The role of medication use and state anxiety on the cognitive components of emotional facial processing: An Event-Related Potentials Study

by

Denis Vaillancourt

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The Faculty of Graduate Studies
Laurentian University
Sudbury, Ontario, Canada

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Thesis Examiners/Examinateurs de thèse:

Dr. Joël Dickinson
(Co-Supervisor/Co-directrice de thèse)

Dr. Annie Roy-Charland
(Co-Supervisor/Co-directrice de thèse)

Dr. Matias Mariani
(Committee member/Membre du comité)

Dr. Charles Collin
(External Examiner/Examinateur externe)

Approved for the Faculty of Graduate Studies
Approuvé pour la Faculté des études supérieures
Dr. David Lesbarrères
Monsieur David Lesbarrères
Dean, Faculty of Graduate Studies
Doyen, Faculté des études supérieures

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Abstract

High levels of anxiety have been associated with a cognitive bias towards threat, impacting attention and emotional facial processes as evidenced at the electrophysiological level from Event-Related Potentials (ERP). This threat-bias can be attenuated by reducing anxiety with Selective Serotonin Reuptake Inhibitors (SSRI), but the relationship between anxiety, psychotropic medications, and attentional resources remains a relatively unexplored area. The current study therefore aimed to examine the impact of anxiety reducing SSRI medication on emotional facial processing by comparing individuals with high and low anxiety and differing medication levels. Participants (n = 50) completed a Rapid Serial Visualization Presentation and were asked to identify emotional facial expressions while ERP and accuracy were recorded. Results suggest SSRIs have an overall emotional attenuation on facial processing. ERP results revealed all participants displayed a dominant early positive bias, with the threat-bias associated with high anxiety originating exclusively in later cognitive components of facial processing.

Keywords

Anxiety, Attention, Emotional Facial Processing, Selective Serotonin Reuptake Inhibitors, Event-Related Potentials

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Table of Contents

List of Figures

List of Appendices

1. Introduction

There is a consensus within the literature that people with high levels of anxiety have an attentional bias towards threat-related stimuli, in contrast to people with low levels of anxiety (Bar Haim et al., 2007). Associated with this bias, we see behavioural and physiological effects that reflect its impact on cognitive processing. There is also evidence to suggest that brief and prolonged exposure to psychotropic substances has an attenuating effect on the attentional bias to threatening stimuli (Murphy et al., 2009), which is reflected in studies using Event-Related Potential (ERP) components (Kerestes et al., 2009). Despite this, no previous study has systematically compared individuals taking psychotropic substances to those who are not while factoring in anxiety level in order to examine cognitive differences in early attentional processing of emotionally salient stimuli. The current study therefore aimed to utilize ERPs to explore the difference in emotional facial processing between selective serotonin reuptake inhibitors (SSRI) medicated and non-medicated participants of varying levels of anxiety. This study was the first to employ an attentional blink paradigm in conjunction with ERP to evaluate the performance and underlying cognitive mechanism of emotional facial processing on an SSRI-medicated population.

Below, we first discuss the impact of anxiety and attentional resources on emotional facial processing as well as the research to date exploring the implications of SSRI class antidepressants before presenting the rationale and hypotheses of the current study.

1.1 Anxiety

The state-trait model of anxiety suggests that anxiety has two aspects – one short-term and situational, the other long-term and constitutional. State anxiety, generally described as the emotional reaction to threatening or dangerous situations, and trait anxiety, the characteristics a

person holds which influence the frequency and intensity of experiencing state anxiety, therefore are suggested to constitute anxiety in general. Typically, people with high trait anxiety would be expected to show elevations in state anxiety (Spielberger et al., 1983). Although there has been discourse regarding whether anxiety is unidimensional or multidimensional in nature (Donat, 1983; Shedletky & Endler, 1974; Endler et al., 1991), recent findings have given supporting evidence that anxiety is a unidimensional construct, such that high trait anxiety positively correlates with high state anxiety (Leal et al., 2017). Essentially, as trait anxiety increases, state anxiety follows suit, and, logically, we would expect that if an individual holds personality traits related to more intense emotional reactions to anxiety-inducing situations (i.e., increased trait anxiety), they would be more likely to exhibit these emotional reactions when confronted with these scenarios (i.e., increased state anxiety).

Heightened levels of anxiety have been shown to be associated with differences in cognitive processing when emotionally salient stimuli are involved (Van Dam et al., 2012; Rossignol et al., 2005). For example, Van Dam et al. (2012), using a Rapid Serial Visualization Presentation paradigm (RSVP) – the rapid presentation of stimuli shown in succession, typically in the same spatial location and ranging from 8 to 16 stimuli per second – observed that relative to individuals with low trait anxiety levels, individuals with subclinical levels of high trait anxiety performed considerably worse when prompted to name the emotional expression of facial stimuli (e.g., happy and fearful faces) among a sequence of distractor images consisting of inverted neutral faces. This was suggested to be the result of a failure to inhibit attention control towards neutral or ambiguous distractions, such that individuals with heightened anxiety had difficulty performing the task (Van dam et al., 2012). Additionally, Rossignol et al. (2005) found that highly anxious participants were faster at detecting rare emotional stimuli than non-anxious

subjects. In an odd ball paradigm – a series of presented images where the occurrence of an emotional face was rare – individuals with heightened anxiety levels were faster to detect the deviant stimuli (e.g., happy and fearful faces) regardless of the emotion presented. Upon analysis of ERP components, it was suggested that, in this study, individuals with heightened anxiety levels were less responsive to the emotional content of facial stimuli, reflected by decreased N300 amplitudes, which was then compensated by an increase in conscious processing and subsequent accelerated decision making, reflected by increased P300 amplitudes (Rossignol et al., 2005). Taken together, there is evidence to suggest emotional processing differs as a function of anxiety level, where individuals with heightened levels of anxiety may exhibit faster, albeit less accurate, emotional recognition.

An attentional bias to threatening stimuli has also been associated with heightened levels of anxiety (Fox, 2002; Mathews et al., 2003; Van Bockstaele et al., 2014). An extensive review conducted by Van Bockstaele et al. (2014) analyzed the relationship between attentional biases, fear, and anxiety, and concluded that there was a causal relationship between them. Comparing studies using different methods of exploiting this attentional bias, a small-to-moderate correlation was found between attentional bias and fear and anxiety, indicative of a noticeable relationship. Furthermore, the authors concluded it was unlikely that this bias explicitly led to fear and anxiety. Rather, they suggested the attentional bias towards threat was a consequence of fear and anxiety (Van Bockstaele et al., 2014). Given that the attentional bias towards threat appears to be a consequence of anxiety, studies comparing groups based on anxiety level can be inferred to be measuring the relative strength of the associated attentional bias towards threat.

As a result of this attentional bias, there has been speculation that the difference in processing of emotional stimuli between individuals with high and low anxiety may indeed be

linked to attention (Eldar et al., 2010; Sass et al., 2010), and there is supporting evidence that there are differences in early attentional components within ERPs between high and low anxious groups (Morel et al., 2014; Gallant, 2017). Interestingly, this negative emotional bias has been reported to be reduced with the administration of Selective-Serotonin Reuptake Inhibitors (SSRI), at least in individuals with Generalized Anxiety Disorder (GAD) (Mogg et al., 2004). After four weeks of SSRI treatment, participants with GAD perceived significantly fewer threatening words during a homophone task compared to their performance on the same task pre-treatment. The authors speculated that although the changes in behaviour were relatively sudden, they did not necessarily reflect a change in state anxiety as SSRI treatment may be clinically effective due to a modification in trait anxiety related vulnerability (Mogg et al., 2004). These findings were compelling as they suggested SSRIs reduce anxiety not by reducing symptoms during anxiety-induced states, but rather by attenuating the overall mechanisms which dictate how susceptible a person is to anxiety itself. In other words, SSRI administration appears to function in reducing both state and trait anxiety which coincides with their unidimensional nature.

Nonetheless, the relationship between anxiety, medication, attentional resources, and processing of emotional stimuli is an unclear and relatively unexplored area. Therefore, the aim of the current study was to explore the relationship between anxiolytic medication, anxiety level, attentional resources, and processing of emotional stimuli.

1.2 Attentional Resources

Attention can be described in terms of the mental resources required for cognitive processing (Kahneman, 1973). This capacity model of attention implies that attention is limited and, as a result, can only be sustained and allocated to a finite number of activities. Despite our

complex neural network, which allows us to process incredibly complicated information within fractions of a second, we experience difficulty when attempting to simultaneously complete more than one task at a time (Marois & Ivanoff, 2005).

Numerous studies have showcased this attentional limitation with the use of the RSVP (Van Dam et al., 2005; Wyble et al., 2012; Dux & Marois, 2007). For example, when tasking an individual to identify a stimulus immediately following the identification of another stimulus, the accuracy of successfully identifying the second stimulus suffers significantly (Raymond et al., 1992). This phenomenon, known as an attentional blink, refers to how the identification and perception of a second stimulus (commonly referred to as T2) is impaired when attentional resources are directed towards the first (referred to as T1). Raymond et al. (1992) were the first to directly test the attentional blink effect. They presented a stream of black letters in rapid succession, amongst which were occasional white letters. Participants were required to identify a white letter (T1) and then identify a black letter *X* (T2). They found participants had significant impairments in detecting T2 when it was between 180 and 450ms after T1. It was concluded that the deficits observed could not be the result of a sensory issue due to significantly better performance when participants were told to ignore T1 (Raymond et al., 1992). As a result, evidence supported that these findings were due to attentional factors (Raymond et al., 1992). The attentional blink is therefore limited to a temporal window approximately 200 to 500 ms following the first target. Within this time frame participants seem to experience attentional "blinks", which cause unawareness of T2. Furthermore, the attentional blink can be avoided if participants are instructed to ignore T1 and only report T2, or if the presentation of T2 falls outside the 500ms temporal window (Raymond et al., 1992).

There have however been some cases in which the attentional blink can be avoided regardless of the temporal position of T2. For example, when T2 is one's own name, we find that an attentional blink does not occur (Shapiro et al., 1997), suggesting that emotionally salient stimuli may be immune to blinks. Additionally, there has been evidence that emotionally salient stimuli have an impact depending on their temporal location and position within an attentional blink paradigm (Fox et al., 2005; Arend & Botella, 2002; Luo et al., 2010; Zhang et al., 2014).

1.3 Event-Related Potentials

ERPs are physiological measurements that are composed of time-locked voltage changes recorded from the scalp using electroencephalography (EEG). Divided into specific components, ERPs are especially useful in their ability to infer underlying neural activity with high temporal resolution (Luck, 2014). Their temporal specificity and sensitivity to experimental manipulation allows ERP measurements to be used to isolate and examine certain cognitive processes, which are thought to be indexed by particular components. These components are generally named based on their polarity and the time at which the voltage change occurs (e.g., P300 refers to a positive going deflection approximately 300ms post-stimulus onset). As more and more studies provide evidence that behavioural measures alone are not a satisfactory reflection of underlying cognitive mechanisms (Kappenman et al., 2015; Gallant, 2017; Dickinson & Szeligo, 2008), physiological methods which are more sensitive to experimental manipulation grow increasingly in value.

1.4 Processing of Emotional Expressions

With respect to facial processing, there are well known ERP components which outline the initial stages. Among these components are the P100 – observed in the occipital region and related to early visual processing – and the N100 – typically recorded in the central region (e.g.,

top of the scalp) and usually seen in reaction to expressive stimuli (Campanella et al., 2002). Following early attentional components are the N170, observed in the occipito-parietal region, and its reversal in polarity, the VPP (Vertex Positive Potential). It should be noted that the N170/VPP, while sensitive to familiarity in general, shows greater amplitudes to human faces (Bentin & Deouell, 2000), in that they are significantly evoked by the processing of facial stimuli.

Fox et al. (2005) compared individuals with low and high trait anxiety on an RSVP dual and single task mode procedure to measure attentional blink when presented with either neutral, happy, or fearful faces (T2) following a target image (T1; image of a fruit or flower). Regardless of anxiety level, attentional blinks were observed across all groups and conditions. However, the effect was significantly attenuated towards fearful faces in highly anxious participants relative to low anxious participants. Results from this study indicated that individuals with high anxiety require attentional resources in order to process emotional stimuli, but to a lesser degree than required by individuals with low anxiety. This was concluded as individuals with high anxiety experienced attenuated attentional blinks when T2 was in a later temporal position in the sequence; a finding absent in the low anxiety group.

Similarly, Arend and Botella (2002) compared individuals with low and high trait anxiety using an RSVP procedure to detect a single white word (T1) amongst a stream of black words (T2). The authors found that for highly anxious participants, when the white word was emotional (e.g., fear), participants had decreased difficulty in detecting T2, suggesting the attentional blink effect was attenuated relative to low anxious participants. Taken together, results from these studies indicate that although low- and high-anxious participants experienced attentional blinks in the presence of emotional stimuli, the size of this effect was modulated by anxiety. In other

words, the attentional blink was attenuated in highly anxious participants. These findings coincide with Fox et al. (2005) where they outline the need for attentional resource to actively process emotional stimuli within individuals with heightened anxiety. With that being said, it is reasonable to suggest from these results that although attentional blinks occur at a decreased magnitude in highly anxious individuals, they still occur, indicating that individuals with higher levels of anxiety require at least partial conscious cognitive mechanisms to process incoming emotional information.

In contrast to the above findings, Luo et al. (2010) found that when tasking participants to identify two target images (T1: house; T2: happy, fearful, or neutral faces) among a series of distracter images in an RSVP paradigm, participants exhibited more accuracy towards fearful faces than they did with happy and neutral faces. Increased accuracy was also observed towards happy faces compared to neutral faces. Essentially, participants had greater ability to detect T2 when the emotional expression was fearful in comparison to happy and neutral expressions, but overall had increased performance when detecting happy facial expressions over neutral ones. The authors concluded that processing emotional stimuli, especially threatening ones, did not require extensive attentional involvement. In this study, they also analyzed electrophysiological data and proposed a three-stage model of facial processing from ERP results. The first stage distinguished potentially threatening expressions from others, such that larger N100 and P100 amplitudes should be evoked in the presence of fearful expression, relative to happy or neutral expressions, reflecting rapid processing to identify possible threatening stimuli. The second stage was proposed to reflect the identification of emotional stimuli, but not specificity of emotion, as indicated by increased N170 and VPP amplitudes to emotional but not neutral stimuli. The third

and final stage, identifiable by enhanced N300 and P300 for fearful faces in comparison to happy and neutral faces, involved emotional expression identification (Luo et al., 2010).

Zhang et al. (2014) expanded on this by conducting a similar procedure with the use of adjectives in place of imagery. They achieved similar results, in that positive (e.g., heroic) and negative (e.g., selfish) words resulted in higher accuracy in comparison to neutral adjectives (e.g., busy). Results from this study corroborated with previous research (Luo et al., 2010) that processing emotional related stimuli is not subject to the top-down control of attentional resources, but is rather an unconscious process (Zhang et al., 2014).

Another study looked at the difference between high and low anxious participants when processing facial stimuli and found no effect of anxiety level on components related to facial processing (Rossignol et al., 2005). Despite this, there has been evidence that early ERP components associated with facial processing are susceptible to modulation with respect to anxiety level. Gallant (2017) compared individuals with high and low trait anxiety in an attentional blink paradigm with emotional stimuli (e.g., happy, fearful, and neutral faces). Although behavioural results yielded no difference in accuracy in detecting faces, regardless of emotion (e.g., fearful, happy, or neutral) or anxiety level, physiological data provided evidence that high anxious participants showed an early attentional bias to threatening stimuli followed by later avoidance while simultaneously favouring positive stimuli (Gallant, 2017). This was the first study to use ERPs to look for differences in attentional resources between low and high anxious participants, and even though physiological data showed subtle differences between levels of anxiety, behavioural results did not, and ironically provided evidence against both areas it meant to clarify (Fox et al., 2004; Arrend and Botella, 2002; Luo et al., 2010; Zhang et al., 2014; see above). Specifically, differences in early attentional ERP components showed that

participants with high anxiety showed an increased N100 and decreased N170 when viewing fearful faces. The author suggested the increased N100 reflected the attentional bias individuals with high anxiety possess towards fearful stimuli, whereas the decreased N170 demonstrated later avoidance of fearful stimuli (Gallant, 2017). Furthermore, Morel et al. (2014) demonstrated that individuals with high trait anxiety display larger P100 amplitudes when viewing happy faces, indicative of an overall emotional bias in individuals with high anxiety, as well as larger N170 amplitudes to fearful faces in comparison to neutral faces, suggestive of amplification in the processing of negatively-valanced emotions (Morel et al., 2014).

Differing levels of trait anxiety have also been shown to have an effect on later ERP components (Fox et al., 2008; Rossignol et al., 2005; Gallant, 2017). Fox et al. (2008) were able to elicit larger N2pc amplitudes for highly anxious participants when presented with angry facial expressions. The N2pc is an early negative voltage deflection which is thought to reflect attentional selection (Eimer, 1996). The P300, a component thought to be part of an attention-orienting complex (Campanella et al., 2002) sensitive to stimuli detection and conscious decision making, and the N300, thought to be more sensitive to affective (e.g., feelings) rather than physical (e.g., expression) characteristics of stimuli, have been found to be modulated by anxiety levels. Rossignol et al. (2005) found decreased N300 in participants with high anxiety in comparison to participants with low anxiety in response to fearful stimuli, suggestive that individuals with high anxiety are less perceptive to emotional salience. Moreover, they discovered P300 amplitudes with earlier latencies for participants with high anxiety, which they proposed was a way to control for the insufficient emotional judgement as showcased by the reduced N300 (Rossignol et al., 2005). In contrast, Gallant (2017) found that participants with high anxiety showed larger N300 for fearful faces over happy faces, but only when attentional

resources were abundant during an RSVP single task procedure. The author proposed that the reduced N300 during more demanding tasks where attentional resources are much more limited (e.g., RSVP dual task procedure) suggested highly anxious individuals utilize a type of cognitive avoidance – that is, in situations of added pressure, they tended to be more susceptible to threat (Gallant, 2017). Taken together, these results give evidence that anxiety is interconnected with an attentional bias towards threatening stimuli, which can be seen in more pronounced early and later ERP components (Fox et al., 2008; Rossignol et al., 2005; Gallant, 2017).

Evidently, the literature to date has yielded mix findings in the realm of emotional facial processing and impact of anxiety level. On one hand, there is evidence conveying the need for top-down control when processing emotional stimuli, yet there are findings supporting a more stimulus-driven model of the processing of emotional stimuli. As it pertains to ERPs, current findings are equivocal, ambiguous, and have yet to be consistently reproduced. Thus, the current study is proposing a new variable which may aid in explaining past conflicting findings. It has yet to be observed how individuals taking psychotropic substances, compared with those who do not, perform on attentionally demanding tasks within differing levels of anxiety.

1.5 The Role of Psychotropic Substances

It is widely known that anti-depressants are at least as useful in the treatment of anxiety disorders as they are with depressive disorders (Uthman & Abdulmalik, 2011; Schmitt et al., 2004). From 2007 to 2011, approximately 14% of Canadian women ages 25-79 reported taking anti-depressants and, for Canadian men, the prevalence ranged from 4% for ages 25-44, and 8% for ages 45-64 (Rotermann et al., 2014). Indeed, given the number of individuals taking antidepressants, either for treatment of anxiety or another psychological disorder, it is pertinent to the current study to discuss the possible implications such substances may have on processing

emotional stimuli. To our knowledge, previous research has not examined the role psychotropic substances may on emotional facial processing and the implication of attentional resources and anxiety level. Consequently, this unaccounted-for variable may be in part responsible for the ambiguity in previous literature.

It has been observed that prolonged use of SSRI results in reduced cognitive bias towards threatening stimuli (Mogg et al., 2004; Murphy et al., 2009; Harmer et al., 2006). For example, Murphy et al. (2009) compared participants on an attentional probe paradigm before and after taking either citalopram, an SSRI, reboxetine, a serotonin-norepinephrine re-uptake inhibitor, or a placebo for seven days. Using happy, fearful, and neutral faces, the authors aimed to determine their impact on threat-relevant biases. Participants were subjected to briefly view two facial images on-screen – either happy-neutral, fear-neutral, or neutral-neutral – after which a semi-colon would appear in either location. Participants were instructed to indicate the location of the semi-colon as quickly and as accurately as possible. Results from this study found that citalopram significantly reduced attentional vigilance towards fearful stimuli (Murphy et al., 2009). Whereas the reboxetine and placebo groups showed a significant bias towards fearful faces, the citalopram group did not. The authors suggested this was the result of a possible pharmacological mechanism where the dense serotonergic-innervation of the amygdala may be mediated by this class of SSRI. This suggestion was congruent with the literature in that hyper-arousal in the amygdala is reflective of individuals with anxiety disorders when faced with threatening stimuli (Mathews et al., 2004).

A more recent study compared participants classified as either low or high in neuroticism on ocular exploration, as well as the effect of citalopram on individuals classified as highly neurotic on ocular exploration of facial stimuli (Di Simplicio et al., 2014). In this context,

neuroticism relates to a variety of traits which are broadly related to certain psychopathology, which include anxiety or depression (Clark & Watson, 1991). Results showed that repeated SSRI administration modified ocular exploration on a task requiring participants to indicate the gender of happy, fearful, or neutral faces with varying ranges of intensity. More specifically, after short-term exposure to the SSRI, participants' ocular exploration patterns for emotionally salient faces, regardless of emotion, revealed significantly less avoidance than the placebo group. Additionally, in comparison to the placebo group, participants treated with SSRI administration showed significantly lower facial exploration of fearful faces with medium emotional intensity. The authors suggested that short-term SSRI administration is associated with the correction of negative biases in emotional recognition (Simplicio et al., 2014).

There seems to be prominent evidence of the attenuating effects of SSRI treatment on the attentional bias to threat-related stimuli in individuals with high anxiety. Conversely, there is considerably less research when considering ERPs and the effects of psychotropic substances on relevant components. One study, however, exclusively investigated the effects of SSRI and NRI (norepinephrine reuptake inhibitor) treatment on the processing of emotional faces by specifically examining ERP components that are connected to facial processing (Kerestes et al., 2009). More specifically, key components observed were the N170, reflecting facial structural encoding, and the N250 and LPP, later components reflective of emotional expression decoding, and more complex cognitive integration of emotional faces, respectively. Results suggested SSRI and NRI treatments promoted a shift in attentional bias from negative to positive emotional stimuli, as indicated by larger N250 amplitudes. This was postulated as an amplitude "switch" was observed for the N250. Whereas the placebo group had greater N250 amplitudes for sad faces in comparison to happy faces, the SSRI and NRI groups had greater N250 amplitudes for

happy faces, suggestive of a switch from a predominantly negative to positive bias (Kerestes et al., 2009). Therefore, it is reasonable to suggest then that psychotropic substances, specifically SSRIs in this setting, have a moderating effect on ERP components as it pertains at least to cognitive processing for emotional faces.

It appears obvious then that SSRI treatment has a pronounced effect on anxiety in regard to threatening stimuli. With that being said, the lack of comparison between those who are and those who are not taking anti-depressant medication in past literature may be an explanation for the overall contradictory results discussed above in relation to the effect of anxiety.

1.6 Current Study

The current study therefore examined the effect of specific psychotropic medication (i.e., SSRIs) on emotional facial processing in individuals with varying levels of anxiety. An RSVP procedure was used to measure differences in attentional blinks depending on type of stimuli presented as T2 (e.g., happy, fearful, or neutral facial expression) to infer the impact on cognitive processing between different levels of anxiety and medication use. EEG data was recorded for later ERP analysis related to emotional facial processing for a more thorough understanding of the underlying cognitive components of facial recognition.

Thus, the current study has value for two major reasons. First, examination of SSRI effects on anxiety during an emotion RSVP task will provide a better understanding to the nature of emotional facial processing with respect to the influence of top-down (conscious) or bottom-up processes (automatic). Furthermore, with the exceptional temporal specificity provided by ERPs, and by dividing groups based on medications shown to reduce anxiety levels, the current study will be able to add to the limited literature on the interaction between SSRIs and anxiety towards emotional facial processing. Examination of ERPs can also aid in classifying whether

the previously discussed differences between high and low anxious groups are in fact a result of anxiety.

To achieve these goals, the current study replicated the design of Luo et al. (2010) and Gallant (2017) in order to compare behavioural and physiological results. In the aforementioned studies, a RSVP consisting of 14 images – two acting as targets and the remaining 12 acting as distractors – were presented to participants in rapid succession. The first target image consisted of one of three neutral stimuli (e.g., a house) whereas the second comprised one of three types of faces (e.g., neutral, happy, or fearful). Distractor images consisted of inverted neutral faces. The task was set up with two modes; The single task mode was used as a control to establish a baseline and asked participants information only of the second target image whereas the dual task mode asked participants for details of both the first and second target images. The first target image was equally displayed in either the third, fourth, or fifth position of the sequence, while the second target image was equally displayed in the second or sixth position following the first. Manipulation of the temporal position of the second target image during the dual task mode allowed us to manipulate the amount of attentional resources required to process it. In other words, more attentional resources would be required to process the second target image if it were in the second position as opposed to if it were in the sixth.

As mentioned, the RSVP procedure allowed us to manipulate attentional resources thus hypothetically increasing attentional blinks in the more demanding tasks. This manipulation, along with analyzing the performance and difference in ERP components between individuals with high and low anxiety levels, and between those not medicated with those taking SSRIs, will enable the exploration and examination of relative components of facial processing and the attentional bias to threat-related stimuli.

1.7 Research Questions

The current study attempted to answer two major questions. One, what is the effect of SSRI medication on heightened levels of anxiety and emotional facial processing? Psychotropic medication has previously been unaccounted for in studies employing strict behavioural measures and have been entirely excluded in past research with respect to using the RSVP procedure in conjunction with ERP. This may account for the contradicting findings of whether or not individuals with high anxiety experience an attenuated attentional blink when faced with threatening stimuli (e.g., fearful faces), providing inconsistencies with respect to the nature of how emotional stimuli are processed. For example, Luo et al. (2010) concluded that emotional facial processing requires significantly fewer attentional resources, especially when processing fearful faces, whereas Fox et al. (2005) concluded processing emotional faces was subject to top-down processing for high and low anxious participants, as attentional resources were required regardless of emotional salience, although less so for fearful faces in highly anxious participants. More recently, Gallant (2017) concluded that regardless of anxiety level, there was no effect of facial expression on attentional resources. In this study, the emotional salience did not aid participants in processing different facial expressions. The author suggested these results meant that, regardless of anxiety level, emotional facial processing does not happen automatically (Gallant, 2017). Each of these studies utilized an RSVP procedure to manipulate attentional resources, but they either did not identify or completely excluded participants who could have been taking psychotropic medication. The current study hypothesized that the high-anxiety, non-medicated group would display the least number of attentional blinks for emotional content, specifically with respect to fearful facial expressions. If individuals with high anxiety are more susceptible to an attentional bias to threatening stimuli, a reduced number of attentional blinks

would be expected for fearful faces, as well as overall larger ERP amplitudes reflecting increased cognitive processing (Luck, 2014). Conversely, the opposite is expected for participants with low-anxiety, both non-medicated and medicated groups, and for the high-anxiety medicated group, whereas in the absence of an attentional bias, we would expect increased attentional blinks and smaller ERP amplitudes regardless of facial expression.

Second, the current study examined if previously observed differences in ERP data between high- and low-anxiety individuals were indeed a factor of anxiety. SSRIs have been shown to reduce anxiety levels after acute administration, thus it was hypothesized that the non-medicated and medicated low-anxiety groups as well as the high anxiety medicated group would display similar if not identical ERP presentations, whereas the high-anxiety, non-medicated group would significantly differ. In keeping with previous studies (Luo *et al*,. 2010; Gallant, 2017), six ERP components related to emotional facial processing will be examined in the current study: N100, P100, N170, LPP, N300, and P300. As discussed above, results from studies investigating emotional facial processing while using ERP have provided mixed results. Therefore, the current study does not have specific predictions relative to ERP components between groups. That said, it is predicted that ERP component patterns will be consistent between the non-medicated low anxious and medicated groups – that is, the non-medicated high anxiety group will display prominent differences in ERP components when faced with emotional stimuli than the non-medicated low anxiety or medicated groups. Logically, this is expected if differences in ERP components are the result of heightened anxiety levels. The reduction of anxiety, predicted to be revealed by the medicated group with high anxiety, should eliminate said differences.

On that account, by using ERPs to analyze underlying cognitive processes, and by identifying and isolating individuals taking psychotropic medication, the current study will examine the effect of specific anxiety-reducing psychotropic medication on emotional facial processing in an attentionally demanding task. Furthermore, separating individuals taking anxiolytic medication may allow us to isolate ERP components which may be a direct consequence of heightened anxiety levels, thus providing a better understanding of how individuals with high anxiety process information.

2. Method

2.1 Participants

A total of 57 participants took part in this study. Data from 5 participants was excluded from the overall analysis due to eligibility or equipment errors. Two additional participants were classified as extreme outliers upon analysis of accuracy (i.e., +3 SD) and were thus excluded from the overall analysis. After exclusions, a total of 50 (8 Male) participants participated in this study. Ages ranged from 17 to 67 (M = 22.76 SD = 8.63). To be eligible for this study, participants had to be right-handed, have normal or corrected-to-normal vision, have no history of neurological impairment which may have affected EEG recordings, and could not have been taking psychotropic medication – excluding SSRIs. Participants were assigned to one of four groups based on scores derived from the State Trait Anxiety Inventory (STAI; Spielberger & Gorsuch, 1983) and medication use. The four groups were as follows: High anxiety medicated (n = 10); High anxiety non-medicated (n = 10); Low anxiety medicated (n = 11), Low anxiety non-medicated (n = 19). The procedure for group division is outlined below.

2.2 Materials

2.2.1 Anxiety

To assess levels of state and trait anxiety, the STAI (Spielberger & Gorsuch, 1983) was used. The STAI is a 40-item questionnaire, requiring a minimum grade 6 reading level, with 20 items designed to assess state anxiety and 20 items designed to assess trait anxiety. State anxiety questions required the participant to identify how they felt "right now, at the current moment" using a 4-point Likert scale to rate the items (1 = Not at all, 2 = Somewhat, 3 = Moderately so, 4 = Very much so). Similarly, trait anxiety question required the participant to identify how they felt in general, also using a 4-point Likert scale to rate related items (1 = Almost Never, 2 = Somewhat, 3 = Often, 4 = Almost Always).

2.2.2 Depression

Although not used as a grouping variable, depression level was measured as a covariate. Recent literature has outlined high rates of comorbidity between depressive and anxiety disorders (Spinhoven et al., 2011), therefore it is of relevance to the current study to measure in order to test for possible confounding properties. The Quick Inventory of Depressive Symptomatology, Self-Report (QIDS-SR; Rush et al., 2003) was used to assess levels of depression symptomatology. This questionnaire consists of 16 items which address the nine symptom domains of depression: sad mood, concentration difficulty, self-criticism, suicidal ideation, interest, energy/fatigue, sleep disturbance, fluctuation in appetite or weight, and psychomotor agitation (Rush et al., 2003). Each item required the participant to answer a 4-point Likert scale to rate related issues, with 0 representing the lowest severity out of 3 (e.g., During the past seven days…: 0 = I never take longer than 30 minutes to fall asleep; 1 = I take at least 30 minutes to fall asleep, less than half the time; 2 = I take at least 30 minutes to fall asleep, more than half the

time; 3 = I take more than 60 minutes to fall asleep, more than half the time). Depending on the total score, participants received a severity score of either no depression, mild depression, moderate depression, severe depression, or very severe depression.

2.2.3 Stimuli

Stimuli composed 60 facial expressions and 3 upright house images. 24 of the 60 face stimuli were inverted neutral faces used as distractor images, while the remaining 36 were used as target images, consisting of 3 unique upright facial expressions (e.g., happy, fearful, and neutral facial expressions), with each emotional expression acted out by 12 different individuals. Gender differences were controlled for in both target and distractor stimuli (i.e., males and females had equal representation), and were presented consistently – trials with male target images were paired with male distractor images, and trials with female target images were paired with female distractor images. Distractor image order was completely randomized during the experiment. Facial stimuli were retrieved from the Karolinska Directed Emotional Faces inventory, and were cropped into the shape of an ellipse, eliminating all features (e.g., ears, hair) besides the individuals' faces.

2.3 Assigning participants to groups

To separate groups into categorizes corresponding to low and high levels of anxiety, we first ran correlations between participants' depression severity scores and both state and trait anxiety. Moderate to strong positive correlations were observed between Depression Severity and Trait Anxiety (r = .80) and Depression Severity and State Anxiety (r = .63), therefore Depression Severity was used a covariate throughout the ANOVAs of both Accuracy and ERP amplitudes in the analysis.

Next, a moderately strong correlation (r = .65) was observed between Trait and State anxiety, therefore a mixed-design ANOVA was conducted using Anxiety type (Trait, State) as a within-subjects independent variable and Medication (SSRI, non-med) as a between-subjects independent variable. A main effect was found for Anxiety type [$F(1,48) = 72.27$, $p < .001$, $\eta^2_p = .59$] and Medication [$F(1,48) = 9.06$, $p < .05$, $\eta^2_p = .15$]. A significant interaction was also found between Anxiety Type and Medication [$F(1,48) = 8.22$, $p < .05$, $\eta^2_p = .15$], and tests of the simple effects of Medication revealed no significant difference in State anxiety scores between the non-med and SSRI group ($p = .075$), but there were significantly higher Trait anxiety scores for participants in the SSRI group compared to the non-med group ($p < .001$). Simple effects of Anxiety as a function of Medication revealed that, regardless of Medication group, State anxiety was significantly lower than Trait anxiety (all ps <.001). Criteria for separating individuals into high and low anxiety groups for subsequent analyses were therefore based on State anxiety scores for two reasons: (1) State anxiety scores did not differ significantly as a function of Medication, and (2) State anxiety levels have been suggested to be more accurate than Trait anxiety when analyzing performance as a function of anxiety (Fox et al., 2001).

To separate groups based on anxiety level, a score a 36 and above on state anxiety was used as the cut off for the high anxiety group, where a cut off of below 36 was used for the low anxiety group. This criterion was chosen to remain as close as possible to the suggested cut-off of 39-40 for clinically significant anxiety symptoms on the State Anxiety scale (Julian, 2001) and to separate groups as evenly as possible (SSRI: HA n=10, LA n=11; Non-med: HA n=10, LA n = 19). To verify significant separation, a 2 (Anxiety: Low, High) by 2 (Medication: SSRI, Non-med) between-subjects ANOVA was conducted with state anxiety scores as the dependent variable and Depression severity as a covariate. As expected, the main effect of Anxiety was

significant [$F(1,45) = 59.44$, $p < .001$, $\eta^2_p = .57$], where the high anxiety group had significantly higher state anxiety scores than the low anxiety group. The main effect of Medication [$F(1,45) = 3.46$, $p = .07$, $\eta^2_p = .07$] and the interaction of Anxiety and Medication [$F(1,45) = 3.42$, $p = .07$, $\eta^2_p = .07$] were not significant, indicating that state anxiety did not significantly differ between medication groups at the assigned high and low anxiety levels (see Figure 1). Thus, significant group differences on the basis of Anxiety (high vs low) can be inferred to be the effect of participants' anxiety levels at the time of the experiment.

2.4 Procedure

After completion of informed consent and two questionnaires relating to demographics, ERP screening, and handedness (see Appendix A) participants were fitted with an EEG net and guided into a sound-attenuated booth. Participants were then provided with a verbal description of what the experiment would entail, after which the experimenter left the booth and initialized the experimental task.

The design chosen for the RSVP procedure was modeled after Luo et al. (2010) and Gallant (2017), which allowed the monitoring of the attentional blink phenomenon. The experiment was programmed and displayed to the participant using E-Prime 2.0, which simultaneously collaborated with NetStation to record EEG signals. At the start of the program, a white fixation point was displayed in the center of the screen for 500ms, then replaced by a blue fixation point for 300ms, indicating the start of a trial. Trials consisted of 14 images, including both target and distractor images, presented in rapid succession in the center of the screen. Each image was displayed for 119ms. The first target image (T1) consisted of one of three images of an upright house, whereas the second target image (T2) consisted of one of three images of a facial expression: happy, fearful, or neutral. Each target image had equal probability of

occurrence. T1 was presented with equal frequency in the third, fourth, or fifth position within the 14-image sequence. Subsequently, T2 appeared equally in either the second or sixth position following T1 (referred to as Lag2 and Lag6, respectively). The experiment was comprised a single- and dual-task mode, which differed in terms of the demands placed on the participants. That is, during the single task mode, following the end of the 14-image sequence, participants were asked if they witnessed a picture of a face (T2) by responding yes or no. In contrast, during the dual task mode, participants were asked both if they saw a picture of a face (T2; yes/no response) *and* if they saw a picture of a house (T1; yes/no response). Single-task mode served as a control, where participants were only instructed to identify faces and not houses, requiring fewer attentional resources than the dual task mode thus resulting in fewer, if any, attentional blinks. Instructed to respond as accurately as possible, participants were allotted an unlimited amount of time to indicate a response for each trial. Inter-stimulus intervals were 500ms. Dual- and single-task trials were presented individually, with four blocks for each mode containing 120 trials each. Block order was randomized and disclosed to the participants prior to beginning. Participants were allocated breaks in-between each block. An example trial can be seen in Appendix B.

Baseline conditions were also included in the tasks and were based on the methods of previous studies (Gallant, 2017; Luo et al., 2010; Vogel et al., 1998; Sergent et al., 2005) in order to account for random responding. Specifically, in the baseline conditions there was no facial stimulus at T2; Instead a blank screen was presented, with other experimental parameters remaining unchanged. Thus, the experiment overall included 16 conditions: 4 conditions for the second target (happy face; fearful face; neutral face; T2 absent for baseline) by 2 lags (Lag2;

Lag6) by 2 tasks (Single; Dual). Each condition consisted of 60 trials, for a total of 960 trials in the entire experiment.

2.5 ERP Acquisition and Analysis

A 64-electrode HydroCel Geodesic Sensory Net (Electrical Geodesics, Inc., Eugene, OR) paired with NetStation software 4.5.7 was used to record EEG data from participants. Data was digitized with a 250 Hz sampling rate, and the vertex electrode was used as the reference (Luo et al., 2010; Gallant, 2017), which was then re-referenced to the average mastoid reference. EEG waveform data was processed live with a 0.1 Hz high-pass filter, which was then stored on a computer for later offline analysis. Upon analysis, data was processed through an operational script which applied a 0.3-30 Hz band pass filter and segmented the waveform into 1200ms temporal sections (epochs), beginning 200ms pre-stimulus onset and continuing 1000ms post-stimulus onset. Data then underwent artifact detection where deflections in amplitude of at least 100μV at eye-blink electrodes were considered to be eye-blinks. Horizontal eye-movements artifacts were filtered using a 55μV threshold. Following this, bad channel replacement and baseline corrections to 200ms pre-stimulus onset were applied. ERP segments then underwent averaging within each participant resulting in a single waveform per condition. During this process, no more than 15% of the trials could be removed in order to be analyzed.

Grand average waveforms were then created in order to visually inspect for ERP components (Luck, 2014). Based on visual inspection, waveforms were divided up into the following epochs for the following components: 90 to 140 ms (P100), 140 to 190 ms (N100), 160 to 300 ms (N170), 190 to 280 ms (VPP), 280 to 420 ms (N300), 420 to 550 ms (P300). Montage channel groups were used to average the electrical activity across different brain regions for each component based on previous literature (Luo et al., 2010): Occipital (P100;

electrodes 33, 34, 36, 38), Frontal (N100, VPP; electrodes 3, 6, 8, 9), Left Temporal (N170; electrodes 32, 30), Right Temporal (N170; electrodes 43, 44), Left Frontal (N300; electrodes 13,18, 19), Right Frontal (N300; electrodes 56, 58, 59), Frontocentral (P300; electrodes 3, 4, 6, 7, 8, 9, 15, 16, 51, 53, 54). Mean amplitude data was extracted for each montage at the corresponding component epoch time interval for later analysis.

Differences in waveform activity are expected across different regions of the brain, but main effects of regions of interests (montages) are not discussed as they do not directly relate to stimulus condition, therefore they are only discussed in interactions where relevant.

3. Results

3.1 Accuracy

A 2 (Anxiety: High Anxiety, Low Anxiety) x 2 (Medication: non-med, SSRI) x 2 (Lag; Lag2, Lag6) x 2 (Task: Single, Dual) x 4 (Expression: Fearful, Happy, Neutral, Blank) mixed design ANOVA was conducted with Anxiety and Medication as between-subjects factors and Lag, Task, and Expression as within-subjects factors to examine their effect on accuracy. According to Mauchly's test, sphericity was violated and thus Greenhouse Geisser values are reported where necessary.

Results revealed a significant main effect for Task [$F(1,45) = 15.35$, $p < .001$, $\eta^2_p = .25$] and Lag [$F(1,45) = 9.63$, $p < .05$, $\eta^2_p = .18$], but not for Expression [$F(1,45) = 49.13$, $p = .07$, $\eta^2_p = .06$], Anxiety [$F(1,45) = 0.62$, $p = .43$, $\eta^2_p = .01$], or Medication [$F(1,45) = 0.001$, $p = .97$, $\eta^2_p < .01$]. A significant two-way interaction was found between Task and Expression [$F(1.69,76.19) = 4.24$, $p < .05$, $\eta^2_p = .09$] and Lag and Expression [$F(1.87,84.15) = 5.42$, $p < .05$, $\eta^2_p = .11$]. Finally, results revealed a significant three-way interaction between Task, Anxiety, and Medication [$F(1,45) = 4.28$, $p < .05$, $\eta^2_p = .09$] and four-way interaction between Task,

Anxiety, Medication, and Lag [$F(1,45) = 4.74$, $p < .05$, $\eta^2_p = .09$]. None of the other interactions were significant (all Fs < 1.63, ps > .18).

Tests of simple effects were conducted for the interaction between Task and Expression. Dunn's correction was applied to alpha levels to correct for multiple comparisons, thus to be considered significant, p values had to be smaller than .038. Tests of simple effects of Expression as a function of Task revealed significantly higher accuracy for fearful ($p < .001$), happy ($p < .001$), and blank ($p < .038$) expressions compared to neutral expressions in the single task mode. In dual task mode, happy facial expressions had significantly higher accuracy than fearful ($p < .038$), neutral ($p < .001$), and blank expression ($p < .038$), and fearful expressions had significantly higher accuracy than neutral faces ($p < .001$). When examining Task as a function of Expression, it was revealed that for every expression, accuracy was significantly higher in the single task compared to the dual task (all ps < .001),

Tests of simple effects were also conducted for the interaction of Lag and Expression. Dunn's correction was applied to alpha levels to correct for multiple comparisons, thus to be considered significant, p values had to be smaller than .038. When analyzing Expression within each level of Lag, on lag6 trials, significantly higher accuracy was found for fearful expression over both neutral ($p < .001$) and blank ($p < .001$) expressions, and for happy expressions over neutral ($p < .001$) and blank ($p < .001$) expressions. On lag2 trials, significantly higher accuracy was found for happy expressions compared to both fearful ($p < .01$) and neutral ($p < .001$) expressions, fearful expressions over neutral expressions ($p < .001$), and blank expressions over neutral expressions ($p < .01$). When examining Lag as a function of Expression, all facial expressions had significantly higher accuracy (p < .001) aside from the blank condition (p = .75)

in Lag6 trials compared to Lag2 trials. Figure 2 highlights the interactions between Lag x Expression and Task x Expression.

Finally, tests of simple effects were used to explore the four-way interaction between Task, Anxiety, Medication, and Lag. Dunn's correction was applied to alpha levels to correct for multiple comparisons, thus to be considered significant, *p* values had to be smaller than .046. Tests of the simple effects of Lag revealed no significant differences in accuracy between lag2 and lag6 in the single task for participants in the high anxiety SSRI group ($p = .24$), as well as no difference in accuracy between lag2 and lag6 in the dual task for participants in the high anxiety non-med group ($p = .05$); all other conditions revealed significantly higher accuracy for lag6 compared to lag2 (all $ps < .046$). Test of simple effects of Task using LSD comparisons showed no significant difference in accuracy between tasks in lag2 trials for participants in the high anxiety non-med group ($p = .07$), and in lag6 trials for participants in the low anxiety SSRI group ($p = .06$). All other conditions had significantly higher accuracy in the single task compared to the dual task (all $ps < .046$). No significant differences in accuracy were observed when analyzing simple effects of Anxiety or Medication.

3.2 Event-Related Potentials

A series of 2(Anxiety) x 2(Medication) x 2(Lag) x 2(Task) x 3(Expression) mixed ANOVAs were conducted for four out of the six ERP components: N100, P100, VPP, and P300. For the N170 and N300 ERP components, identical mixed-design ANOVAs were conducted with the added variable of Region of Interest (ROI; Left Hemisphere, Right Hemisphere) to correspond with their respective montages (Luo et al., 2010). Blank conditions were not included in ERP analyses as accuracy results showed no significant differences for Lag and to remain in line with ERP analyses conducted by Luo et al. (2010). Mean amplitudes for facial expressions

across anxiety and medication groups can be found in Figure 6. Sphericity was checked for all analyses, and Greenhouse Geisser values are reported where violations occurred. Although not statistically significant, certain trends approaching significance were included and discussed with relevance to ERP interpretation (Luck, 2014).

3.2.1 N100

N100 amplitudes showed a main effect of Lag [$F(1,45) = 19.91$, $p < .001$, $\eta^2_p = .31$]. There was no main effect of Anxiety [$F(1,45) = 0.24$, $p = .63$, $\eta^2_p = .01$], Medication [$F(1,45) = 3.75$, $p = .06$, $\eta^2_p = .08$], Task [$F(1,45) = 1.71$, $p = .19$, $\eta^2_p = .04$], or Expression [$F(1,45) = 0.74$, $p = .48$, $\eta^2_p = .02$]. Amplitude results revealed a significant two-way interaction between Task and Anxiety [$F(1,45) = 4.39$, $p < .05$, $\eta^2_p = .09$]. None of the other interactions were significant (all Fs < 3.03, ps > .05), however there was a trend of the three-way interaction between Lag, Expression, and Medication [$F(1.82,45) = 3.03$, $p = .059$, $\eta^2_p = .06$].

For the two-way interaction, test of simple effects of Anxiety as a function of Task did not show significant differences between participants with low and high anxiety. When analyzing Task within each level of Anxiety, participants with high anxiety showed significantly larger N100 amplitudes in the single task compared to the dual task ($p < .05$). No differences were found between single and dual tasks for participants with low anxiety ($p = .37$).

For the trend of the three-way interaction between Lag, Expression, and Medication, LSD pairwise comparisons of the simple effects of Expression revealed that, in the lag2 condition, participants in the SSRI group displayed significantly larger N100 amplitudes for fearful expressions compared to happy expressions ($p < .05$), and participants in the non-med group displayed significantly larger N100 amplitudes for both happy ($p < .05$) and neutral ($p < .05$) expressions compared to fear (see Figure 3). Neither participants in the SSRI group or the non-

med group showed significance differences in N100 amplitudes between facial expressions in the lag6 condition (all *p*s > .06). Test of simple effects of Medication revealed participants in the non-med group displayed significantly larger N100 amplitudes than the SSRI group in lag2 trials containing happy expressions ($p < .05$). When analyzing simple effects of Lag, regardless of Medication or Expression, all participants displayed significantly larger N100 amplitudes for lag2 compared to lag6 (all *p*s < .001).

3.2.2 P100

P100 amplitudes showed a main effect of Lag [$F(1,45) = 6.05$, $p < .05$, $\eta^2_p = .12$]. There was no main effect of Anxiety [$F(1,45) = 0.32$, $p = .57$, $\eta^2_p = .01$], Medication [$F(1,45) = 0.001$, $p = .98$, $\eta^2_p < .01$], Task [$F(1,45) = 1.24$, $p = .27$, $\eta^2_p = .03$], or Expression [$F(1,45) = 0.24$, $p = .79$, $\eta^2_p = .01$]. P100 amplitudes were significantly higher in lag2 conditions compared to lag6 conditions. None of the interactions were significant (all *F*s < 1.75, *p*s > .18).

3.2.3 N170

N170 amplitudes showed a main effect of Lag [$F(1,45) = 21.73$, $p < .001$, $\eta^2_p = .33$] and Anxiety [$F(1,45) = 4.94$, $p < .05$, $\eta^2_p = .10$]. No main effect was found for Medication [$F(1,45) = 0.43$, $p = .84$, $\eta^2_p < .01$], Hemisphere [$F(1,45) = 2.70$, $p = .11$, $\eta^2_p = .06$], Task [$F(1,45) = 0.3$, $p = .87$, $\eta^2_p < .01$], or Expression [$F(1,45) = 1.90$, $p = .16$, $\eta^2_p = .04$]. Amplitude results revealed significant two-way interactions between Lag and Medication [$F(1,45) = 4.56$, $p < .05$, $\eta^2_p = .09$], Task and Anxiety [$F(1,45) = 7.18$, $p < .05$, $\eta^2_p = .14$], and Hemisphere and Lag [$F(1,45) = 7.74$, $p < .05$, $\eta^2_p = .15$], as well as significant three-way interactions between Hemisphere, Lag, and Anxiety [$F(1,45) = 8.24$, $p < .05$, $\eta^2_p = .16$], Hemisphere, Lag, and Expression [$F(1.83,82.28) = 4.12$ $p < .05$, $\eta^2_p = .08$], and Task, Expression, and Medication [$F(1.89,45) = 3.35$, $p < .05$, $\eta^2_p = .07$]. Finally, a significant four-way interaction was found between

Hemisphere, Medication, Anxiety, and Task [$F(1,45) = 5.85$, $p < .05$, $\eta^2_p = .12$]. None of the other interactions were significant (all Fs < 2.09,ps > .15).

To explore the two-way interaction between Lag and Medication, test of simple effects of Lag as a function of Medication revealed both participants in the non-med ($p < .001$) and SSRI groups ($p < .001$) displayed significantly larger N170 amplitudes in lag2 compared to lag6.

For the interaction between Hemisphere, Lag, and Anxiety, LSD comparisons of test of simple effects of hemisphere as a function of a Lag and Anxiety revealed significantly larger N170 amplitudes in the right compared to the left hemisphere for participants in the high anxiety group in lag2 conditions ($p = .001$). There were no significant differences in N170 amplitudes between the left and right hemisphere for the high anxiety group in lag6 ($p = .07$), or for the low anxiety group in lag2 ($p = .19$) or lag6 ($p = .15$).

For the interaction between Hemisphere, Lag, and Expression, LSD pairwise comparisons of the simple effects of expression revealed significantly larger N170 amplitudes in the right hemisphere for happy expression over fearful expressions in lag2 trials ($p < .05$). There were no significant differences in N170 amplitudes between facial expressions in the left hemisphere for the lag6 condition ($p = .97$) or in the right hemisphere for lag2 or lag6 conditions (ps > .05).

For the interaction between Task, Expression, and Medication, LSD pairwise comparisons of the simple effects of Expression revealed significant differences in N170 amplitudes between facial expressions for participants in the non-med group in the dual task mode, where significantly larger N170 amplitudes were found for happy expressions over both fearful ($p < .05$) and neutral expressions ($p < .05$). When analyzing simple effects of Task, significant differences in amplitudes were found for the SSRI group when processing fearful

expressions, where larger N170 amplitudes were observed in the single task compared to the dual task ($p < .05$) (See Figure 4). Tests of simple effects of Medication did not show significant differences between the non-med and SSRI group within the levels of Task and Expression (all ps < .27)

Finally, for the four-way interaction between Hemisphere, Medication, Anxiety, and Task, tests of simple effects of Hemisphere revealed significantly larger N170 amplitudes in the right compared to the left hemisphere ($p < .05$) in the single task mode for participants in the low anxiety and non-med group Analyzing the simple effects of Task revealed significantly larger N170 amplitudes in the dual task compared to the single task ($p < .05$) in the left hemisphere for participants in the high anxiety and SSRI group. In the right hemisphere, significantly larger N170 amplitudes were found for the single task compared to the dual task ($p < .05$) for participants in the low anxiety and non-med groups.

3.2.4 VPP

VPP amplitudes showed a main effect of Lag [$F(1,45) = 29.19$, $p < .001$, $\eta^2_p = .39$] and Anxiety [$F(1,45) = 4.33$, $p < .05$, $\eta^2_p = .09$]. Participants in the low anxiety group displayed significantly larger VPP amplitudes than those in the high anxiety group. No main effect was found for Medication [$F(1,45) = 0.58$, $p = .45$, $\eta^2_p = .01$], Task [$F(1,45) = 0.48$, $p = .49$, $\eta^2_p = .01$], or Expression [$F(1,45) = 1.38$, $p = .26$, $\eta^2_p = .03$]. Amplitude results revealed significant two-way interactions between Task and Expression [$F(1.99,89.71) = 3.58$, $p < .05$, $\eta^2_p = .07$] and a three-way interaction between Task, Expression, and Lag [$F(1.99,89.92) = 3.51$, $p < .05$, $\eta^2_p = .07$]. None of the other interactions were significant (all Fs < 2.47,ps > .09).

To explore the three-way interaction between Task, Expression, and Lag, LSD pairwise comparisons of the tests of simple effects of Expression as a function of Lag and Task revealed

that, for single task mode, significantly larger VPP amplitudes were observed in lag6 for happy expressions compared to fearful expressions ($p < .05$), whereas there were significantly larger VPP amplitudes for happy expressions compared to neutral expressions in lag2 ($p < .05$). In the dual task mode, significantly larger VPP amplitudes were found in lag6 for fearful expressions compared to happy expressions ($p < .05$) as well as marginally higher VPP amplitudes for fearful expressions compared to neutral ($p = .072$). In dual task lag2 conditions, marginally larger VPP amplitudes were observed for happy expressions compared to neutral expressions ($p = .058$).

3.2.5 N300

N300 amplitudes showed a main effect of Lag [$F(1,45) = 35.98$, $p < .001$, $\eta^2_p = .44$]. There was no main effect for Anxiety [$F(1,45) = 3.61$, $p = .064$, $\eta^2_p = .07$], Medication [$F(1,45) = 2.81$, $p = .10$, $\eta^2_p = .06$], Hemisphere [$F(1,45) = 0.20$, $p = .65$, $\eta^2_p < .01$], Task [$F(1,45) = 0.14$, $p = .71$, $\eta^2_p < .01$], or Expression [$F(1,45) = 0.26$, $p = .77$, $\eta^2_p < .01$]. Amplitude results also revealed significant three-way interactions between Hemisphere, Task, and Lag [$F(1,45) = 7.76$, $p < .05$, $\eta^2_p = .15$], Task, Expression, and Anxiety, [$F(1.94,45) = 3.49$, $p < .05$, $\eta^2_p = .07$], and Task, Lag, and Expression [$F(1.94,45) = 3.34$, $p < .05$, $\eta^2_p = .07$]. None of the other interactions were significant (all Fs < 2.89, ps > .08).

For the interaction of Hemisphere, Task, and Lag, tests of simple effects of Lag as a function of Task and Hemisphere revealed significantly larger N300 amplitudes for lag6 compared to lag2 for each condition of Hemisphere and Task (all ps <.001).

Next, for the interaction of Task, Expression, and Anxiety (see Figure 5), LSD pairwise comparisons of the simple effects of Expression revealed that the low anxiety group displayed significantly larger N300 components for happy ($p = .001$) and neutral ($p = .001$) expressions compared to fearful expressions in the dual task. For the high anxiety group, marginally larger

N300 amplitudes were found for happy expressions compared to fearful expression in the dual task ($p = .067$). When examining tests of simple effects of Anxiety as a function of Expression and Task, those in the high anxiety group displayed significantly larger N300 amplitudes than the low anxiety group for happy ($p < .05$) and neutral expressions ($p < .05$) in the single task. In the dual task, participants in the high anxiety group displayed significantly larger N300 amplitudes than the low anxiety group for fearful expressions ($p < .05$).

LSD pairwise comparisons of the tests of simple effects of Expressions as a function of Lag and Task were used to explore the interaction between Task, Lag, and Expression. Results revealed significantly lager N300 amplitudes in the dual task for happy expressions compared to both fearful ($p < .05$) and neutral expressions ($p < .05$) in lag6 trials. When analyzing the interaction by simple effects of Task, significantly larger N300 were found for single task compared to dual task mode in lag6 trials containing fearful expressions ($p < .05$).

3.2.6 P300

P300 amplitudes showed a significant main effect of Lag [$F(1,45) = 40.69$, $p < .001$, $\eta^2_p = .48$] and, but not for Medication [$F(1,45) = 0.11$, $p = .92$, $\eta^2_p < .01$], Anxiety [$F(1,45) = 1.93$, $p = .17$, $\eta^2_p = .04$], Task [$F(1,45) < 0.001$, $p = .99$, $\eta^2_p < .01$], and Expression [$F(1,45) = 2.08$, $p < .13$, $\eta^2_p = .04$]. P300 amplitudes were significantly larger in the lag2 condition compared to the lag6 condition. None of the interactions were significant (all Fs < 3.82, ps > .06), but a trend was observed for two-way the interaction between Task and Expression [$F(1,45) = 2.53$, $p = .086$, $\eta^2_p = .05$].

To explore the trend of the interaction between Task and Expression, LSD pairwise comparisons of the test of simple effects of Expression as a function of Task were used. In the single task, significantly larger P300 amplitudes were found for happy ($p < .05$) and neutral

expressions ($p < .05$) compared to fearful expressions. In the dual task, significantly larger P300 amplitudes were found for fearful ($p < .05$) and neutral expressions ($p < .05$) compared to happy expressions.

4. Discussion

The current study examined the underlying cognitive mechanisms involved in emotional facial processing and the resulting effect of anxiety level and SSRIs. Previous studies have demonstrated that individuals with high levels of anxiety display an attentional bias towards threat, leading to the speculation that emotional processing is an automatic process which does not require top-down control, but rather is stimulus driven (Luo et al., 2010). However, there are some inconsistencies which go against this speculation more in support of conscious attentional control (Fox et al., 2005), which leaves an unclear understanding of emotional facial processing as a function of anxiety. Furthermore, there is evidence which suggests that SSRIs can reduce levels of anxiety (Uthman & Abdulmalik, 2010) and subsequently reduce the associated threat-related bias (Murphy et al., 2009). The current study aimed to expand on the literature with respect to SSRI effects on emotional facial processing in individuals with high and low levels of anxiety, where the overall goal was to gain a better understanding of how emotions are processed at the cognitive level.

A modified version of the RSVP (Luo et al., 2010) was utilized to manipulate attentional resources to infer cognitive processing by measuring the intensity of the attentional blink. The RSVP presents a rapid sequence of images where participants are required to answer questions based on what they saw. If participants are tasked to identify two targets (T1, T2) and T2 follows T1 within a 200-500ms temporal window, a “blink” in attention is thought to occur (Raymond et al., 1992). In other words, the participant will fail to detect T2 if presented immediately after T1.

By contrasting medication and anxiety groups based on behavioural performance and ERP presentation, the current study aimed to clarify the existing literature with respect to emotional processing and anxiety as a function of medication usage. A secondary aim was to identify cognitive components unique to heightened levels of anxiety at the physiological level. It was hypothesized that individuals with high levels of anxiety would exhibit fewer attentional blinks due to an increased attentional bias towards threatening stimuli (i.e., fearful faces). However, those who were at the time taking an SSRI class antidepressant would show an increase in attentional blinks as the associated anxiolytic effects should reduce this bias. Individuals with low levels of anxiety would therefore display an increase in attentional blinks, regardless of medication, due to the absence of anxiety related attentional biases. From an electrophysiological perspective, the current study did not have concrete predictions pertaining to individual ERP component presentation due to the current ambiguity in the literature relating to emotional facial processing. However, it was hypothesized that we would find similar ERP profiles amongst the following groups: high anxiety medicated, low anxiety medicated, and low anxiety non-medicated. Hypothetically, if anxiety is the cause of differential ERP presentations while processing facial expressions, it then follows that individuals treated with medication known to reduce anxious symptoms (Mogg et al., 2004; Schmitt et al., 2005; Uthman & Abdulmalik, 2010; Simplicio et al., 2014) would show a reduction in anxious symptoms. As a result, we predicted that individuals in the high anxiety non-medicated group would show the most unique ERP presentation.

Overall, there were two major findings surrounding effects of medication and anxiety. First, it was found that individuals taking SSRI antidepressants may not experience a reduction in an attentional bias towards threat, but rather an overall reduction in emotional identification

for both positive and negative faces. Second, regardless of medication status and anxiety level, participants appear to display an overall bias towards positive emotions. This positive bias however became overpowered in individuals with high levels of anxiety by the attentional bias towards threat but only in the later stages of processing as evidenced by ERP results.

4.1 Overall Positive Emotional Bias

It was initially hypothesized that a reduction in attentional blinks would be observed for individuals with high anxiety who were non-medicated. The rationale being that as anxiety increases, and is left untreated, the attentional bias towards threat would subsequently increase. This attentional bias would in turn "break through" the attentional blink time window (200-500ms) when presented with fearful facial expressions in the RSVP procedure. Upon examining accuracy results, it became clear that the attentional manipulation was successful. As a whole, participants were most accurate in identifying facial expressions in the single task mode and when the facial expression appeared later in the RSVP sequence (Lag6). In other words, when the demand for attentional resources was greater in the dual task mode, and when the facial expression appeared immediately following the first target (i.e., picture of a house), participants exhibited significantly more attentional blinks.

Contrary to our hypotheses, however, we did not observe an effect of anxiety or medication on the ability to detect emotional facial expressions within the RSVP procedure. This goes against findings from previous studies which suggest increased anxiety level leads to increased accuracy in detecting emotions when attentional resources are limited, especially fearful facial expression (Fox et al. 2005; Arend & Botella, 2002). This may be due to the fact that the current study utilized state anxiety scores to separate groups. A study by Fox et al. (2001) however separated groups based off state anxiety and found that individuals high in state

anxiety scores exhibited longer dwell times on threat-related stimuli. That is, participants in the high anxiety group displayed an increased difficulty in disengaging from fearful stimuli. While these results indicate the presence of a threat-related bias when using state anxiety as a grouping variable, results from the current study do not directly support this conclusion. This may be because of the nature of the current RSVP procedure as an attentional orientation task (Raymond et al., 1992), which measures one's ability to direct their attention towards a stimulus. In other words, the RSVP employed in this study may not be able to capture the disengagement aspect of the associated threat-bias since the to-be detected stimuli were located in the T2 position. Put more plainly, the current study's design measured the accuracy of *detecting* an emotional face following a neutral image, not *shifting* attention away from an emotional face to a neutral image. This would explain the contrast with behavioural results as a function of state anxiety seen in previous studies which seem to only affect the ability to disengage from distracting stimuli (Fox et al., 2001).

An effect of facial expression was observed regardless of participants' anxiety level or medication status. Specifically, it was found that participants were more accurate at identifying happy facial expressions overall in the dual task mode and on trials when the facial expression was located in the attentional blink window (Lag2). To a lesser degree, identification of fearful facial expression was more accurate in comparison to neutral expressions. This suggests that emotional expressions overall attenuate the attentional blink, yet positive emotional stimuli carry a greater effect. This is supported by a recent meta-analysis conducted by Pool et al. (2016) which concluded that a significant positive-emotional bias was present in comparison to neutral stimuli in a sample of 243 studies. Of interest to the current study, this positive bias was observed to be larger in experiments capturing initial orientation rather compared to studies

which use attentional disengagement paradigms. Notably, the positive bias was largest in experiments utilizing the RSVP, which may explain the unexpected results found for the anxiety associated attentional bias in the current study. The RSVP is a task which captures one's ability to orient to a given stimuli, therefore participants' increased ability to detect positive stimuli over fearful and neutral stimuli supports the notion of a prominent positive-emotional bias in the current study (Pool et al., 2016).

When analyzing ERP components, participants exhibited larger amplitudes related to facial processing when presented with happy facial expressions. Specifically, participants evoked larger N170 amplitudes for happy facial expressions in the right hemisphere. In the current study, this N170 effect was captured in the right temporal region near the fusiform facial gyrus, a structure within the brain thought to be responsible for encoding of face specific stimuli (Bentin & Deouell, 2000). The VPP is a positive amplitude often associated as the positive counterpart of the N170 component and, generally, larger N170 and VPP amplitudes were found for happy facial expressions. More specifically, larger VPP amplitudes were found during the single mode for happy facial expressions compared to fearful and neutral expressions when it was located outside and inside the attentional blink window, however only when compared to neutral expressions for the latter. For the dual task, larger VPP amplitudes were observed for fearful over happy expressions, however marginally larger VPP amplitudes were found for happy expressions compared to neutral when the faces were located later in the sequence. Coupled with behavioural results where participants were more accurate overall when detecting happy facial expression, the increase in N170 and VPP amplitudes for happy facial expressions provides further evidence for an initial positive bias. Not only is this positive bias evident from a

physiological perspective, but there is also an observable, behavioural impact on participants' accuracy.

While an effect of anxiety or medication was not observed on the participants' ability to detect emotional facial expressions, an overall positive bias was observed. Coupled with the fact that participants were, to a lesser degree, more accurate at detecting fearful facial expressions compared to neutral expressions, these results give evidence that emotional processing is less subjected to top-down, conscious processing. This partially coincides with Luo et al. (2010) where accuracy was improved significantly for both fearful and happy facial expressions compared to neutral. While the effect was greater overall for fearful faces for Luo et al. (2010), results from the current study nonetheless suggests that emotions are processed without significant attentional involvement compared to processing neutral stimuli. Furthermore, these emotional biases apply to participants regardless of their anxiety level or current medication status. Research going forward may need to account for emotional biases previously thought only to affect individuals with high anxiety (i.e. attentional bias to threat) considering that all participants in the current study displayed biases towards both positive and negative emotional stimuli.

4.2 Effects of SSRI Antidepressants

The hypothesis of an interaction between SSRI medication and anxiety was not supported as no significant differences in accuracy or ERP components were found as a function of medication status and anxiety level. That is, regardless of anxiety level or medication status, neither an increase nor decrease of attentional blinks was observed. However, relying solely on behavioural results to infer cognitive processing may not be an entirely accurate or appropriate approach (Kappenman et al., 2015; Dickinson & Szeligo, 2008; Torrence & Troup, 2018).

Results from the current study's physiological ERP data suggests that SSRI administration did have an effect on overall processing.

Notably, it was found that individuals who were not taking psychotropic medication displayed larger N100 amplitudes for happy facial expression compared to those taking SSRI antidepressants. When looking within the SSRI group specifically, those who were taking SSRIs exhibited larger N100 amplitudes when processing fearful facial expressions compared to happy facial expressions. This was an unexpected finding given previous evidence that SSRI administration results in a reduced attentional bias towards threat. The N100 component is an early perceptual component involved in early stimuli detection of expressive information (Campanella et al. 2002), and the fact that there was no SSRI attenuation effect on the processing of fearful faces suggests that the N100 component may not be moderated by serotonergic effects during facial processing. Given the frontal scalp location of the N100 component captured in the current study, this is inconsistent with Harmer et al. (2006) where acute SSRI administration had a modulating effect on the prefrontal cortex while processing threat-related emotions. However, authors in this study examined participants who had never displayed depressive symptoms, whereas the current study used depression scores a co-variate because depressive and anxious symptoms were highly correlated. The depressive (and/or anxious) symptom presentations within the current sample may have played a role in N100 amplitude moderation, which warrants future research on the interaction of depressive symptoms and SSRIs on early attentional components.

Differences in N170 amplitudes were observed between individuals taking an SSRI class antidepressant and those who were not taking any type of psychotropic medication, although in different presentations. Specifically, it was found that while individuals who were not on

medication had stronger N170 amplitudes for happy facial expression overall, individuals on SSRI antidepressants showed no differences in amplitudes regardless of facial expression. More so, differences in N170 amplitudes for the non-medicated group only occurred in the more demanding task. The N170 component is a face specific ERP negative peak that has been shown to be unaffected by the emotional salience of a stimulus (Eimer et al., 2003), however recent findings have suggested otherwise (Morel et al. 2014; Luo et al., 2010). Results from the current study therefore give support to the emotional susceptibility of the N170 component and provide further evidence of an initial positive bias seen early on in cognitive processing, at least for individuals who are not taking psychotropic substances, regardless of anxiety level. The lack of N170 amplitude differences between facial expressions for those taking SSRI antidepressants, however, is an interesting finding as it carries the implication of an attenuation of emotional perception as a whole.

In the current study, individuals who endorsed taking SSRI antidepressant medication did not show N170 amplitude differences while processing either happy, fearful, or neutral facial expressions. This finding gives partial support to our hypothesis that SSRI administration would result in a reduction in anxiety level, thus reducing the attentional bias towards threat. This also partially supports results of previous studies which showcased only a reduction in threat-related biases as a result of SSRI administration (Murphy et al., 2009; Mogg et al., 2004), as well as studies examining cortical pathways activated during threat evaluation (Phan et al., 2013; Harmer et al., 2006). One study found that the amygdala and hippocampus, both structures implemented in emotional processing, are attenuated by SSRI administration (Harmer et al., 2006), whereas another observed decreased amygdala activation in response to fearful faces amongst socially phobic individuals following SSRI administration (Phan et al., 2013). While the

current study employed a temporal neuroimaging technique and can only infer towards the implications of neural functioning, results suggests an attenuation mechanism when contrasting N170 differences between medicated and non-medicated participants. However, unlike previous experiments, results from the current study appear to suggest an overall emotional attenuation in place of a fear-reduction mechanism. SSRIs may then function to reduce cortical activation not only to threat-related but emotionally charged stimuli as a whole. Conversely, the majority of the current literature has found threat-bias reductions paired with an increased positive bias following SSRI administration (see Browning et al., 2010, for a review), therefore the notion of an overall SSRI emotional attenuation is a unique finding which warrants future exploration. One explanation could be the fact that previous studies have focused on one type of SSRI antidepressant (e.g., mainly citalopram or fluoxetine). It could be that other less studied SSRIs have differing effects at the cortical level with respect to attentional biases. In other words, the current study's use of self-report where participants endorsed their current (and commonly chronic) SSRI medication and dosage allowed for a broader examination of SSRI effects. This contrasts with previous methodologies of acute administration using an exclusive form of SSRI, which may explain these unique findings.

Further examination of the N170 component revealed that although participants who were taking SSRI medication did not display differences in amplitudes between the emotions of the facial expressions, there were differences within the emotions when comparing task modes. Specifically, when examining N170 amplitudes for fearful facial expressions, it was found that individuals taking SSRI antidepressants had larger N170 amplitudes in the single task mode and smaller N170 amplitudes in the dual task mode. In the current study, the dual task mode in the RSVP required participants to identify both T1 (house) and T2 (upright face), whereas the single

task mode only required identification of T2. Put differently, the dual task mode can be viewed as the more attentionally demanding, or stressful, task of the two. Decreased N170 amplitudes for fearful faces in the dual task may reflect a psychopharmacological efficacy of SSRIs in high stress situations.

This apparent reduction in fear recognition in the more demanding situation may be a consequence of a reduced attentional bias towards threat stemming from SSRI usage which could indicate a serotonergic advantage in high stress situations. Future research is therefore warranted to further explore SSRI efficacy depending on situational context.

4.3 Attentional Bias to Threat in Late Stage Processing

It was also predicted that participants in the non-medicated group with high levels of anxiety would exhibit a distinct ERP presentation. This was hypothesized as we would expect that participants who either had low anxiety or were taking anxiolytic medication (or both) would be less susceptible than non-medicated individuals with high anxiety to the anxiety-associated attentional threat bias. The N300 and P300 component were examined to infer emotional processing (e.g., encoding/decoding of affect; Luo et al., 2010) to draw conclusions pertaining to the attentional bias towards threat. That said, an interaction between anxiety level and medication status was not observed in this domain, therefore results do not suggest a moderating effect of SSRI administration on emotional processing, at least in the later stages of facial processing (see above). This finding goes against previous literature which demonstrated an attenuation effect of SSRI administration on negative emotional stimuli (Mogg et al., 2004; Murphy et al., 2009). However, similar to the current study, Kerestes et al. (2009) did not observe a modulation of an ERP component related to emotional processing (N250) towards negative emotions, but an increase in amplitudes towards positive emotional stimuli was found

after acute SSRI administration. One difference between the current and previous studies which may account for these contrasting results is the method of the population used. In the aforementioned studies, healthy participants were recruited to examine the effects of SSRI medication (i.e., physically and psychologically well), whereas the current study utilized individuals ranging in anxious and depressive symptoms. The recruitment method for participants who were already prescribed and taking a certain medication at the time of the experiment may then account for the difference in results observed from the current study. In other words, the effect observed in previous studies may have been augmented by the fact that participants were healthy controls, which may then subsequently be attenuated in populations with increased psychopathology as observed in the current study. Results from the current study may be a more accurate representation of individuals living with both high and low levels of anxiety.

When focusing on anxiety level, results revealed that anxiety did have an effect on emotional processing at the physiological level. As mentioned, an effect of anxiety on accuracy was not observed when participants were presented with different emotional facial expressions. There were distinct differences, however, between facial expressions when comparing high and low anxiety groups on the N300 and P300 amplitudes, components related to emotional processing of affect recognition (Luo et al., 2010). First, in the more demanding dual task, participants with low levels of anxiety displayed larger N300 amplitudes for happy facial expressions which coincides with the overall behavioural trend leaning towards a positive bias. Relating to the attentional threat bias associated with high anxiety, it was found that when comparing groups based on anxiety level, individuals with high levels of anxiety had greater N300 amplitudes than those with low anxiety when processing fearful facial expressions in the

dual task. This suggests that the attentional bias towards threat-related stimuli originates in later staged processing following earlier cognitive components related to stimuli identification (N100/P100) and face specific encoding (N170/VPP). This pattern was not observed in accuracy data where an overall positive bias was observed, however since the N300 effect occurs later in the ERP presentation, this may affect processes of attentional shifting and disengagement more so than those of initial orientation. A meta-analysis conducted by Bar Haim et al. (2007) revealed a moderate effect size in support of an anxiety related threat-bias, however the authors were unable to examine the impact on the individual sub-components of attention given the limited differentiation within the literature. As discussed, the current study employed an RSVP procedure where the emotional expression was located at T2, therefore the participants' ability to disengage from a given stimuli was not explicitly measured. The N300 effect was also only observed in the more attentionally demanding dual task where participants were required to search for both T1 and T2. In the single task mode, individuals with high anxiety only displayed larger N300 amplitudes for happy and neutral expressions compared to those with low anxiety. Indeed, this suggests that the attentional bias towards threat-related stimuli may be more prominent in high-stress situations. Likewise, a P300 effect was observed regardless of anxiety level, with larger amplitudes for happy and neutral expressions in the single task mode and larger amplitudes for the fearful and neutral expressions in the dual task mode. It may be then that the N300 component plays a critical role in modulating the attentional bias towards threat for individuals with high levels of anxiety. Future research is warranted with respect to the N300's role in tasks of attentional disengagement in conjunction with high anxiety and to further explore the impact of situational demands.

4.4 Limitations

One factor should be noted which may have impacted the results of the current study. Participants were recruited and subjected to self-report questionnaires in order to identify those taking SSRI antidepressants and those not taking any form of psychotropic medication. Unlike previous studies which measured the effect of a specific dose/medication directly administered to the participant, the current study's methodology of self-report allowed the inclusion of a more diverse sample. Given the variability of reported dosage and SSRI medications, definitive conclusions cannot be drawn with respect to the efficacy of specific medication type. However, to qualify for analysis, participants taking an SSRI medication must have met the standard minimum prescribed dosage for their respective medication. Although specific SSRI effects can only be inferred, obtaining a diverse sample provides insight into the overall effects from the SSRI class and from a more realistic sample.

In the current study, trait anxiety scores significantly differed between participants taking SSRIs and participants not taking any psychotropic medication, whereas state anxiety scores did not. As a result, state anxiety was used to divide participants. Studies examining the attentional bias to threat in individuals with high anxiety have typically relied on trait anxiety as an overall measure of anxiety, therefore the contrast in behavioural results found could be the result of a difference in methodologies. However, given that state and trait anxiety scores had a strong positive correlation, and previous research has suggested that they exist as a unidimensional construct (Leal et al., 2017), state anxiety may in fact reflect a more accurate representation when examining the effect of anxiety at the time of the experiment (Fox et al., 2001).

Finally, when referring to Figures 3, 4, and 5, it becomes clear that several grand average waveforms do not have 0-voltage baselines. Put differently, this could be the result of

insufficient interstimulus intervals thus resulting in possible cognitive interference from the preceding trial. However, given that there is consistency between conditions despite uneven baselines, facial processing can still be examined. Thus, changes in amplitudes can be attributed to the stimulus presented at the 0-millisecond time period as visual inspection does not suggest baseline variation between the conditions themselves.

5. Conclusion

The current study examined the effect of SSRI medications and high levels anxiety to explore the effects on emotional facial processing. Results point to two major findings where individuals high in anxiety may exhibit an attentional bias towards threat in the later stages of cognitive processing, potentially impacting the ability to shift away or disengage from negatively charged stimuli. Second, results suggest that SSRI medication may function to attenuate emotional processing as a whole (i.e., both positive and negative information) as opposed to reducing the attentional bias to threat documented in previous studies. These finding support the existence of an anxiety-associated attentional bias to threat-related stimuli; however, they also give evidence for a dominant, early cognitive positive-emotional bias in both those with high and low levels of anxiety. These findings can provide insight into developing treatment for those with anxiety disorders and suggest that interventions should focus on cognitions with the goal of threat-disengagement in situations where stress levels may be elevated. More specifically, results suggest that individuals with high anxiety do not appear to experience difficulty with avoiding initial orientation towards threatening information, therefore treatments may prove more beneficial in developing coping strategies for dealing with maladaptive cognitions as they are encountered to avoid ruminative behaviour.

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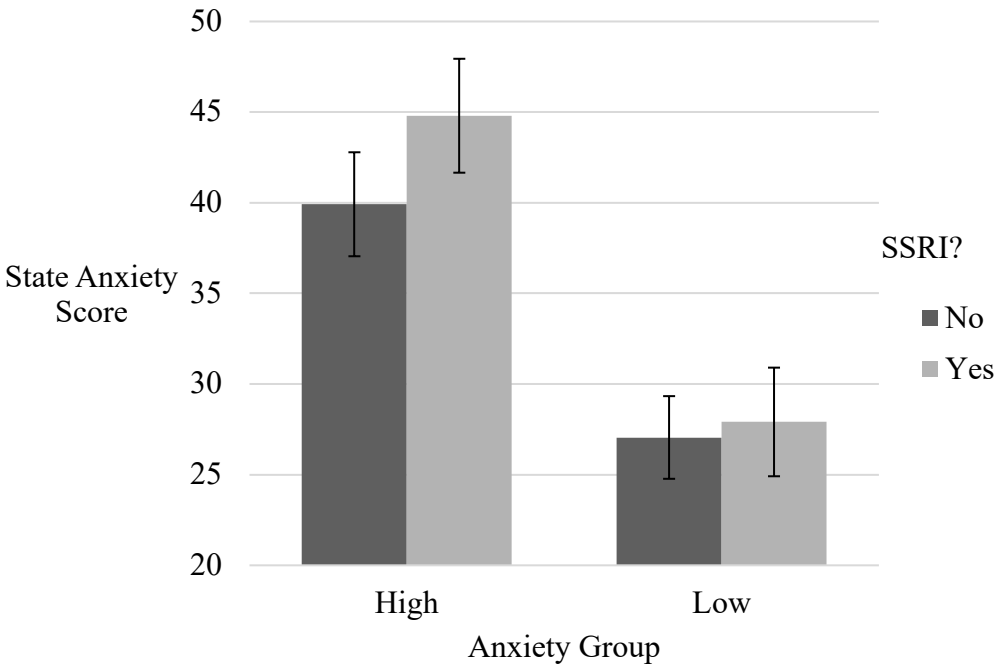


Figure 1. Anxiety scores separation grouped by Anxiety Group (High vs Low) and SSRI status (Yes vs No) displaying the significant difference in anxiety scores between group, but not between SSRI status. Error bars were created using the Standard Error of the Mean.

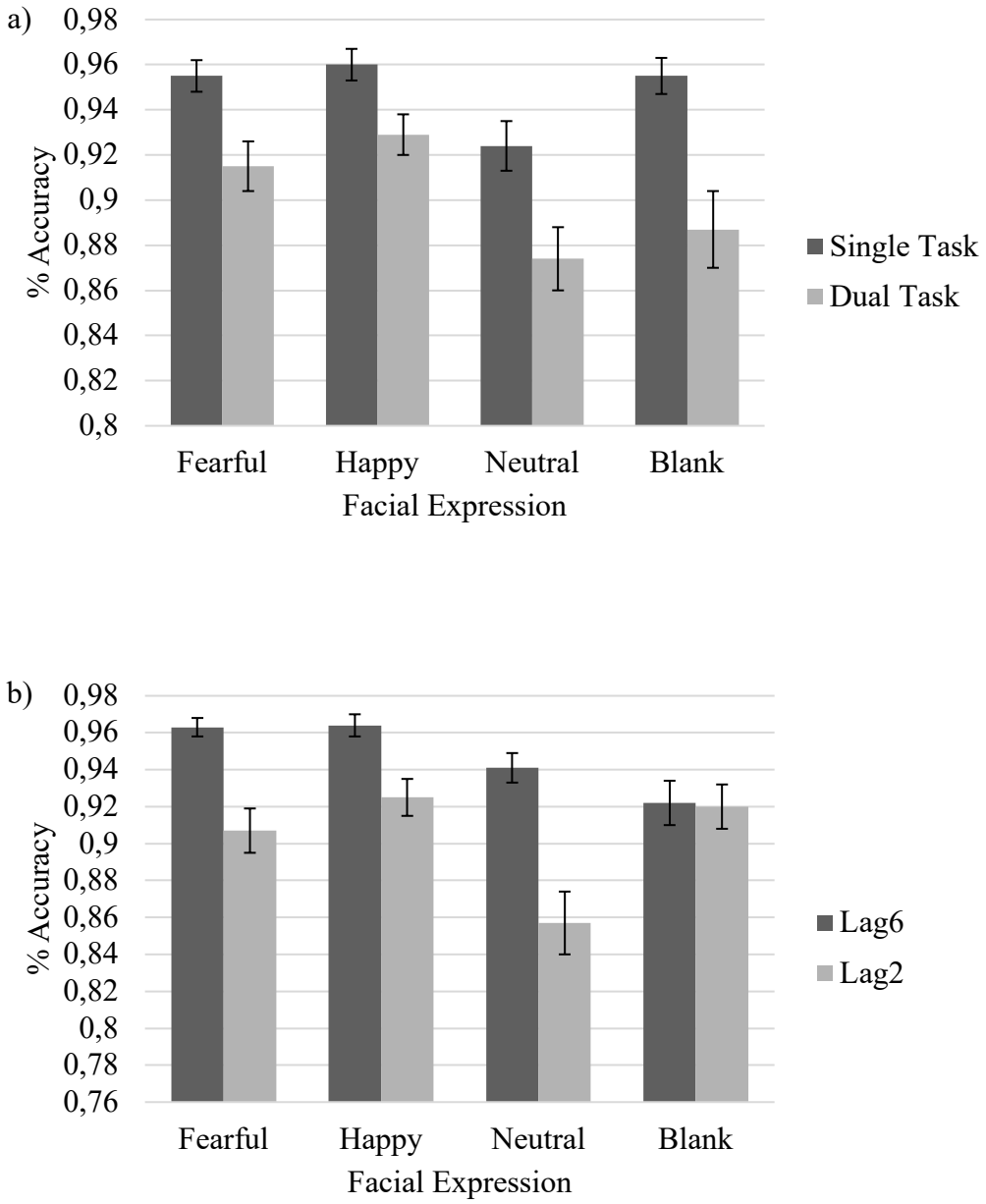


Figure 2. Significant differences in accuracy scores by expression within each level of Task (a) and Lag (b). Error bars were created using the Standard Error of the Mean.

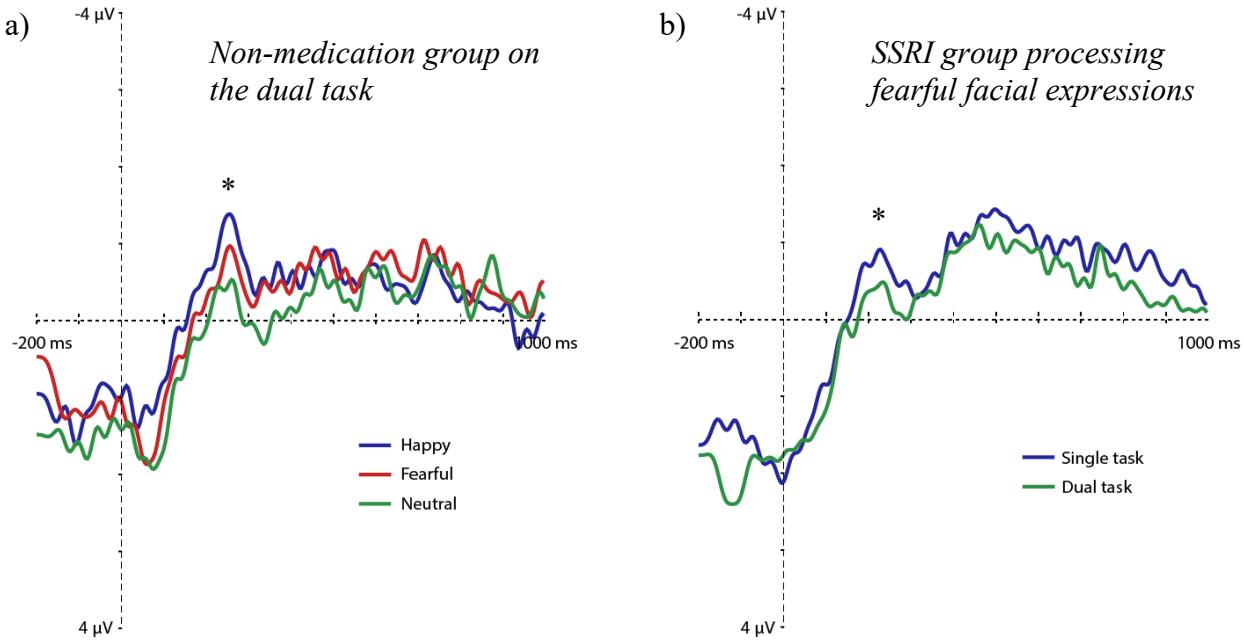


Figure 3. Grand average waveforms from electrode 43 (occipitoparietal) highlighting N170 amplitude differences for participants not taking psychotropic medications (a) and participants taking SSRI antidepressants (b). Waveform 3a highlights amplitude differences between facial expressions in the dual task mode. Waveform 3b highlights amplitude differences for processing fearful facial expression between the single and dual tasks.

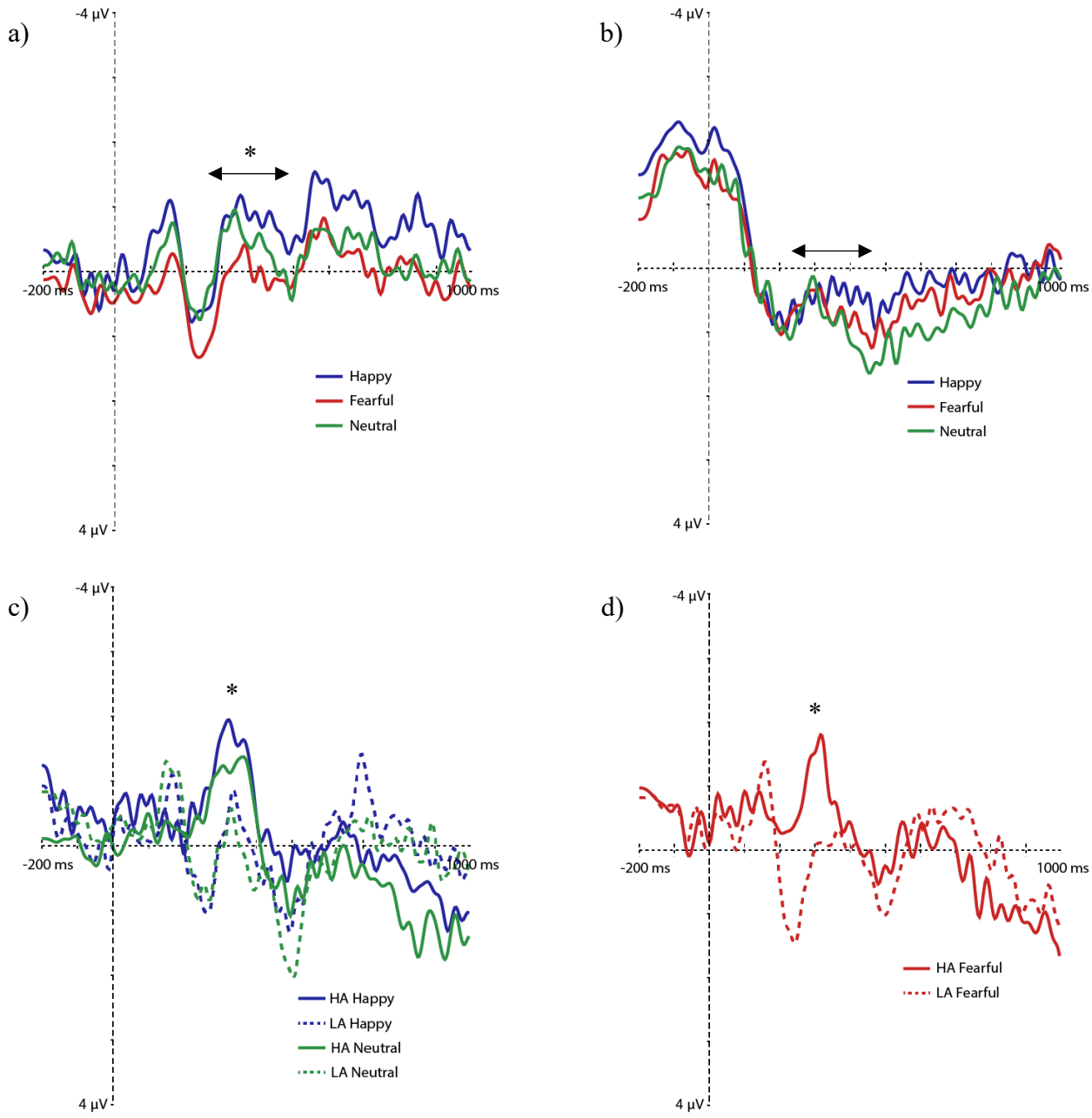


Figure 4. Grand average waveforms from electrode 19 (a/b; frontal) and electrode 59 (c/d; frontal) highlighting N300 differences in various conditions. 4a and 4b denote N300 differences in expression in the dual task for participants with low (a) and high (b) anxiety. 4c and 4d represent N300 differences between participants with low and high anxiety while processing

happy and neutral facial expressions in the single task (c) and fearful facial expressions in the dual task (d).

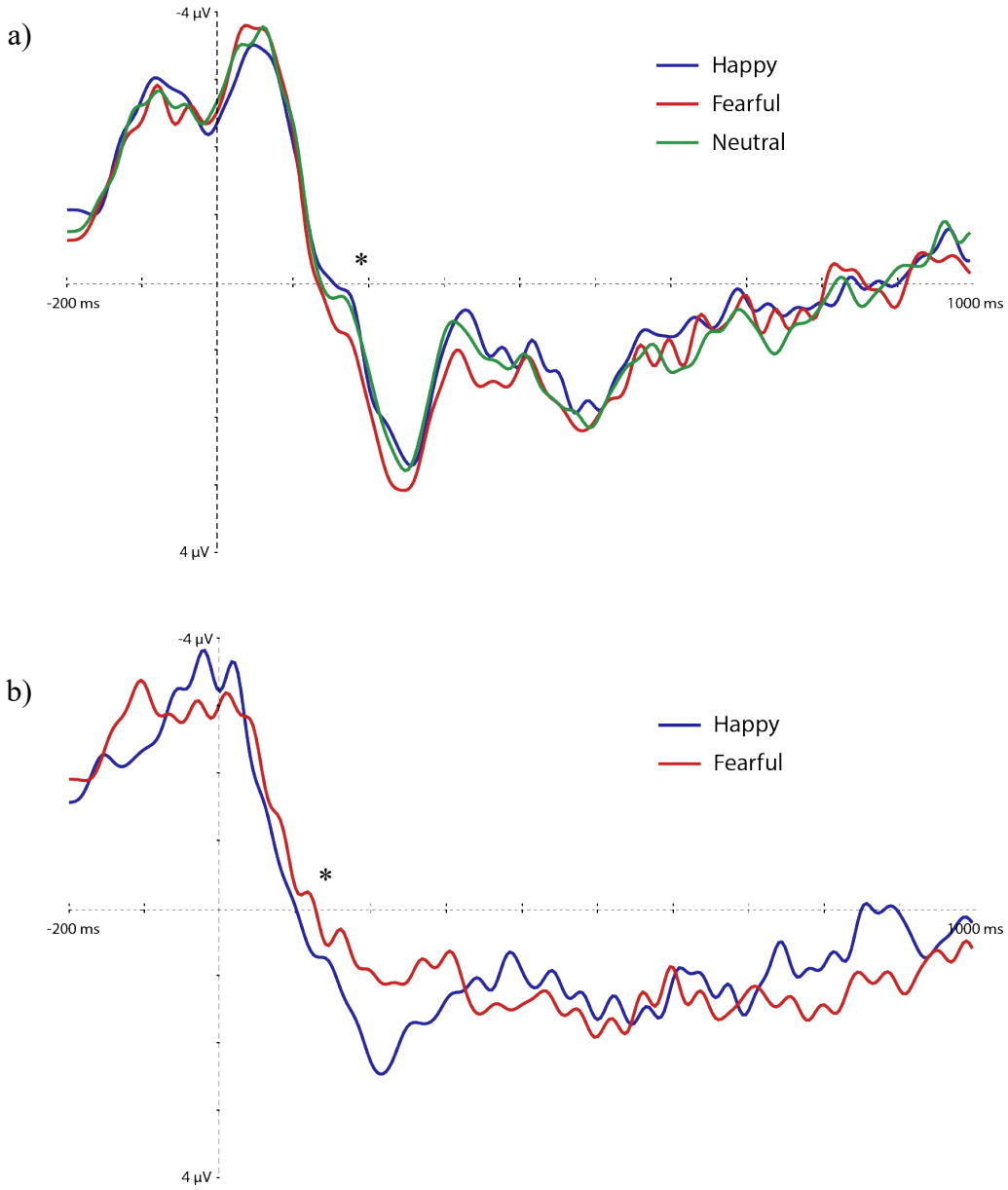
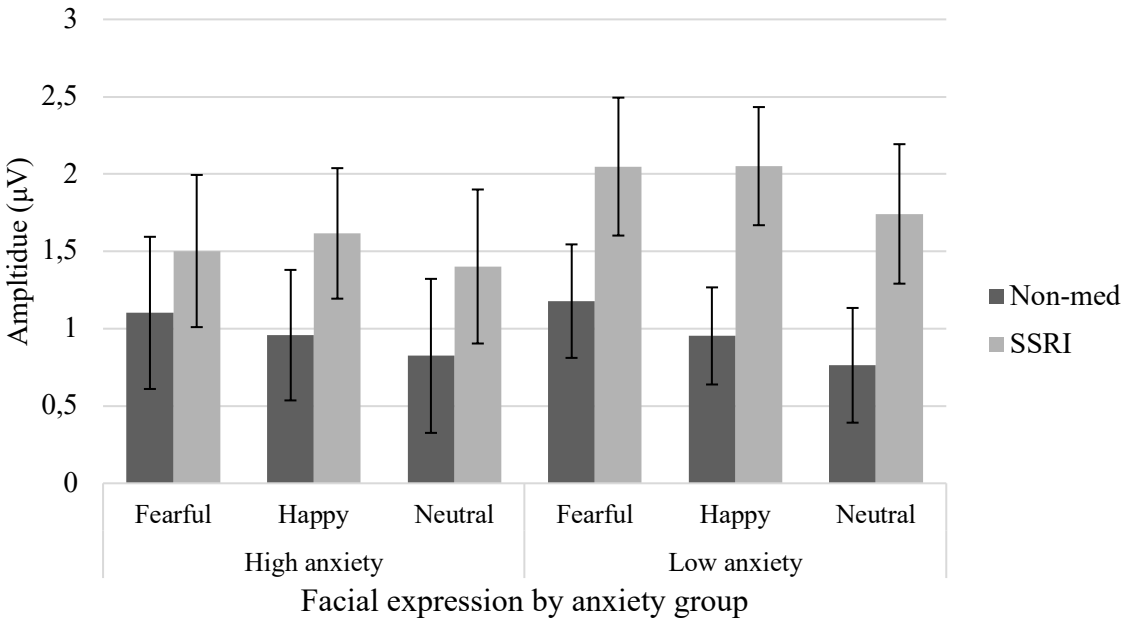
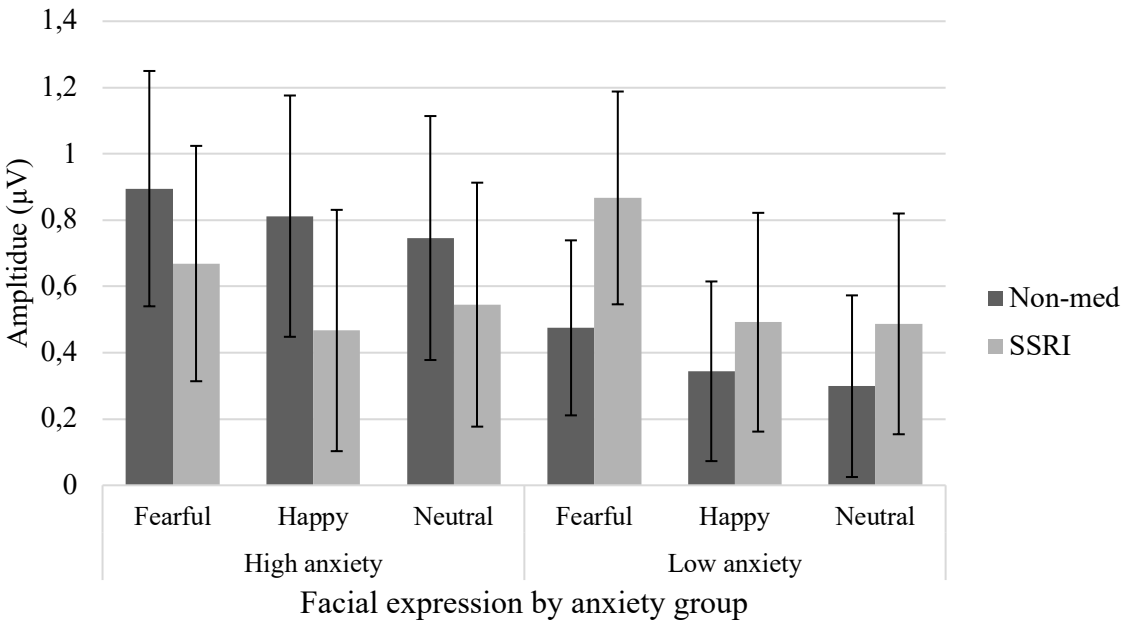


Figure 5. Grand average waveforms from electrode 9 (frontal) highlighting N100 amplitude differences between facial expressions for participants not taking psychotropic medications (a) and participants on SSRI antidepressants (b).

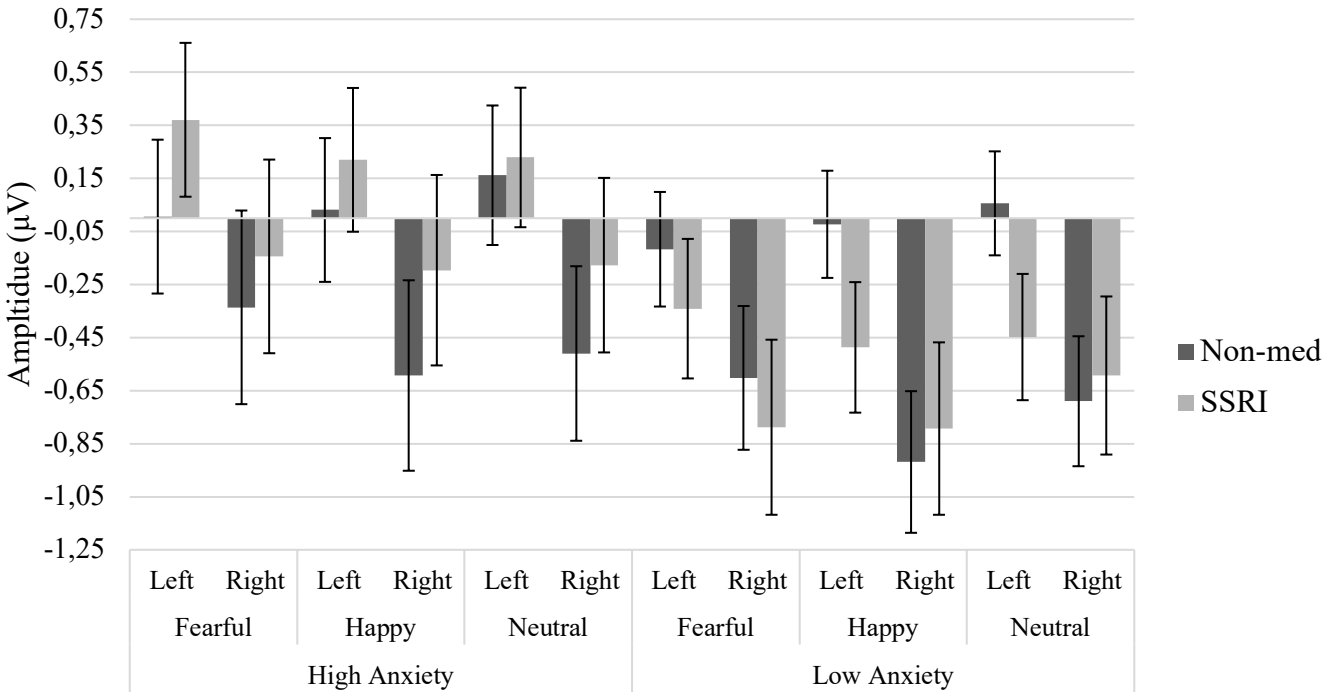
a) N100 *


3
2,5
2
1,5
1
0,5
0
Ampltidue (µV)
Fearful
Happy
Neutral
Fearful
Happy
Neutral
High anxiety
Low anxiety
Facial expression by anxiety group
Non-med
SSRI

b) P100

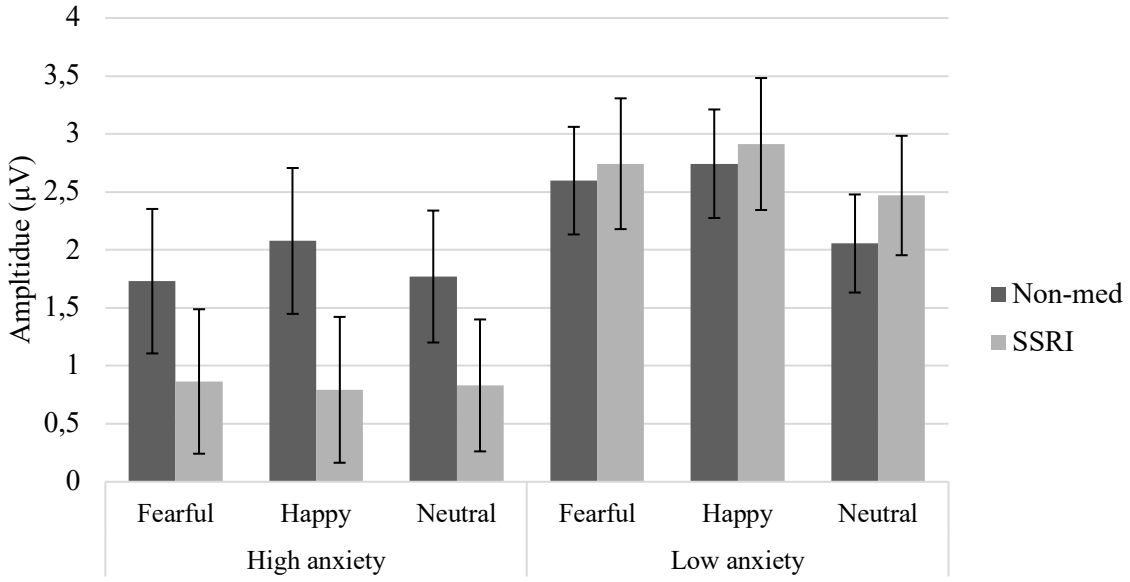

1,4
1,2
1
0,8
0,6
0,4
0,2
0
Ampltidue (µV)
Fearful
Happy
Neutral
Fearful
Happy
Neutral
High anxiety
Low anxiety
Facial expression by anxiety group
Non-med
SSRI

c) N170 *



Facial expression by anxiety group (high vs low) and hemisphere (left vs right)

d) VPP



Facial expression by anxiety group

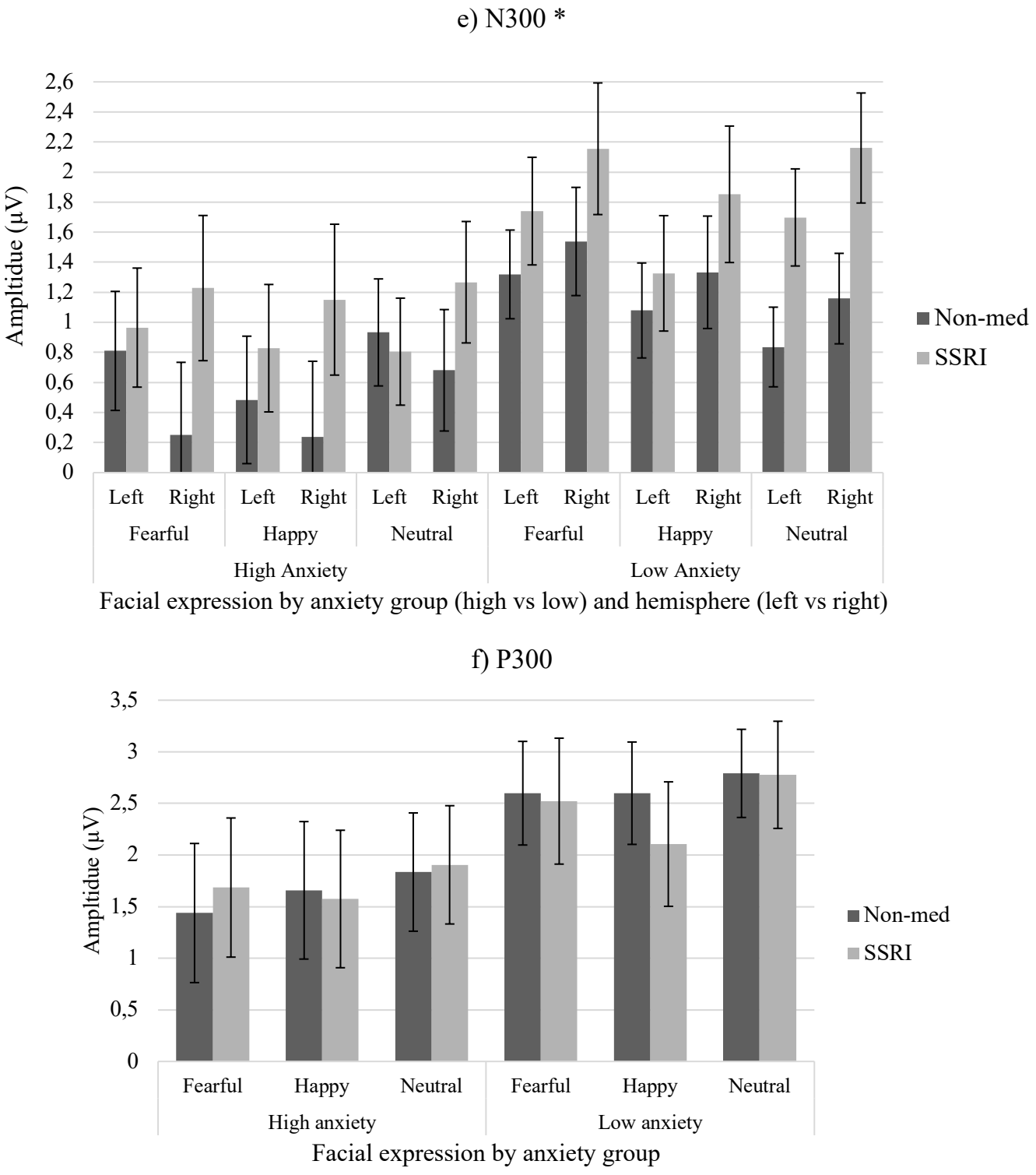


Figure 6. Mean amplitudes per facial expression between anxiety groups (and hemispheres for [c] and [e]). Error bars were created using Standard Error of the Mean. Note: charts with (*) are indicative where smaller amplitudes represent larger effects.

Appendices

Appendix A: Demographics/ERP screening and Handedness Forms

Demographics and ERP Screening

Participant ID: _____

Age: _____
Gender: _____
Year in University (or number of years completed in university, if applicable): _____

Please answer all questions to the best of your ability:

1. Do you have any neurological conditions? YES NO
   If yes, please describe:

2. Do you have any conditions that may affect your emotions or mood (incuding claustrophobia, panic attacks, or psychiatric conditions)? YES NO
   If yes, please describe:

3. Do you have any other medical conditions that may affect your performance or alertness? YES NO
   If yes, please describe:

4. Are you currently taking any SSRI class of antidepressants? (e.g., Citalopram/Celexa, Escitalopram/Lexapro, Fluoxetine/Prozac, Fluvoxamine/Luvox, Paroxetine/Paxil, Sertraline/Zoloft)

   YES NO

   If yes: Please list:

   How long have you been taking this medication?: _____
   What is the current dosage?: _____

5. Are you taking any other medications? YES NO
   If yes, please list:

6. Do you have a learning disability? YES NO
   If yes, please describe:

7. Do you have 20/20 vision? YES NO
   If no, do you wear contact lenses or glasses (state what you have with you today)
   _____
   If contact lenses do you wear: HARD SOFT

Handedness Questionnaire Participant ID: _____

Have you ever had an injury or other problem that caused you to change your hand preference?

YES NO

If so, please give the date of the change and the reason for it:

Which hand do you use for each of these things?
If your preference is not that strong, put +
If you would never use the other hand unless forced to, put ++
If you might use either hand put + in both columns

	LEFT	RIGHT
1. Writing	_____	_____
2. Drawing	_____	_____
3. Throwing	_____	_____
4. Scissors	_____	_____
5. Toothbrush	_____	_____
6. Knife (without a fork)	_____	_____
7. Spoon	_____	_____
8. Broom (upper hand)	_____	_____
9. Striking a match (match)	_____	_____
10. Opening box (lid)	_____	_____
11. Which foot do you prefer to kick with	_____	_____
12. Which eye do you used when using only one? (e.g. for a telescope)	_____	_____

Is anyone in your family left-handed, including parents, siblings, and grandparents? _____

If yes, give relationship(s): _____

_____

_____

_____

_____

Appendix B: Example RSVP trials with T1 in the 5th position and T2 in Lag6