already past appropriate
compensatory behaviours. They will have incorporated negative emotions into their self-concept, so no conflict signal was engaged and rumination on negative material is possible. Consistent with this logic, depressed individuals are less able to differentiate positive and negative feedback (Foti & Hajcak, 2009), a pattern that appears to be driven by current levels of sadness (Foti & Hajcak, 2010). Thus, prolonged exposure to a sad mood state might reduce the impact of positive reinforcers, thereby contributing to a negative world view. This clearly suggests that mood state lies at the heart of the cognitive profile of depression.

If this line of reasoning is correct, then an emotional state that is congruent with a person’s self-concept should result in rumination. If material that is incongruent with an individual’s self-concept triggers a conflict signal, then no such signal would be engaged for material that is congruent with the person’s self-concept. Without this conflict signal, resources are not deployed to remove the congruent material from WM making rumination possible. Because of the innate bias towards a positive self-image (Koster, De Lissnyder, Derashan, & De Readt, 2011), a positive mood state would be most congruent with a low-depressed trait person’s self-concept. However, the more negative self-concept of individuals at greater risk for developing depression would be matched more closely by a negative mood state. Thus, comparable amounts of rumination should be observed for positive material in low-depressed trait participants during a positive mood state, and for negative material in high-depressed trait individuals while in a negative mood state. Some evidence suggests this speculation is correct. When in a negative mood state, high-depressed trait individuals showed longer RT on the NAP task irrespective of the word valence. Similarly, the low depressed trait group was slowest following an induced positive mood (Booy & Liotti, 2015). Thus, when the induced mood matches a pre-existing internal
state (e.g. experiencing depressed symptoms) rumination occurs suggesting mood state plays an important role in the negative ruminatory cycle.

1.3. The current study

With relatively little research examining the role of mood state on the NAP effect, it is difficult to judge the validity of an emotion regulation account presented above. This is compounded by insufficient knowledge on the cognitive mechanisms involved in the task. Thus, to determine if factors beyond the negative ruminatory cycle influences the NAP effect, two questions in particular need to be addressed: Firstly, to what extent is the NAP effect attributable to dispositional factors? And secondly, how is the task processed by the brain?

In order to address these, a modified version of the NAP task was created allowing us to examine negative priming effects for each word valence independently. In the literature, control trials are typically defined as trials where the probe target valence is opposite to the prime distractor valence. In other words, on a control trial, if the probe target was negative, the prime distractor was necessarily positive, whereas if the probe target was positive the prime distractor was inevitably negative. This design leads to two problems: First, because emotional material are part and parcel with the affective context wherein they are perceived (Grzybowski, Wyczesany, & Kaiser, 2014), in designs that contrast positive and negative content directly, there are no priming free trials, and so, no true control trials. For example, a positive distractor might prime a positive mental set which may be more difficult to disengage from if the current target is negative resulting in a deceivingly inflated NAP effect. Second, it is unclear if the lack of a NAP effect can be attributed to the effect of negative words. Instead, it may be driven by altered processing of positive words, or changes in the cognitive treatment of both positive and negative
words. The modified version of the NAP task proposed here, seeks to dissociate the effects of negative and positive words by implementing true control trials. Therefore, on control trials in this modified task, the preceding distractor was a neutral word ensuring no negative priming effect was present. This enabled us to isolate differences in negative priming for each word. Specifically, we expected that the NAP effect for positive words would be smallest, and the NAP effect for negative would be largest.

The modified NAP task was implemented in two studies. The first experiment sought to determine whether the severity of depressed symptoms or dispositional factors contributed more to the NAP effect. The second experiment aimed to determine the nature of the NAP effect using event related potentials (ERPs). Given that previous studies were unable to truly dissociate positive and negative material, it is necessary to determine if positive and negative material are processed differently. The temporal resolution of EEG allows us to examine the cognitive processes prior to making a response, and thereby gain insight into the cognitive mechanisms underlying the NAP task.
Chapter 2.

Experiment 1

2.1. Introduction

Much of the research using the NAP paradigm has used clinical populations, focussing on currently depressed, relative to previously depressed, and never depressed individuals. If the task does measure an innate vulnerability towards depression, then a sub-clinical sample (individuals who show a propensity towards depression but who are not currently depressed) should show the same reduced NAP effect for negative words.

Two studies have examined the NAP effect in non-clinical populations. In the first study, participants were divided into dysphoric and non-dysphoric groups based on their Centre for Epidemiologic Studies Depression Scale (CES-D) scores. As predicted, the dysphoric sample showed a significantly reduced NAP effect for negative words (Joormann, 2004). In the second study, subjects were divided into high and low depressed trait groups using a median split based on their Beck Depression Inventory (BDI) scores. Again, the expected reduced NAP effect for negative words was found (Frings, Wentura & Holtz, 2007).

However, these studies could not distinguish vulnerability towards depression due to dispositional/personality factors (‘trait’ effects, likely innate), from the actual presence and severity of symptoms of negative affect (‘state’ effects precipitated by environmental factors). This is because, both the BDI and CES-D require respondents to indicate how they have been feeling in the recent past. This particular phrasing of the questionnaires asks participants to think about their emotional state over the previous two weeks which is congruent with the diagnostic criteria for depression. Thus, they measure the current
severity of depressive symptoms; symptoms that include negative affect, feelings of worthlessness and sadness. A measure of trait depression should focus on a person’s *typical* emotional response *in general* and not only in a specified time period. Hence, the conclusion that a predisposing towards depression in the form of reduced inhibition for negative words results in negative affect may not be warranted. It is equally possible that severe or sustained negative affect results in the reduced NAP for negative words resulting in greater risk for developing depression. These explanations indistinguishable using the BDI or CES-D as a measure of depressed trait.

The present study sought to expand this line of research by dissociating the effects of ‘trait’ and ‘state’ depression. To do this, respondents completed the NEO-PI-R N3 subscale in addition to the BDI-II. While the NEO-PI-R asks respondents to consider how they typically think and act, the BDI-II asks them to consider how they have felt recently. Thus, the former can be considered a measure of ‘trait’ depression; a more general, possibly innate, predisposition to experience negative emotions when confronted with environmental challenges. The latter however, measures ‘state’ depression; the presence of depressed symptoms due to environmental factors. This allowed us to address the first research question: are dispositional factors primarily responsible for the NAP effect?

Although the focus is typically on negative material, previous studies do show numeric if not statistical differences in the NAP effect for positive words as well. Given that the modified NAP task was designed to dissociate the effects of positive and negative words it was predicted that larger differences would be observed for both positive and negative words. Specifically, because of the general positive self-bias exhibited by most individuals, the NAP effect for positive words was expected to be reduced, while the NAP effect for negative words was expected to be increased compared to neutral words.
Because of the emphasis the BDI-II instructions places on emotional state we suspected that previous findings might represent an effect of mood state. Therefore, it was predicted that symptom severity rather than trait depression would be the primary force behind altered processing of valenced material. Lastly, no group differences would be present as a function of 'trait' depression.

2.2. Methods

2.2.1. Participants

184 female undergraduate students ($M_{Age}=19.13 \ SD=1.74 \ Min=17 \ Max=26$) with normal or corrected to normal vision, and no reported history of depression or anxiety, were recruited via the online Research Participation System at Simon Fraser University receiving course credit for their participation. Students admitting to a history of affective disorder were excluded to avoid unnecessary biases in the results. Since mood disorders and vulnerability to depression are more common among women, (Kornstein, Schatzberg, Thase, et al, 2000) and women tend to show more symptoms, higher symptom severity, and report more subjective distress compared to depressed men (Seney & Sibille, 2014) we restricted the sample to females. Participants with accuracy below 50% for any word type were discarded, yielding a final sample of 137 individuals ($M_{Age}=19.17 \ SD=1.77 \ Min=17 \ Max=27$).

2.2.2. Procedure

After obtaining informed consent, participants completed a medical history questionnaire containing some demographic questions, the NEO-PI-R N3 subscale and the BDI-II. They then completed the modified NAP task.
2.2.3. Design

During the NAP task, a central fixation cross was displayed for 500ms, followed by a response slide. The response slide contained two words presented one above the other, in the centre of the screen and remained on screen for up to 2.5sec. The words were separated by a 1cm edge-to-edge gap which contained a white fixation cross. The words were coloured in yellow and pink, indicating which word was to be ignored and which was to be attended to. The attended colour was counterbalanced such that half of the participants attended to the yellow word and half attended to the pink word. The font colour was independent of valence.

Table 1: The modified NAP task.

<table>
<thead>
<tr>
<th>Prime - Distractor</th>
<th>Positive Word</th>
<th>Negative Words</th>
<th>Neutral Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgnRep</td>
<td>Control</td>
<td>IgnRep</td>
<td>Control</td>
</tr>
<tr>
<td>+</td>
<td>N</td>
<td>-</td>
<td>N</td>
</tr>
<tr>
<td>Probe - Target</td>
<td>IgnRep</td>
<td>Control</td>
<td>IgnRep</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>positive word (+)</td>
<td>negative word (-)</td>
<td>neutral word (N)</td>
<td></td>
</tr>
</tbody>
</table>

Because each slide served as the prime for the next slide as well as the probe for the previous slide the probe target and prime distractor varied. This allowed for a more trials within a shorter time period in order to avoid fatigue effects. Additionally, systematic effects of the prime target and probe distractor would average out, ensuring any effects is due to the prime distractor, probe target combination. The NAP effect for neutral words is not of particular interest in the present study. Future studies should focus on validating this task. In particular, the differential priming effects of negative versus positive words can be identified within the control condition for neutral words.

A slide could contain a positive and a negative word, a neutral and a positive word, or a negative and a neutral word, but never two words of the same valence. Nor could any target be preceded by a target of the same valence (see table 1) and only IgnRep and corresponding control trials were present in the experiment. These criteria were chosen to maximize the amount of trails in the experiment while limiting the time required for
completing the task. This reduced the risk of fatigue effects and the possibility of systematic mood effects resulting from boredom of frustration.

Six trial lists were generated according to the following criteria: First, each of the six conditions (IgnRep and Control for each word valence) had to appear five times in each list. Second, none of the words could be repeated within the same list, though the same words may appear in multiple lists. Third, the order of the conditions could not be the same across lists. These constraints determined the order of the six conditions in each mini-block. Participants completed two repetitions of each of the six trail lists (consisting of 30 trials each) for a total of 360 experimental trials. Additionally, subjects completed 15 practice trials. Any trials on which subjects made an incorrect response, or with RT below 300ms were excluded from the analysis. No response was recorded after 2500ms.

Words were selected from the Affective Norms for English Words (ANEW) database. The ANEW database provides the average valence, arousal and dominance ratings for commonly used English words (Bradley & Lang, 1999). Ratings range from 1-10 with higher values indicating higher levels of the construct. 64 positive, 64 negative, and 50 neutral words were selected based on valence rating, and controlling for length and arousal ratings. Words with valence ratings above 6 were considered for the positive list, between 4 and 6 for the neutral list, and below 4 for the negative list. Because of their highly arousing properties to a sub-portion of people, any words that are commonly associated with fear (such as snake, serpent, spider, etc.) were excluded from consideration to control extraneous factors as much as possible.
2.2.4. Variables

**NEO-PI-R**

The depression (N3) subscale from the NEO Personality Inventory Revised (NEO-PI-R) was used to measure a subject’s propensity towards depression. It includes eight statements and participants indicate how well a statement describes them on a 5-point scale from 0 (*strongly disagree*) to 4 (*strongly agree*). Theoretically, scores range from 0-32 and ranged from 0-29 in the present study. This measure has good internal consistency (N3 coefficient $\alpha=.83$) and inter-rater reliability (N3 cross-observer $r=.51$; McCrae, Martin & Costa, 2005).

**BDI-II**

The Beck Depression Inventory-II (BDI-II) is a 21-item questionnaire used to measure the severity of depressive symptoms during the preceding two weeks including today. Responses corresponding to no symptoms are assigned a score of 0, while severe symptoms are scored 3. Theoretically, scores range from 0 – 63 and ranged from 0-34 in the present study. The BDI – II is well established as a reliable and valid measure of depressed symptoms (outpatient coefficient $\alpha =.92$, $n=500$; correlation with Hamilton Psychiatric Rating Scale for Depression $r=.71$, $n=87$; Beck, Brown & Steer, 1989).
Table 2: Demographics

<table>
<thead>
<tr>
<th></th>
<th>AGE</th>
<th>BDI-II</th>
<th>NEO-PI-R N3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiment 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>19.17 ± 1.77</td>
<td>8.99 ± 6.61</td>
<td>13.84 ± 5.11</td>
</tr>
<tr>
<td>H_{BDI}</td>
<td>19.06 ± 1.68</td>
<td>12.65 ± 5.71</td>
<td>15.52 ± 4.71</td>
</tr>
<tr>
<td>L_{BDI}</td>
<td>19.35 ± 1.91</td>
<td>3.00 ± 1.98</td>
<td>11.10 ± 4.56</td>
</tr>
<tr>
<td>HD</td>
<td>19.09 ± 1.54</td>
<td>11.88 ± 7.41</td>
<td>18.36 ± 3.32</td>
</tr>
<tr>
<td>LD</td>
<td>19.23 ± 1.93</td>
<td>6.86 ± 5.03</td>
<td>10.52 ± 3.34</td>
</tr>
<tr>
<td><strong>Experiment 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>18.74 ± 1.62</td>
<td>9.05 ± 6.84</td>
<td>13.66 ± 4.91</td>
</tr>
</tbody>
</table>

Mean and standard deviation for each group on important variables. The H_{BDI} and L_{BDI} groups differed significantly in terms of BDI scores while the HD and LD groups differed significantly in terms of NEO-PI-R N3 scores.

2.2.5. Statistical Analysis

T-tests comparing the accuracy (ACC) for each word valence were conducted to determine if performance across the three word valences were comparable. Tests were run at the $\alpha'=.033$ significance level capping family-wise error rate at $\alpha=.1$.

To address the research question of whether there are differences in the priming effect for different word valences, a single factor, within-subject analysis of variance (ANOVA) to examine the differences in the NAP effect for each word valence (Positive, Neutral and Negative). The NAP effect is defined as the difference between RTs to IgnRep and the corresponding control trials for each word valence. Follow-up t-tests were conducted to compare specific conditions relevant to the a-priori hypotheses. Family-wise error rate was capped at $\alpha=.1$, using a Bonferroni correction which kept the significance level for individual test at $\alpha'=.025$.

To determine if dysphoria is characterized by alterations in processing of negative material only, subjects where split into high BDI (H_{BDI}) and low BDI (L_{BDI}) groups. Consistent with the cut-offs used by Frings, Wentura and Holtz (2007) subjects who scored
7 or greater on the BDI-II were assigned to the $H_{BDI}$ group ($n=85$) while subjects scoring 6 or below were assigned to the $L_{BDI}$ group ($n=52$). An independent samples t-test comparing BDI scores in the $H_{BDI}$ ($M=12.65$, $SD=5.71$) and $L_{BDI}$ ($M=3.00$, $SD=1.98$) groups confirmed that the groups were significantly different; $t_{113.07}=11.74$, $p<.001$. The mean BDI score for each group in the current study was similar to the mean BDI score of the corresponding group in the Frings, Wentura & Holtz (2007) study. A 2 (BDI group) x 3 (WordValence) ANOVA was then conducted on the NAP scores for each word valence. This was followed up by paired samples t-test comparing the $H_{BDI}$ and $L_{BDI}$ NAP scores for each word valence. All tests were run at the $\alpha'=0.05$ significance level capping the family-wise error rate at $\alpha=0.2$. Due to the unequal sample sizes, sphericity and equality of variance was not assumed and corrected significant values are reported.

To determine if any word valence effect can be attributed to depressed ‘trait’, participants were then divided into a high-depressed trait (HD) and low depressed trait (LD) group based on their depression scores from the NEO-PI-R N3 subscale. An independent samples t-test comparing N3 scores in the HD ($M=18.36$, $SD=3.318$) and LD ($M=10.52$, $SD=3.34$) groups confirmed that the groups were significantly different; $t_{123.50}=13.61$, $p<.001$.

The standardized mean for college age women on this subscale is 14. Consequently, subjects scoring 14 or below were included in the LD group ($n=79$) while those scoring 15 or greater constituted the HD group ($n=58$). A 2 (N3 group) x 3 (WordValence) ANOVA was then conducted on the NAP scores for each word valence. This was followed up by paired samples t-test comparing the HD and LD NAP scores for each word valence. All tests were run at the $\alpha'=0.05$ significance level capping the family-wise error rate at $\alpha=0.2$. Due to the unequal sample sizes, sphericity and equality of variance was not assumed and corrected significant values was reported.
2.3. Results

2.3.1. Accuracy

ACC for positive words was significantly higher than both positive and negative words, \( t_{136}=8.21, p<.001 \); \( t_{136}=2.95, p=.004 \), respectively. However, no differences were observed between positive and negative words, \( t_{136}=-1.76, p=.08 \). This indicates that positive words were significantly easier to identify correctly than both negative and neutral words. It is possible that this had a systematic effect on RTs to positive words, however numerical differences between ACC for the word valences were small, as was the variability in ACC to all word types. Therefore, the influence of these differences was not anticipated to be a large problem for the present study.

### Table 3: Accuracy

<table>
<thead>
<tr>
<th></th>
<th>Positive Words</th>
<th>Negative Words</th>
<th>Neutral Words</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiment 1</strong></td>
<td>.79±.05</td>
<td>.75±.06</td>
<td>.77±.08</td>
</tr>
<tr>
<td><strong>Experiment 2</strong></td>
<td>.86±.06</td>
<td>.85±.07</td>
<td>.91±.04</td>
</tr>
</tbody>
</table>

Mean ACC and standard deviation for each word valence. In Experiment 1, ACC to positive words was significantly higher than ACC to other word valences. This lead to more stringent criteria for including specific word in the list. Consequently, in Experiment 2, ACC to neutral words was significantly higher than ACC to other word valences.

2.3.2. Overall NAP effects

The t-tests on the NAP effect for each word valence indicated significant differences between the three word valences. Positive words showed a facilitation effect while negative and neutral words both showed a delay (see table 2). The NAP effect for positive words (PosWordNAP) was significantly lower than the NAP effect for both negative (NegWordNAP) and neutral (NeuWordNAP) words; \( t_{136}=-9.67, p<.001 \) and \( t_{136}=-4.56, p<.001 \) respectively. The smaller difference between NegWordNAP and
NeuWordNAP was also significant; $t_{136}=4.79$, $p<.001$. These results suggest that the traditional NAP effect is composed of two sub-processes, a facilitation effect for positive words, and an impeding effect for negative words.

2.3.3. Effects of ‘state’ depression on NAP effect

A 2 between (BDI group: High vs. Low) x 3 within (Word valence: Negative, Neutral, or Positive) subject mixed-factors ANOVA revealed a main effect for word valence; $F_{(1.98,269.54)}=36.99$, $MSE=2570.82$, $p<.001$, consistent with the word valence differences described above. More critically, the two-way interaction between BDI group and word valence was significant, $F_{(2,269.54)}=4.235$, $MSE=2570.82$, $p=.016$. Independent samples t-tests revealed that the HBDI group had a significantly reduced NAP score compared to the LBDI group for positive words (on average 18.79 ms); $t_{115.62}=-2.133$, $p=.016$. Additionally, the HBDI group was had an increased NAP score compared to the LBDI group for negative words (on average 17.55ms). However, this difference approached but did not reach significance, $t_{119.09}=1.82$, $p=.063$ (see figure 1).
Figure 1: NAP Effect

The NAP effect to each word valence. The HBDI group showed an increased NAP to negative words and a facilitation effect for positive words relative to the LBDI group. No differences were observed between the HD and LD groups. This suggests that symptom severity and not dispositional factors are behind altered processing of valenced material in dysphoric individuals, and that that the effect is not limited to negative material. Importantly, the same pattern of results is observed in all conditions.

2.3.4. Effects of ‘trait’ depression on NAP effect

The One-Between-One-Within ANOVA (N3 group x Word Valence) again revealed a main effect for word valence; $F_{(2,270.00)}=44.24$, $p<.001$. This again emphasizes the word valence pattern described above. Critically however, the two-way interaction N3 group X
word valence was not significant; \( F(2,270.00) = .18, p = .84 \). Consistently, HD and LD groups were similar on PosWordNAP and NegWordNAP scores; \( t_{129.01} = -.267, p = .79 \) and \( t_{128.07} = .51, p = .612 \) respectively (see figure 1).

2.4. Discussion

The first novel finding of this study is that in the modified NAP task, designed to dissociate the influence of a prior positive or negative word, two subcomponents of the NAP effect were identified; a facilitation effect for positive words, and an impeding effect for negative words. This overall pattern supports the first prediction, and suggests that the sample of female college students displayed a general orientation towards positive material, with avoidance of negative material. This pattern held true irrespective of current dysphoria or depressed trait, which may be an artifact of the subclinical sample. Following inhibitory accounts of negative priming, this would suggest that subjects were less able to ignore positive words, and more able to ignore negative words. Thus, while a positive distractor might prime a positive mental set, inhibition for negative material following a negative distractor needs to be overcome before a response can be made.

The second prediction, that participants would exhibit differences in processing both positive and negative material as a function of current depression symptoms (BDI status) was also supported. However, the direction of the effects was unexpected. The \( H_{BDI} \) group showed a larger NAP effect for negative words and a smaller NAP for positive words than the \( L_{BDI} \) group. Thus, it seems that \( H_{BDI} \) subjects were more responsive to positive words and less responsive to negative words compared to normal controls. One possible interpretation of these results is that our sample of healthy participants with subclinical dysphoria were employing compensatory mechanisms to counteract the higher levels of depressed symptoms they were experiencing. This explanation is consistent with
findings suggesting previously depressed individuals in clinical remission are biased towards positive material (Joormann & Gotlib, 2010) as well as the positive bias found in the general population (Koster, De Lissnyder, Derashan, & De Readt, 2011).

The third prediction, that ‘trait’ depression would have less influence on NAP effects, was also upheld. When subjects were divided into the HD and LD groups based on the N3 subscale, no significant group differences were found. This suggests that more stable, dispositional traits may not be responsible for the apparent difference in the NAP results seen between the BDI groups. Rather it appears that the presence of depressed symptoms is responsible for differences in responses to negative and positive material.

In general, results suggest greater depressed symptoms are responsible for altered processing of emotional material, but that these differences are not due to innate factors. Rather they appear to be compensatory mechanisms used to counteract higher levels of negative affect.

Table 4: Mean # of Trials Retained

<table>
<thead>
<tr>
<th></th>
<th>Positive Words</th>
<th>Negative Words</th>
<th>Neutral Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgnRep</td>
<td>42.08 (9.39)</td>
<td>43.70 (8.13)</td>
<td>45.97 (6.62)</td>
</tr>
<tr>
<td>Control</td>
<td>42.38 (8.29)</td>
<td>42.65 (7.56)</td>
<td>46.24 (7.41)</td>
</tr>
</tbody>
</table>

The average number of retained trials for Experiment 2 after discarding trials contained artifacts (blinks, etc.) and incorrect responses. Consistent with the accuracy results, more trials were retained for neutral words.
Chapter 3.

Experiment 2

3.1. Introduction

The general pattern of results from experiment 1 suggests that positive and negative words are processed differently regardless of currently mood. However, it is not clear if this depends on bottom-up or top-down effects (Grzybowski, Wyczesany, & Kaiser, 2014).

A large body of research investigating the electrophysiology of emotion suggest that both early and late stages of processing are affected. A robust finding is that relative to neutral stimuli, emotion enhances the amplitude of the late positive potential (LPP), a sustained wave with broad distribution over posterior scalp, peaking between 400-700ms, thought to reflect conscious (top-down) evaluation of a motivationally salient stimulus (e.g., Moser, Hajcak, Bukay, & Simons, 2006; Hajcak, MacNamara, & Olvet, 2010). Shorter latency ERP effects in the P2 family (180-300ms), have also been reported, with both posterior (Early posterior negativity or EPN, Schupp, Flaisch, Stockburger, & Junghöfer, 2006), and anterior scalp distribution (Early anterior positivity or EAP: Taake, Jaspers-Fayer, & Liotti, 2009; Williams, Palmer, Liddell, Song, & Gordon, 2006), thought to reflect more automatic or even pre-attentive (bottom-up) aspects of attentional capture. This suggests that both top-down and bottom-up mechanisms are involved in the processing of emotional material. Therefore, the differences in RT to positive and negative words, might reflect variations at different stages of processing.

Yao, Liu, Liu, Hu, Yi & Huang (2010) addressed this question by examining the ERP waveforms associated with the NAP task in depressed patients and normal controls.
They found reduced amplitude of the centro-parietal P2 and latency of the late positive complex (LPC) components within the patients for negative words. On the other hand, the control group showed increased amplitude of P2 component over left-central scalp and a longer LPC latency to negative targets. This suggests that both early and late stages of processing are affected by depression. However, because the primary concern of this study was to compare patients to normal controls, it did not attempt to isolate the effects of state versus trait depression. Specifically, it could not be determined whether altered patterns in early or late processing of negative material reflects the presence of negative affect or a predisposition towards depression. More importantly, the study employed a design similar to Joormann (2004), in which positive and negative words are directly contrasted with one another. Thus, on IgnRep trials for negative words, the prime slide contained a negative distractor and a positive target, while the probe slide contained a negative target and a positive distractor. On control trials for negative words, both the distractor and target was positive while the probe slide contained a negative target and a positive distractor. This prevents the priming effects of positive and negative words from being fully dissociated from one another.

One other study examined the NAP effect in the context of ERPs. Using a facial variant of the NAP task, researchers compared never depressed, previously depressed and currently depressed individuals (Dai, Feng & Koster, 2011). The task presented subjects with happy, sad or neutral faces. Two pictures appeared simultaneously, one above the other, and subjects were asked to indicate if the face in colour (as opposed to black and white) was happy, sad or neutral. Currently depressed participants showed greater P1 and P3 amplitude for sad faces, indicating deficient inhibition for negative material. Unfortunately, given that written words hold symbolic meaning only (Grzybowski, Wyczesany, & Kaiser, 2014), and are processed differently from faces, it is unlikely that
the cognitive processes underlying the facial and verbal variants of the NAP task are directly comparable. However, again changes in both early and late processing were evident. The particular design of this task contrasted happy and sad faces in a manner similar to previous studies described. Thus, it is still not clear whether the NAP effect is driven by altered processing of negative words only.

Using the modified version of the word NAP task, the present study set out to dissociate the priming effect of positive and negative words and determine which stage of processing drives the effect for each word valence. Participants completed the task while continuous EEG was recorded. Distinct ERP waveforms were then extracted for IgnRep and Control trials for each of the three word valences. Behaviourally a pattern of results similar to that found in experiment one was expected since the tasks are virtually identical.

Given that this variant of the NAP task used words, modulations within the P2 and LPP time ranges were expected consistent with findings by Yao et. al. (2010). With regards to the P2, it was predicted that IgnRep trials would elicit a larger positivity than control trials due to increased salience of the target. This difference would be best characterized as an early anterior positivity (EAP) because the EAP is thought to index the self-relevance or emotional salience of valenced material (Taake, Jasper-Fayer & Liotti, 2009). However, it was predicted that the EAP would be larger for negative words relative to positive and neutral words due to a possible association with threat detection systems (Grzybowski, Wyczesany, & Kaiser, 2014). For example, someone expressing anger might indicate an imminent physical attack. Similarly, disappointment expressed by group members might indicate that a relationship is in jeopardy. In both cases early detection of the negative emotion is essential in order to act appropriately and mitigate the perceived threat.

The LPP is defined as a late positive deflection in response to emotional, relative to neutral, stimuli and is thought to indicate rumination or maintenance of relevant
information in WM. Therefore, a positivity within this time window was expected for negative and positive words only. The amplitude of the LPP was predicted to be larger for IgnRep trials since more conscious processing might be required in order to overcome inhibition of the previous distractor and make a correct response. However, due to the positive bias shown by most individuals (Koster, De Lissnyder, Derashan, & De Readt, 2011), it was predicted that this difference would be greatest for positive words.

3.2. Methods

3.2.1. Participants

46 female undergraduate students ($M_{Age}=18.67$ $SD=1.32$ $Min=17$ $Max=24$) were recruited via the online Research Participation System at Simon Fraser University receiving course credit for their participation. The same exclusion criteria as experiment 1 was applied. Thus, only individuals with normal or corrected to normal vision, and no reported history of depression or anxiety were included in the sample. Additionally, because any trials containing incorrect responses or artifacts such as blinks are discarded, subjects with fewer than 30% of trials retained for any condition were removed from analysis. Thus, the final sample consisted of 37 individuals ($M_{Age}=18.67$ $SD=1.36$ $Min=17$ $Max=24$).

3.2.2. Procedure and Design

Very little was altered between the two experiments in order to maintain consistency and comparability. Thus, after providing informed consent, participants completed the medical questionnaire, the NEO-PI-R N3 subscale, and the BDI-II while the EEG cap was being prepared. This allowed us to compare the current sample to Experiment 1 on some key variables (see table 2). Scores on the BDI-II ranged from 0-27 while scores on the NEO-PI-R N3 scale ranged from 5-25 in the present study. Following
this, they completed the modified version of the NAP task while continuous EEG was recorded.

The NAP task was almost identical to the one used in experiment 1 with a few minor adjustments to ensure compatibility with ERP methodology and to address the concern of systematic ACC differences present in Experiment 1. Primarily this required a jittered inter-stimulus interval (ISI) of 300-800ms during which a fixation cross is presented. Additionally, a pilot study was conducted to select which words were to be included in the study. Words between 4 and 6 letter long were selected from the Affective Norms for English Words (ANEW) database. Words with valence ratings above 6 were considered for the positive list, between 4 and 6 for the neutral list, and below 4 for the negative list, while controlling for word length and arousal ratings. Any words that may be associated with fear (such as snake, serpent, spider, etc.) were excluded from consideration. This yielded 80 positive words, 91 negative words, and 71 neutral words. Pilot study participants then completed a simple task where they simply responded to each word, indicating if it's positive, neutral or negative. Words with the lowest probability of being correctly identified (ACC<70%) were excluded from the list. Following this, to ensure the same number of words for each word valence was utilized in the study, words with extreme RTs (highest or lowest RT within each word valence) were trimmed until 62 words from each lists with the highest accuracy and RT closest to the list average remained. This was done to maximize the strength of the manipulation, and reduce variability in RT and accuracy. Trial lists were then generated according to the same rules as in experiment 1 (see table 1).

3.2.3. Electrophysiological Recording

Continuous EEG was recorded using 64 Ag/AgCl electrodes mounted in an elastic cap (Electrocap Inc.) arranged in a standard 10-20 montage. Additional electrodes were
placed on the left and right mastoids, approximately 1cm lateral to the external canthi (measuring horizontal eye movements) and approximately 2cm below each eye (measuring vertical eye movements and blinks). Voltage at each site was determined against a common mode sense (CMS) electrode and recorded at a sampling rate of 512Hz.

EEG for each subject was digitally filtered (0.01Hz high-pass, 30Hz low-pass, zero phase, 12dB/octave slope) and re-referenced to the average mastoid (BESA 5.3). Visual inspection as well as semiautomatic artifact rejection were performed to eliminate trials containing blinks and eye movements. Distinct ERP averages were obtained for each of the 6 conditions (IgnRep and Control for each word type) time-locked to word onset (200ms pre-stimulus baseline and 800ms post-stimulus). Subjects with fewer than 30% usable trials in any condition were discarded from the analysis.

3.2.4. Statistical Analysis

**Behavioural**

T-tests comparing the accuracy (ACC) for each word valence were conducted to determine if performance across the three word valences were comparable. Tests were run at the $\alpha'=0.033$ significance level capping family-wise error rate at $\alpha=0.1$.

This was followed by a single factor, within-subject analysis of variance (ANOVA) to examine the differences in the NAP effect for each word valence (Positive, Neutral and Negative). The NAP effect is calculated as the difference between IgnRep and the corresponding control trials for each word valence, providing a measure of the cost associated with previously ignoring a word of the same valence as the current target. Follow-up t-tests were conducted to compare specific conditions relevant to the a-priori
hypotheses. Family-wise error rate was capped at $\alpha=.1$, using a Bonferroni correction which kept the significance level for individual test at $\alpha'=0.025$.

**ERP**

Through visual inspection of the grand average waveforms for each condition, 2 different ERP time windows where IgnRep and control waveforms diverged were identified. The first effect was a positive polarity enhancement spanning roughly 200-300ms primarily over left-lateral frontal scalp, closely resembling the Early Anterior Positivity (EAP). The second effect was a later positive polarity modulation over posterior scalp, spanning 500-700ms, resembling the late posterior potential (LPP).

EAP mean amplitudes were calculated between 190-260ms over a left anterior (F1, F3, F5) region of interest (ROI). A 3x2 within-subjects repeated-measures ANOVA was conducted comparing the effects of WordValence (PosWord vs. NegWord vs. NeuWord) and TrailType (IgnRep vs. Control). This was followed by 3 t-test comparisons examining differences between the IgnRep and Control trials within each word valence. Visual inspection of the ERP waveforms suggested amplitude of the EAP for both TrailType to positive words was comparable to the EAP amplitude to negative words on IgnRep trials. T-test comparisons were conducted to test this impression. In total, 6 statistical tests were conducted at the $\alpha'=.04$ significance level capping family-wise error rate at $\alpha=.24$.

LPP mean amplitudes were calculated between 500-700ms post stimulus over a posterior region of interest (ROI; P3, P1, Pz, P2, P4). A 3x2 (WordValence x TrailType) within-subjects repeated-measures ANOVA was conducted, after which t-test comparisons were run. These examined the differences between the overall mean amplitudes for each word valence as well as the difference in IgnRep and Control trials for
each word valence. A total of 8 statistical tests were conducted at the $\alpha'=.03$ significance level capping family-wise error rate at $\alpha=.24$.

3.3. Results

3.3.1. Behavioural

Accuracy

No differences were observed between positive and negative words, $t_{36}=46$, $p=.65$. However, ACC for neutral words was significantly higher than both positive and negative words, $t_{36}=-4.39$, $p<.001$; $t_{36}=-5.04$, $p<.001$, respectively (see table 3). This suggests that neutral words were much easier to identify than both positive and negative words. However, this is not deemed problematic for the experiment since neutral words are compared to themselves in the IgnRep and Control conditions, just as is done for the positive and negative words. Thus, although neutral words might in general be easier to identify, this would be the case in both the IgnRep and Control conditions. Moreover the primary purpose of the neutral words were to dissociate the effects of positive and negative words and no differences between positive and negative words were observed. Thus, none of the variance in RT on positive and negative words can be attributed to differences in difficulty.

NAP

A visual inspection of the results indicates that the overall pattern in NAP scores from Experiment 1 was also present here in Experiment 2 (see figure 1). Specifically, previously ignoring a positive word improved performance for a positive target, while previously ignoring a negative word resulted in slowed RT for a negative target. The within-subjects ANOVA revealed no significant differences between the NAP effect for each word valences, $F_{(2,72)}=1.88$, $MSE=2263.26$, $p=.16$. It is possible that the study suffered from a
lack of power due to the large variability in RTs as well as the small sample size. Consistent with expectations, the difference between NAP effects for positive and negative words was large, but not significant \(t_{36}=-2.01, p=.05\). This could indicate that an effect is present, but that the present study is unable to detect it. However, no other effects approached significance. Given that the overall pattern is similar to that found in experiment 1 (see figure 1), the tasks must be operating on the same underlying processes and are thus comparable.

3.3.2. ERP

**EAP (190-260ms)**

The 3x2 within-subjects ANOVA revealed a significant main effect for Trail Type, \(F_{(1,36)}=4.82, MSE=3.03, p=.04\). However, neither the main effect for WordValence nor the 2-way interaction was significant, \(F_{(2,72)}=2.89, MSE=3.23, p=.41, F_{(2,72)}=2.04, MSE=2.19, p=.93\). Visual inspection of the ERPs suggest that mean amplitude for IgnRep was more positive than mean amplitude for Control trials, and that the effect was largest for negative words (see figure 3). This is in line with the a-priori hypothesis and thus, follow-up t-tests were conducted to examine the differences between IgnRep and Control trials within each word valence. Consistent with the hypothesis, the difference in mean amplitude between IgnRep and Control trials was significant for negative words, \(t_{36}=2.41, p=.02\). However, no differences were observed for positive and neutral words, \(t_{36}=1.35, p=.18, t_{36}=.48, p=.64\), respectively. Thus, IgnRep trials elicited a larger positivity for negative words, relative to control trials. Interestingly, the amplitude of the EAP to negative words on IgnRep trails appeared visually similar to the EAP amplitude to positive words regardless of trial type. Consistent with this suspicion, no differences were observed between positive word
IgnRep trials and negative word IgnRep trials, nor between positive word control trials and negative word IgnRep trials, $t_{36}=.65$, $p=.52$, $t_{36}=-.78$, $p=.44$, respectively.

**LPP (500-700ms)**

The 3x2 within-subjects ANOVA yielded significant main effects for both TrialType and WordValence, $F_{(1,36)}=50.03$, $MSE=6.00$, $p<.001$; $F_{(2,72)}=21.22$, $MSE=4.80$, $p<.001$, respectively. Follow-up t-tests indicate that the main effect of word valence was driven by large differences between positive and neutral words as well as negative and neutral words regardless of TrialType, $t_{36}=8.82$, $p<.001$, $t_{36}=8.87$, $p<.001$, respectively (see figure 2). However, the 2-way interaction was not significant, $F_{(2,72)}=2.71$, $MSE=4.26$, $p=.07$.

Given that the a-priori hypothesis predicted that IgnRep and Control trial effects would manifest differently across the three word valences, follow-up t-tests were conducted to examine these differences more directly.

These revealed that the difference in mean amplitude between IgnRep and Control trials was significant for positive and neutral words, $t_{36}=3.98$, $p<.001$, $t_{36}=2.20$, $p=.03$, respectively. However, no differences were observed for negative words, $t_{36}=1.87$, $p=.07$. Thus, IgnRep trials elicited a larger positivity for positive and neutral words, relative to their respective control trials (see figure 4). However, the lack of a significant difference between IgnRep and Control trials for negative words, seems to be driven by a larger LPP for control trials. Accordingly, neither the mean amplitude on IgnRep nor Control trials for negative words, differed significantly from the mean amplitude on IgnRep trials for positive words, $t_{36}=-1.41$, $p=.17$, $t_{36}=-.03$, $p=.98$, respectively. Thus, a negative target elicited a large LPP regardless of the valence of the previous distractor (see figure 3).
Figure 2: ERPs to Word Valences

Average mastoid referenced ERP waveforms to IgnRep and Control trials for each word valence regardless of TrialType. As expected, a large LPP was observed for both positive and negative targets.
Average mastoid referenced ERP waveforms to IgnRep and Control trials for negative words. In stark contrast to positive words (figure 4), IgnRep trials for negative words elicited a larger EAP which is most evident at F3. This indicates that previously ignoring a negative word, increases the salience of a negative target at early stages of processing. Also of note is the large positivity to both IgnRep and control trials, suggesting that salience of a negative target at later stages of processing was not affected by TrialType.
Figure 4: ERPs to Positive Words

Average mastoid referenced ERP waveforms to IgnRep and Control trials for positive words. Clearly evident is a large LPP to IgnRep trials across the entire scalp, although the difference between IgnRep and control trials is largest over parietal regions. This indicates that previously ignoring a positive word, increased the amount of resources devoted to conscious processing of a positive target.
Figure 5: Topographic Maps

Topographic maps based on the average referenced differences waves between IgnRep and Control trials for each word valence (positive and negative words). Importantly, the primary difference for negative words lies over left anterior scalp in both epochs. In contrast, a large positive deflection to IgnRep trails was observed for positive words within the LPP time window.

3.4. Discussion

In the present study, the modified version of the NAP task enabled us to completely dissociate the priming effects of positive and negative words. Consistent with expectations, modulations in both an early (EAP) and late (LPP) component were identified. These components conform to those found by Yao et. al. (2010) suggesting that similar cognitive processes underlie both variants of the task, and consequently inspiring
confidence in the validity of the modified NAP task used in the present study. The presence of these components suggest that both early and late stages of processing are affected by the presentation of emotional material.

### 3.4.1. EAP

The prediction that IgnRep trials would elicit a larger positivity than control trials within the P2 time window was supported. The EAP is a positive deflection within the P2 family over anterior scalp and is thought to index bottom-up attentional capture of emotional material (Schupp, Flaisch, Stockburger, & Junghöfer, 2006; Taake, Jasper-Fayer, & Liotti, 2009; Asmaro, Carolan & Liotti, 2014). Consequently, it likely reflects early and implicit capture by motivationally salient emotional stimuli (Taake, Jasper-Fayer & Liotti, 2009). Consistent with this explanation, marijuana users show an enhanced EAP for drug related stimuli (Asmaro, Carolan, & Liotti, 2014). Drug related stimuli are presumably more relevant to drug users in much the same way as when one notices a particular brand of car more often after purchasing one. Thus, the enhanced EAP to IgnRep trials in the present study suggests that previously seeing a distractor of the same valence as the current target, increased the salience of that stimulus type, and thus the self-relevance of the target.

When separated by word valence, the prediction that the EAP difference (IgnRep vs. Control) would be larger for negative words relative to positive and neutral words was supported. The enhanced EAP on IgnRep trials for negative words indicates that previously presenting an irrelevant negative word, increased the emotional salience of the subsequent negative target. Similar results have been found in a study examining electrophysiological responses to threat-related stimuli in high and low anxiety individuals. In this case the EAP manifested as a larger positive modulation with an anterior scalp distribution to threat-related relative to neutral words regardless of anxiety status (Taake,
Jasper-Fayer, & Liotti, 2009). This would suggest that negative material captures attention more readily, which might represent the need to orient to negative feedback. Thus, in the present study, prior presentation of task-irrelevant negative material might serve as an implicit warning that a negative stimulus is coming.

3.4.2. LPP

The prediction that an LPP for positive and negative relative to neutral words would be observed was supported. The LPP is a component in the P3 family (Grzybowski, Wyczesany, & Kaiser, 2014), and appears as a positive deflection over centro-parietal scalp to both pleasant and unpleasant stimuli beginning approximately 300ms post-stimulus (Hajcak, Weinberg, MacNamara and Foti, 2012). The LPP is thought to originate when WM resources are allocated to the increased processing of motivationally relevant material (Schupp, Flaisch, Stockburger, & Junghöfer, 2006), for example, culturally salient or task relevant stimuli (Asmaro, Carolan & Liotti, 2014). There is also evidence that top-down regulatory processes can modulate the LPP (Hajcak, MacNamara & Olvet, 2010). Therefore, it likely reflects more conscious processing of stimuli (Asmaro, Carolan & Liotti, 2014) and especially its maintenance in WM.

Furthermore, as predicted the amplitude of the LPP was larger for IgnRep than control trials. This might indicate that more conscious processing was required in order to overcome inhibition of the previous distractor and make a correct response. Alternatively, it might also indicate that previously ignoring a word of the same valence as the current target simply increased the motivation to ruminate on the target. The latter explanation is most consistent with the EAP differences observed in the present study since RTs to positive words showed a facilitation effect. However, these explanations cannot be teased apart with in the present study design.
Although not statistically significant, a surprising interaction between WordValence and TrialType was observed. IgnRep trials for positive words resulted in a larger LPP compared to control trials indicating that prior presentation of a positive word resulted in positive words being more prominent at later, more conscious stages of processing. No difference between IgnRep and Control trials was observed for negative words, possibly due to a lack of power. However most interestingly, the lack of a difference between IgnRep and Control trials for negative words with regards to mean LPP amplitude was due to a large LPP to Control trials for negative words. However, mean amplitude for negative word (for both IgnRep and Control trials) within this time window was comparable to mean amplitude on IgnRep trials for positive words. This indicates that more working memory resources was deployed to negative material regardless of the previous distractor valence. Therefore, while it is possible that the present study was simply not able to detect the difference between IgnRep and Control trials, overall negative words require more processing at later stages compared to positive and neutral words.

3.4.3. Behavioural

The ERP results are difficult to reconcile with the observed pattern of RTs. Logically, increased salience of negative material should result in a faster RT on IgnRep trials. However, no such effect is evident in the behavioural results for negative words. Instead, RT is delayed on IgnRep trials relative to Control trials. In contrast, RTs on IgnRep trials were much faster than RTs on Control trials suggesting the presence of a positive distractor during the prime facilitated performance on the probe slide. However, no EAP differences were observed between TrialType suggesting the positive distractor does not affect the salience of a positive target during the probe slide at early stages of processing. The lack of association between EAP amplitude and behavioural response measures in not unusual, with previous studies indicating a similar pattern (see Taake, Jaspers-Fayer,
& Liotti, 2009). Logically, it is not entirely unsurprising given that the EAP represent early stages of processing. Later stages of processing might be more influential in the response selection process and thus, could override whatever effect the EAP may have had.

Therefore, the RT results might be best explained by the differences in the LPP to positive and negative words. Given that the LPP is thought to index top-down processing of emotional material it likely represents a combination of processes rather than a single, discrete process. This is congruent with the temporal overlap between the LPP and P3 components (Hajcak, Weinberg, MacNamara, & Foti, 2012). Thus, the presence of the LPP might require different explanations for positive and negative words. For positive words, the larger amplitude to IgnRep trials might indicate increased resources allocated to the processing of the previous distractor. This would assist the entry and maintenance of positive material in WM and thus, facilitate a response. On the other hand, for negative words, the enhanced LPP for IgnRep and Control trials might indicate increased resources allocated to the suppression of the distractor, which would need to be overcome in order for a response to be made. The increased effort would cause a delay and consequently the increased NAP effect. These two explanations are consistent in that the amplitude of the LPP represents the amount of WM resources allocated to the current target. However, the exact processes these resources are allocated to, cannot be determined under the current study design. This unfortunately means the above explanations are purely speculative.
Chapter 4.

General Discussion

4.1. Implications

Based on the results from these studies it would appear that an affect based explanation of the negative ruminatory cycle and depression is most accurate. Experiment 1 demonstrated that current symptom severity and not more stable, dispositional response patterns account for group differences on the NAP task. This indicates that mood state over the previous few weeks, is associated with altered processing of emotional material. Somewhat surprisingly, more severe depressed symptoms were associated with a smaller NAP for positive words and a larger NAP for negative words. This was interpreted as evidence for compensatory mechanisms being engaged to counteract the negative mood state. Thus, the experience of a negative mood in the recent past, predicted altered performance on the NAP task.

Findings are consistent with an emotion regulation account of depression. Within the sample of female university students without any history of depression or anxiety, regulation of negative affect in particular was evident. Experiment 2 indicated increased self-relevance of positive words (indicated by the larger EAP to both TrialTypes) which is congruent with a general positive bias and avoidance of negative material (Koster, De Lissnyder, Derakshan, & De Raedt, 2011). Further more, the lack of differences between trial types were observed in later stages of processing (indexed by the LPP), suggesting both conditions involved an equal amount of WM resources. It is possible that these resources were engaged to remove or suppress negative material that is in WM because it conflicts with an existent positive bias. The consequent suppression would make a
response more difficult and resulting in the slowed RT on IgnRep trials observed in both experiments. In contrast, when the positive target was preceded by a positive distractor, it elicited a larger LPP, indicating more WM resources were engaged. This could suggest that positive material is more salient at later stages, and thus, more likely to reach conscious awareness and therefore facilitate RT. With positive material more strongly represented in WM, it is easier to make a response to a positive target resulting in the faster RT on IgnRep trials. This would account for the behavioural pattern of results observed in both experiments. Thus, the NAP effect and the ERP correlates observed in the present studies, might reflect emotion regulation strategies to preserve a positive self-image.

These results suggest that previous conclusions based on the NAP task may be inaccurately focussing on altered processing of negative words in depression. In order to distribute the effects of word valence across all trials, these studies directly contrasted positive and negative words in their NAP calculations. Thus, on control trials, positive words were always preceded by a negative distractor, and negative words by a positive distractor. Following the logic used to explain the NAP effect, viewing an emotional item produces a temporary mental set for the treatment of that type of item. For example, a positive distractor would prime a mental set to ignore positive material which affects a response to a subsequent positive target. Under The design described above, the NAP effect is calculated as the difference between RTs to trials that require inhibition of the same word valence and trials that require inhibition of the opposite word valence. Therefore, the NAP effect measures a combination of inhibition for positive words, and inhibition for negative words, rather than inhibition for any single word valence. The current modified NAP task enabled the effect of inhibition for positive and negative words to be dissociated more directly. Results from the experiment 1 suggests dysphoria is
characterized by changes in processing of both positive and negative material. Hence, conclusions that depression relies only on reduced inhibition for negative words may need to be revised. However, further research needs to be conducted in particular focussing on the influence of negative affect on this variant of the NAP task, as well as the performance of currently depressed patients.

4.2. Limitations and Future Research

It should be noted that the validity of the NAP calculations used in the present study has not been determined. Indeed, there exists a confound of word valence since negative targets are never preceded by a positive distractor and positive targets are never preceded by a negative distracter. However, this design was chosen in order to fully dissociate the effects of positive and negative material. To improve on this design, follow-up studies should follow the lead of Frings, Wentura & Holtz (2007) by including a prime distractor (PD) effect in the calculations. In other words, including RTs on trials where the probe target is neutral and the prime distractor was positive in the NAP calculations for negative words, and RTs on trials where the probe target was neutral and the prime distractor was negative in the NAP calculations for positive words. This would account for possible differences priming effects of each word valence. Additionally, a within-subjects study should be conducted examining the effect of the different NAP calculations to determine if indeed this might account for the differences between studies.

Underlying the discussion of the results thus far is the contentious assumption that NP is caused by inhibitory processes. It is thought that the distractor and its attributes on the prime slide is suppressed. The continuation of this suppression results in slowed responses if a similar item is the target on the probe slide (Neill, 1977). However, this Distractor Inhibition Account (DIA) of NP that still pervades the literature on the NAP effect
has largely been abandoned in more theoretical areas (Neill, Valdes, Terry & Gorfein, 1992) since experimental results are not consistent with theories of selective attention. Primarily, NP magnitude diminishes as the interval between response to the prime and presentation of the probe increases (Neill, Valdes, Terry & Gorfein, 1992). Also, when both items on the prime need to be attended to in order to make a response, NP is still observed (MacDonald, Joordens & Seergobin, 1999). Together this suggests that inhibition of the distractor is not involved in NP. Additionally, NP only occurred when perceptual features differed between the distractor and target, while positive priming (PP) occurred when the perceptual features were the same (MacDonald & Joordens, 2000) which is inconsistent with DIA. Consequently, several other interpretations have been proposed to account for a wider range of situations where in NP is observed.

The most robust of these, the Episodic Retrieval Account (ERA) argues that the delayed response results not from an attentional bias induced by the prime, but from the comparison of the probe slide to the memory trace of its prime (Mayr & Buchner, 2007; Milliken, Joordens, Merkle & Seiffert, 1998; Neill, Valdes, Terry & Gorfein, 1992). With the episodic memory of the prime comes a host of other information points, including the response that was made. Attended repetition (AttRep) trials contain a memory trace where a similar target was previously responded to (MacDonald & Joordens, 2000). The current response is simply a repeat of the last response, resulting in a significantly reduced reaction time. On the other hand, on IgnRep trials the most salient memory trace (episodic memory of the prime) is of an item where the current target was ignored and thus an inappropriate response was encoded. This conflicts with the need to make a response on the current trial and so, in order to resolve the conflict, the stimulus must be processed anew. This takes time, and thus causes the NP effect (Mayr & Buchner, 2007). The fact that the NP effect is strongest immediately following a response to the prime (response...
stimulus interval (RSI) = 20-520ms) and decays over a period of 2s (Neill, Valdes, Terry & Gorfein, 1992) supports such an explanation since the strength of the memory trace would fade over time, thus reducing the conflict on IgnRep trials.

From an ERA perspective, the fact that most individuals tend to avoid negative emotions (Koster, De Lissnyder, Derashan, & De Readt, 2011), might indicate that the ignore tag is stronger for negative words and weaker for positive words. This might account for the facilitation effect observed for positive words in the present study. It might be the case that previous studies using the NAP effect were unable to pick up on this difference due to the mutually depended nature of negative and positive words in their NAP calculations. Such explanations are purely speculative at this time and further research needs to be conducted before more precise conclusions can be reached. In particular attempts should be made to clarify which explanation (inhibition or retrieval) best accounts for the NAP effect.
References


# Appendix A. Questionnaires

## Medical Questionnaire

### Demographics

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How many hours per night do you typically sleep? 

How many hours did you sleep last night? 

Are you colour blind? 

Do you require glasses/contacts? 

Are you currently wearing glasses/contacts? 

### Medical and Psychiatric History:

*Please indicate if you’ve ever been diagnosed/treated for any of the following:*

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*Please indicate if you’ve ever had any of the following scans:*

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*Please indicate if you’ve ever experienced any of the following:*

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<td>Migraines</td>
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NEO-PI-R

NEO-PI-R: N3 & E6 Facets

Using the scale below each question, please indicate how accurately each statement describes you. There are no right or wrong answers, and you need not be an “expert” to complete this questionnaire. Describe yourself honestly and state your opinions as accurately as possible.

Answer each question using the following scale:

- **SD** Strongly Disagree
- **D** Disagree
- **N** Neutral
- **A** Agree
- **SA** Strongly Agree

1. I rarely feel lonely or blue.
   
   SD  D  N  A  SA

2. I laugh easily.
   
   SD  D  N  A  SA

3. Sometimes I feel completely worthless.
   
   SD  D  N  A  SA

4. I rarely use words like “fantastic!” or “sensational!” to describe my experiences.
   
   SD  D  N  A  SA

5. I am seldom sad or depressed.
   
   SD  D  N  A  SA

6. I am a cheerful, high spirited person.
   
   SD  D  N  A  SA

7. Too often, when things go wrong, I get discouraged and feel like giving up.
   
   SD  D  N  A  SA
8. I have never literally jumped for joy.
   SD D N A SA

9. I tend to blame myself when anything goes wrong.
   SD D N A SA

10. I am not happy-go-lucky.
    SD D N A SA

11. I have a low opinion of myself.
    SD D N A SA

12. I have felt overpowering joy.
    SD D N A SA

13. Sometimes things look pretty bleak and hopeless to me.
    SD D N A SA

    SD D N A SA

15. I have sometimes experienced a deep sense of guilt or sinfulness.
    SD D N A SA

16. I am not a cheerful optimist.
    SD D N A SA
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