# EMOTIONAL AROUSAL AND FACIAL MIMICRY IN FREE VIEWING OF ANOTHER PERSON: EXPLANATORY RELATIONSHIPS OF ANXIOUS AND DEPRESSIVE SYMPTOMS

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Master's Thesis

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September 2024

UNIVERSITY OF JYVÄSKYLÄ

Department of Psychology

LEHTINEN, DANTE & RANTAKOKKO, ELIAS: Emotional Arousal and Facial Mimicry in Free Viewing of Another Person: Explanatory Relationships of Anxious and Depressive Symptoms

Master's Thesis: 45 p.

Supervisor: Piia Astikainen & Xinyang Liu

Psychology

September 2024

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Facial emotion perception is a key area of interest in the study of social cognition and emotional decoding. However, most studies in this field have used still photographs of emotional faces as static stimulus. This study examines how trait anxiety and depressive symptoms explain variance in two facets of interpersonal emotion transmission: emotional mimicry and emotional arousal. Employing a novel study design, 19 adults with varying degrees of anxious and depressive symptoms watched a living face model present with a series of neutral, sad and angry faces through a liquid crystal screen, that can quickly turn transparent or opaque. Electrodermal activity (EDA) and Electromyography (EMG) data were recorded during a free-viewing study design, to assess degrees of emotional arousal and emotional mimicry, respectively. Simple linear regression analyses were conducted to assess whether trait anxiety or depressive symptoms (operationalized as STAI-Y2 and BDI-II scores, respectively), could explain variance in emotional arousal and emotional mimicry. It was expected that STAI-Y2 scores would positively explain variance in EDA while viewing angry faces, indicating the presence of a threat related bias associated with anxious symptoms. It was also expected that BDI-II scores would positively explain variance in EDA and in *corrugator supercilii* (CS) activity in the EMG data while viewing sad faces, indicating the presence of a negative bias associated with depressive symptoms. The results of this preliminary study, with a small sample size, did not support our hypotheses. However, due to observed habituation effects we ran additional analyses with halved data and found that greater trait anxiety was associated with lesser emotional arousal while viewing angry faces. Thus, our findings do not support previous findings regarding a negative bias and threat related bias. Explanations and implications are discussed.

**Keywords:** Emotional arousal, Emotional Mimicry, EMG, EDA, depression, anxiety

JYVÄSKYLÄN YLIOPISTO

Psykologian laitos

LEHTINEN, DANTE & RANTAKOKKO, ELIAS: Emotional Arousal and Facial Mimicry in Free Viewing of Another Person: Explanatory Relationships of Anxious and Depressive Symptoms

Pro gradu -tutkielma: 45 s.

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Psykologia

Syyskuu 2024

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Emotionaalisten kasvonilmeiden havainnointi on eräs keskeisimpiä sosiaalisen kognition ja tunteiden tulkitsemisen tutkimusalueita. Useimmat tutkimuksista ovat käyttäneet valokuvia stimuluksena. Tässä tutkimuksessa tarkastelemme, kuinka ahdistus- ja masennusoireet selittävät varianssia kahdessa interpersoonallisen tunteiden välittymisen osa-alueessa: emotionaalisten kasvonilmeiden ei-tietoisessa imitoinnissa ja emotionaalisessa viriämisessä. Hyödyntäen uutta tutkimusasetelmaa, jossa elävä kasvomalli toimi stimuluksena vapaassa katselutilanteessa, tarkastelimme, kuinka 19 aikuista koehenkilöä, joilla oli vaihtelevat määrät ahdistus- ja masennusoireita, reagoivat nähdessään neutraaleja, surullisia ja vihaisia kasvoja. Emotionaalinen viriäminen operationalisoitiin ihonsähkönjohtavuutena (EDA) ja emotionaalisten kasvonilmeiden imitointi elektromyografiana (EMG). Piirreahdistusoireiden (STAI-Y2) ja masennusoireiden (BDI II) selitysosuuksia datasta analysoitiin suorittamalla yksinkertaisia lineaarisia regressioanalyysejä. Odotimme, että STAI-Y2-pisteet selittäisivät positiivisesti varianssia EDA:ssa vihaisia kasvonilmeitä katsoessa, ja uskoimme tämän indikoivan uhkien tarkkailuun liittyvää kognitiivista vääristymää. Odotimme myös, että BDI-II-pisteet selittäisivät positiivisesti varianssia EDA:ssa ja *corrugator supercilii* (CS) -lihaksen aktivaatiossa EMG:ssä surullisia kasvonilmeitä katsottaessa. Tämän oletimme indikoivan negatiivista kognitiivista vääristymää. Alustavan tutkimuksemme tulokset eivät tukeneet hypoteesejamme. Havaitun habituaation tähden suoritimme analyysit myös puolitetulla aineistolla ja löysimme yhden tilastollisesti merkitsevän selitysasteen: suurempi STAI-Y2-tulos oli negatiivisessa yhteydessä emotionaaliseen viriämiseen. Täten tuloksemme eivät tue aiemmassa kirjallisuudessa esitettyjä tuloksia ahdistus- ja masennusoireisiin liittyvien kognitiivisten vääristymien osalta. Selityksiä ja seurauksia tästä käsitellään pohdinnassa.

**Avainsanat:** Emotional arousal, Emotional Mimicry, EMG, EDA, depression, anxiety

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# 1. INTRODUCTION

Humans are highly attuned to perceive and interpret the emotional states of others. Infants as young as 4 months of age can discriminate facial expressions by emotion (Farroni et al., 2007; Montague et al., 2001; LaBarbera et al., 1976). Later, the interpretation of emotional facial expressions is key to human social interaction throughout the human lifespan (Frith, 2009; Krause et al., 2019). The aim of this thesis is to examine the effects of depressive and anxious symptoms on emotion transmission. We will use a living face model as a stimulus for increased ecological validity.

Humans appear to be highly susceptible to the influence of perceived emotions to the extent that they reflect them in their own emotional behaviour. Studies have shown that enjoyment is transmitted between teachers and their pupils (Bakker, 2005; Becker et al., 2014; Fenzel et al., 2009), athletes adapt emotional states from their coaches (van Kleef et al. 2019), customers are positively influenced by the positive affect of service providers (Pugh, 2001; Tsai & Huang, 2002) and even virtual human-like characters produce shared emotional states with users (Tsai et al. 2012). In the field of cognitive neuroscience, studies have found that the perception of another's pain can be similarly observed in brain activity measurements (e.g., functional magnetic resonance imaging, fMRI) of the perceiver (Jackson et al., 2005; Ochsner 2008). Furthermore, emotions, such as sadness, joy, and anger, have similar neural mirroring systems (Bastiaansen et al., 2009). The broader phenomenon of an emotional experience transferring from a person to another has been described by several overlapping terms in the literature (e.g., emotional contagion, transmission, reciprocity, reactivity, synchrony, coregulation, crossover, morphogenic covariation; for a review see Butler 2011). For the purposes of this thesis, we will follow Butler's (2011) definition of emotions as temporal interpersonal systems and call this phenomenon interpersonal emotion transmission.

In this thesis we examine the effects of anxious and depressive symptoms on the process of emotion transmission through two subcategories: emotional mimicry and emotional arousal. We introduce a novel study design using living face models to investigate the psychophysiological effects—via electromyography (EMG) and electrodermal activity (EDA)—of perceiving facial expressions of emotion.

### 1.1. Emotional mimicry and electromyography

Interpersonal emotion transmission can be considered an umbrella term for various phenomena, where the affective state or behaviour of a person is transmitted to an observer who in turn reflects these phenomena. One such phenomenon is the behaviour of unconsciously (or automatically) matching one's facial expressions with another's— emotional mimicry (Chartrand & Lakin, 2013; Hatfield et al., 2014; Hess, 2021). This capacity to automatically mimic the facial expressions of others has a notable, nonverbal, social role. For example, associations have been found between emotional mimicry and being liked by others (Chartrand & Lakin, 2013), emotional contagion (Lundqvist & Dimberg, 1995), and social regulation (Hess & Fischer, 2013). From the perspective of social tuning theory, emotional mimicry is a goal-dependent, automatic mimicry of another individual's facial expressions (Hess, 2021; Hess & Fischer, 2013). Although emotional mimicry occurs involuntarily within 300-500 milliseconds of stimulus presentation (Dimberg & Thunberg, 1998; 2002), social tuning theory suggests this behaviour is largely dependent on one's affiliative motivations (Chartrand & Lakin, 2013). As such, mimicry of positively valanced faces is more common than mimicry of sad or angry faces (Hess, 2021; Kraft-Feil et al., 2023). This is because of the motivational consequents of observed emotions. That is, happy faces are more likely to induce affiliative motivations in an observer, whereas the observation of negative emotions is more likely to reduce such motivations (Chartrand & Lakin, 2013; Hess & Fischer, 2013; Johnston, 2002).

Changes in one's facial expressions can be observed by detecting changes in the activity of certain facial muscles. Different emotional facial expressions lead to the contraction of different facial muscles (Dimberg et al., 2002). For example, a smile contracts the *Zygomaticus Major* (ZM)-muscle, thus raising the corners of the lips, whereas the *Corrugator supercilii* (CS)- muscle (above the eyebrow) is relaxed. This pattern is reversed during a frown: CS contracts (leading to the lowering of one's eyebrows and their moving closer together) and ZM relaxes (corners of the lips remain down). Contraction of the CS is also observed in angry facial expressions. Notably, facial expressions that are mimicked without conscious effort tend to be more subtle than consciously expressed emotions (Dimberg & Thunberg, 1998; 2002). However, multiple studies have shown that even subtle changes in facial muscle activity can be reliably measured by applying

electromyography (EMG) electrodes on the skin above the muscle of interest (for a review see Dimberg, 1990).

### 1.2. Emotional arousal and electrodermal activity

Other phenomena associated with emotional mimicry, that can be considered under the umbrella term interpersonal emotion transmission, are emotional contagion and arousal contagion. Emotional contagion refers to the ‘’catching’’ of another’s emotional state through facial observation (Hatfield et al., 2014). Phenomenologically, emotional contagion and mimicry are similar enough, that the two are often confused with one another (Hess, 2021). Hess (2021) argues that emotional mimicry can co-exist with emotional contagion, as indicated by studies where both have been observed (Hess & Blairy, 2001; Lundqvist & Dimberg, 1995), however, the two are conceptually distinct. Emotional contagion is an (shared) emotional state, whereas emotional mimicry is an automatic, goal-dependent behaviour. Although emotional contagion may co-occur with emotional mimicry, it is not its prerequisite (Hess & Blairy, 2001; Lundqvist & Dimberg, 1995). Emotional contagion has been linked to empathy, bonding, and attunement (Decety & Ickles, 2009; Hatfield et al., 1994; Spoor & Kelly, 2004). However, studying emotional contagion may be challenging, as researchers must be able to discriminate the specific emotion(s) the participant is feeling during the observation of stimuli. Moreover, emotions have overlapping traits (Pekrun et al., 2002), which can confound the self-reporting of state emotions. However—depending on the research question—discriminating between specific emotions is not always necessary when studying this phenomenon. That is, in some situations, the challenge of discriminant validity can be avoided by studying ‘’caught’’ arousal, or arousal contagion.

According to Russel’s (1980) circumplex model of affect, arousal is the activation dimension of affect. That is, the arousal dimension contains emotions that ‘’activate’’ people, such as excitement and anger (as opposed to deactivating emotions: sadness and contentment). As such, when a person’s physiology (e.g., sweating) is altered by another in a social setting, it is because of the cognitive-affective exchange between dyad members (Kron et al., 2015; Picard et al., 2016). That is, objectively measurable physiological changes occur in social situations in reaction to, for

example, facial expressions. This is because of the cognitive-affective reactions associated with such emotional stimuli (Bailey, 2017). However, the circumplex model of affect differentiates valence and arousal as separate dimensions. That is, emotions can be pleasant or unpleasant (valence) and activating or deactivating (arousal). Thus, it follows that physiological measures of arousal cannot discriminate between the valence of emotional states. Therefore, changes in emotional arousal (but not valence) can be measured objectively with physiological measures, such as electrodermal activity.

Electrodermal activity has a long history in psychophysiological research as an index of emotional arousal, as well as cognitive processes such as attention (Bailey, 2017; Sharot & Phelps, 2004). EDA refers to measurable electronic currents on the surface of the skin, which are influenced by the amount of sweat being produced by an individual (Bailey, 2017). EDA is an easily accessible indicator of sympathetic nervous system (SNS) activation (Rahma et al., 2022; Sinai et al., 2023), which is associated with fight-or-flight responses to alarming stimuli (Nackley & Friedman, 2021). Therefore, it follows that EDA level has been consistently linked with anxiety (for a review see Barlow, 2002), which is characterized by biased attention towards threatening stimuli (Bar-Haim et al., 2007), as well as enhanced interoception (i.e., perception of one's own internal states, including SNS activity) (Büttiker et al., 2021). In contrast, depressed individuals have consistently shown electrodermal hypoactivity (i.e., less electric activity) during both non-stressful and stressful situations (Pruneti et al., 2014). This hypoactivity is distinguishable from healthy controls and anxious individuals to such an extent that EDA has been suggested as a potential biomarker of depression (Kim et al., 2018).

Individuals with high trait anxiety and/or depressive symptoms present with cognitive biases that predispose them to interpret or observe various stimuli in different ways, compared to those who experience less of these traits/symptoms (Barlow, 2002; Krause et al., 2019). The present study explores the effects of these biases on emotional mimicry and emotional arousal in response to facial expressions of living face models. Moreover, we will operationalize emotional arousal as electrodermal activity. Emotional mimicry, on the other hand will be operationalized by measuring the EMG responses of facial muscles associated with their respective emotional expressions.

### 1.3. Depression and negative bias

According to the World Health Organization (WHO), approximately 280 million people in the world suffer from depression; 3.8 % of the total population, including 5 % of adults and 5.7 % of adults over 65 years (Institute of Health Metrics and Evaluation, 2023). Major Depressive Disorder (MDD) is associated with severe impairment in social functioning (Hirschfeld et al., 2000; Judd et al., 2000). Deficits in the reliable identification and interpretation of emotionally meaningful facial expressions seems to be a significant area of impairment (Bourke et al., 2010; Krause et al. 2019). A meta-analysis of 23 studies, with a total sample of 516 depressed participants and 614 non-depressed control participants, found the overall accuracy of facial emotion recognition in depressed participants to be lower ($g$ = -0.21), compared to non-depressed control participants (Krause et al., 2019). Studies have also indicated that depression may entail a negative bias in perception, where happy faces are more likely to be perceived as neutral and neutral faces are more likely to be perceived as sad (Bourke et al., 2010; Gur et al., 1992; Leppänen et al., 2004; Persad and Polivy, 1993; Rubinow & Post, 1992; Surguladze et al., 2002). An overall tendency to fixate on negative stimuli has also been well documented as a part of depressive psychopathology (Huang et al., 2023). The assumption of a negative bias is strongly rooted in Aaron T. Beck's (2002) cognitive model of depression where depression is seen as essentially a malfunction in information processing.

In this thesis we expect depressive symptoms to explain variance in the mimicry of sad facial expressions as detected via EMG. As the assumption of a cognitive negative bias suggests that people with depressive symptoms pay more attention to negative stimuli, we expect participants with depressive symptoms to show stronger reactions to sad facial stimuli. From the perspective of social tuning theory, it follows that individuals with higher depressive symptoms would be motivated to bond with individuals exhibiting low mood. This is because synchronizing behaviour with another elicits appraisals of similarity and evokes compassion from another (Valdesolo & DeSteno, 2011).

### 1.4. Anxiety and threat-related bias

The World Health Organization (WHO) has estimated that approximately 4 % of the global population experience anxiety disorders (Institute of Health Metrics and Evaluation, 2023). As such, anxious symptoms are among the most common mental health problems. Anxious symptoms present in various modalities, as is made evident by various diagnosable anxiety disorders (e.g. general anxiety disorder and social anxiety disorder). Generally, anxiety is characterized as a future-oriented mood state, with high cognitive preparedness for expected or potentially threatening events (Barlow, 2002). Several studies have suggested that the attentional system of individuals with high levels of self-reported anxiety, and those with clinically diagnosed anxiety disorders, may be biased towards the processing of threat-related stimuli (i.e. threat-related attentional bias) (Bar-Haim et al., 2007). This bias has been suggested to be part of both the aetiology and maintenance of anxiety disorders (Beck, 1976; Eysenck, 1992).

A meta-analysis of 172 studies by Bar-Haim and colleagues (2007) concluded that threat-related bias in high-anxiety individuals is a robust phenomenon that holds under a large variety of settings. Moreover, this bias does not exist in those with low anxiety. However, the observed effect size of this bias was found to be low-to-medium. Bar-Haim and colleagues' (2007) model of the cognitive mechanisms underlying threat processing suggests that individuals with high levels of anxiety may automatically evaluate neutral or slightly threatening stimuli as highly threatening, thereby shifting orientation from current goals toward the observed threat. For example, Fox and colleagues (2010) found that individuals with high self-reported anxiety were slower to disengage from angry faces compared to those with low self-reported anxiety. Moreover, multiple studies using human faces as emotional stimuli have found that individuals with high trait anxiety exhibit an enhanced anger superiority effect (Ashwin et al., 2012; Bar-Haim et al., 2005). Studies employing the Face-in-the-Crowd paradigm have found that angry faces in a crowd capture the attention more easily than happy or neutral faces (Hansen & Hansen, 1988; Lyyra et al., 2014), especially regarding those with high trait anxiety (Ashwin et al., 2012).

In the current thesis we expect anxious symptoms to explain variance in emotional arousal as detected via EDA. This is because EDA is an indicator of sympathetic nervous system activation, which is associated with fight-or-flight responses. As individuals with high self-reported trait anxiety exhibit a threat-related attentional bias, where individuals are slower to disengage from threatening stimuli (Fox et al., 2010), it follows that this attentional bias could be seen in greater EDA activation.

### 1.5. Comorbidity and attentional biases

Major depressive disorders (MDDs) and anxiety disorders (ADs) are highly comorbid and co-occur often. For example, one study with a sample of 34 653 US adults, found that 51 % of people diagnosed with major depressive disorder were also diagnosed with anxiety disorders in the same year, compared to 11.8 % in people without depression diagnoses (Olfson et al., 2017). In general population samples, major depressive disorder and generalized anxiety disorder share many common risk factors, substantial overlap in areas of genetics, demographics, and personality traits of patients (Hettema, 2008), as well as many overlapping symptoms, such as distress, increased disability, negative self-evaluation, and discouragement (Melton et al., 2016).

It has been suggested that the negative bias associated with depression and the threat-related bias associated with anxiety may rely on differing attentional mechanisms. As attention serves as a filter for our perception of the environment there are both goal-oriented (i.e. top-down) and stimulus-driven (i.e. bottom-up) processes of attentive perception (Corbetta & Schulman, 2002). According to Sylvester and colleagues (2015) threat-related attention is more stimulus-driven, a kind of involuntary vigilance-avoidance attention pattern towards threatening stimuli, compared to negative bias attention that seems to be more goal-oriented, a voluntary shift in attention that involves difficulty in disengaging from negative stimuli. Studies have shown that adults with high anxiety tend to engage more rapidly to threatening stimuli (at 100 ms after stimulus onset) and take a longer time disengaging from it compared to adults with low anxiety (Koster et al., 2006) whereas adults with depression do not engage with sad stimuli more rapidly compared to adults without depression (Teachman et al., 2012) but they do take more time disengaging from it (Peckham et al., 2010).

Also, adults with anxiety show higher attentional avoidance to threatening stimuli (200-500 ms after stimulus onset) compared to adults with low anxiety (Koster et al., 2006) whereas lingering on to negative stimulus has been seen as emblematic for the attentional bias of depressed adults (for a review see Mennen et al., 2019).

The effects of comorbid depressive and anxious psychopathology on the attentional biases of the respective disorders have rarely been studied (Bar-Haim et al., 2007). Youth with comorbid anxiety and depression seem to show signs of both threat-related bias and negative bias (Harrison & Gibb, 2015) but few studies have been done with adults. Notably, the few studies that have been done challenge the notion of a negative bias associated with depression existing separately from the threat-related bias associated with anxiety (Elgersma et al., 2018; Markela-Relenc, 2011). For example, when controlling for the effects of comorbid anxiety, Markela-Relenc and colleagues (2011) found no attentional bias towards negative stimuli in depressed participants. Furthermore, they did find a correlation between state anxiety and attentional bias suggesting that anxiety may be an important moderating factor in the attentional biases previously attributed to depresseion. Another study by Elgersma and colleagues (2018) found no evidence of attentional bias towards positive or negative adjectives (i.e. negative bias) in either an MDD-specific group or a mixed group of MDD and AD participants but did find attentional bias towards threatening words (i.e. threat-related bias) in the mixed MDD-AD group also suggesting that the attentional biases in depression may be due to comorbid anxiety.

Therefore, it follows that in the present study, the negative bias that has been traditionally attributed to depressive symptoms may be observable in participants with comorbid anxious symptoms. A strength in the current study is that we examine depressive symptoms alongside anxious symptoms. As the comorbidity of depressive disorders and anxiety disorders is high worldwide this choice in study design also addresses questions of ecological validity.

### 1.6. Static stimuli and dynamic stimuli

Emotions are physiological reactions to external and/or internal stimuli that evoke behaviour (Krause et al., 2019). Ekman and colleagues (1971; 1987) found that there are at least six basic

emotions that are universally and reliably recognized: happiness, sadness, fear, surprise, disgust, and anger. All these basic emotions also have corresponding distinctive facial expressions that are reliably recognized in all cultures (Ekman, 1992; 1999).

Most studies of facial emotion recognition have used high-intensive static stimuli of the six basic emotions in experiment paradigms (for a review, see Paiva-Silva et al., 2016). Criticism has been made against the ecological validity of using still images of caricature-like facial expressions because in real-life scenarios people interpret emotions from moving faces and from various levels of intensity (Chafi, 2012; Goeleven et al., 2008; Roark et al., 2003; Torro-Alves et al., 2013; Willis et al., 2014). There has also been speculation that the use of static stimuli may result in ceiling effects in measurements (Paiva-Silva et al., 2016). According to Schaefer and colleagues (2010) dynamic stimuli, the use of moving faces and a variety of intensity-levels in facial expression, should provide research with a more ecologically valid experiment paradigm.

Notably, the practical application of dynamic stimuli in facial emotion recognition has resulted in some findings that challenge the idea of a cognitive negative bias in depression. There have been studies that found no deficits at all in the facial emotion recognition abilities of depressed participants (Kan et al., 2004; Schaefer et al., 2010). For instance, Kan and colleagues (2004) used videotaped facial expressions as stimuli and found that depressed participants performed normally in facial recognition tasks. Schaefer and colleagues (2010) used animated facial stimuli (the Emotional Expression Multimorph Task, which presented facial expressions in gradation from neutral to 100 % emotional expression of the six basic emotions) and found there was no difference between the unipolar depression group and the control group. Zwick and Wolkenstein (2017) also used videotaped facial expressions and found that acutely depressed participants were less accurate in recognizing happy faces but not in recognizing pride or other emotions implying a specific impairment in the accuracy of recognizing happy faces rather than a general negative bias. They conclude that together these findings may imply that the negative bias associated with depression may be limited to research paradigms of static stimuli and low ecological validity (Zwick & Wolkenstein, 2017). Krause and colleagues (2019) also found that type of stimulus used served as a significant moderator in facial emotion recognition studies: depressed participants were less accurate when stimuli was static-unmorphed (unmoving static faces) ($g$ = 0.29), compared to static-morphed (still faces morphing from neutral to each expression) ($g$ = -0.15) implying that the more ecologically valid graded facial stimuli could be easier to interpret for depressed participants. The meta-analysis by Krause and colleagues (2019) did not include any studies using dynamic stimuli due to the low number of studies found.

Most previous studies with dynamic stimuli have used videotaped facial expressions or animated morphing expressions (Kan et al., 2004; Ridout et al. 2007; Schaefer et al., 2010; Zwick and Wolkenstein, 2017). The current study addresses concerns of ecological validity by utilizing a live face model as a pseudo-dynamic, high-intensity stimulus. A live model should prove to have several advantages as previous studies have found that direct eye-contact elicits affect-related psychophysiological responses in the perceiver (Myllyneva & Hietanen, 2015; Hietanen et al., 2018) and that these responses are dependent on the observer's belief of being seen by another person (Myllyneva & Hietanen, 2015). McIvor and colleagues (2021) have shown that people in general tend to be biased towards self-referential stimuli, i.e. stimuli that entails explicit references to the perceiver or in other ways activates self-awareness. We expect the live model design to activate self-referential processing as participants become more aware of themselves in live human interaction. This, in turn, adds to the ecological validity of the study design as self-referential processing is a natural part of real-life interaction.

### 1.7. **The aim of the current study**

The aim of this thesis is to examine the effects of depressive and anxious symptoms on emotional arousal (as detected via EDA) and emotional mimicry (as detected via EMG). We will use a trained face model in a live setting as a stimulus for increased ecological validity.

Research question: Do depressive and anxious symptoms explain variance in emotional arousal and emotional mimicry?

As the documented phenomenon of a cognitive negative bias suggests depressed individuals to pay more attention to negative facial stimuli: we expect to find a positive explanatory relationship between depressive symptoms and corrugator supercili activity during the viewing of sad facial expressions (hypothesis 1).

In line with the threat-related bias we expect to find a positive explanatory relationship between anxious symptoms and electrodermal activity during the viewing of angry facial expressions (hypothesis 2).

In line with negative bias theory, we expect to find a positive explanatory relationship between depressive symptoms and electrodermal activity during the viewing of sad facial expressions (hypothesis 3).

## 2. METHODS

### 2.1. Participants

The participants were 20 adults (15 women, 4 men, 1 gender unknown, $M_{age}$ = 24.84 years, $SD_{age}$ = 6.12, age range = 18-37 years), most of whom were university students ($M_{education\ in\ years}$ = 15.65). One participant did not provide background information forms. It was agreed that they would provide them later, however, they did not. Therefore, only data from 19 participants was included in hypothesis testing. According to Khamis & Kepler (2010) the minimum sample size to find a medium effect size for a simple linear regression analysis would be $N$ = 25. As such, our sample may be underpowered to find explanatory relationships of medium effects. Participants were recruited by handing out advertisements about the study in the University of Jyväskylä's spaces (e.g., library), by sending recruitment emails to the University's email lists and by word-of-mouth. During the recruitment and measurement process, an Instagram account (@activemindlab) was created for the research group to spread information about the research group in charge of the study and research in cognitive neuroscience in general. Inclusion criteria were as follows: right-handedness, age between 18 and 40 years, understands Finnish language. Exclusion criteria were as follows: pregnant or breastfeeding, sensory impairments (not including impaired vision corrected with glasses), current or past psychiatric illness (not including possibly depressive or anxiety disorder), neurological disorders, brain damage, heart disease, high blood pressure or type 2 diabetes, regular pain or general conditions that cause difficulty in movement, mobility or concentration, substance abuse (defined as alcohol consumption more than 12 doses per week or drug use in the last five years), medication affecting the nervous system (not including medication for anxiety or depression), daily nicotine use. All inclusion and exclusion criteria were introduced to participants in written form so that they had a chance to evaluate their own eligibility for the study

prior to the experiment. The study design was reviewed and approved by the Ethics Committee of the University of Jyväskylä.

### 2.2. Stimuli

Five research assistants acted as face models during the experiment. The models were between 21 and 28 years of age ($M_{age}$ = 24.80, $SD_{age}$ = 3.27), three were female and two were male. All face models were of caucasian complexion and native speakers of Finnish. Participants were matched with a face model with the same gender in each experiment. The face models presented with either neutral, sad, or angry faces and were instructed to make their facial expressions as clear as they could. Facial expressions were of high-intensive quality (caricature-like expressions). We refer to our stimulus as pseudo-dynamic, because even though face models were advised to hold their expressions as unchanged as possible, there were always a certain amount of facial tremor, micro-movements and expressive shifts, that added to the naturalistic quality of the facial stimulus. The face models were instructed to form their facial expressions before their faces became visible to the participant, and to hold the facial expression static until they were no longer visible. The models' facial expressions were practiced and assessed as satisfactory by the research team before they could act as face models. As calculated from the data of the first eleven participants, recognition accuracy for sad faces was 91.80 %, for neutral faces 98.20 % and for angry faces 95.50 %. Moreover, on a scale of 1-3, the mean intensity of the facial expressions was 2.35 for sad and 1.63 for angry faces (Sorsa, 2024). For neutral faces, faces were rated based on their clarity, rather than intensity, as a neutral facial expression may not be interpreted as intense. The clarity of neutral facial expressions was rated as 2.34. Therefore, facial expressions of the face models were deemed valid.

## 2.3. Procedure

The current study was conducted as a part of a larger study on emotional facial expression perception. The Multiface study was designed by Xinyang Liu and Piia Astikainen from the Active Mind Lab of the University of Jyväskylä. It has since grown to become a joint venture between the University of Jyväskylä and the University of Tartu. Notably, the present study does not use data collected from the University of Tartu. The Multiface study comprises of a two-part experiment, an EEG recording during viewing pictures of faces and a psychophysiological recording during the viewing of a real person. The current study deals exclusively with the second part of the experiment.

When arriving to the lab the participants were introduced to the facilities and personnel present at the experiment. After this the experimenter obtained informed consent from the participants. In the first part of the experiment participants were fitted with EEG sensors. In the second part of the experiment the participants were fitted with EDA, ECG and EMG sensors. Notably, ECG and EEG data were collected, however, that data was not used in the present study. To avoid demand characteristics, the purpose of the EMG sensors was masked: the participant was told that the sensors measured the temperature of the skin. At this point the face model arrived in the lab, briefly greeted the participant, and proceeded to the experiment room to prepare.

After the introductions and sensor instalments the participant was transferred to a separate soundproof, electronically shielded experiment room which was monitored via video and audio. The video feed was used, in part, so that researchers could see that the participant's hand (where the EDA electrodes were attached) remained still. The experiment room was divided in two parts by a curtain and a liquid crystal screen. The liquid crystal screen can be manipulated to turn opaque or transparent in 1ms. The dimensions of the window were 44 cm horizontally and 53 cm vertically. While the participant was introduced to the experiment room and psychophysiological measures were attached to the amplifiers, the face model covered their side of the room with curtains, to ensure that light from their side did not get through to the participant's side. Lights were turned off from the participants side to ensure that they could see the face model. Next, the face model took

their position behind the screen, sitting approximately 1,5 m away from the participant at eye level (see. Figure 1). The face model did not see the participant clearly as only a silhouette of the participants face was made visible to them. This was done so that the face model could concentrate on their task fully and to ensure minimal nonverbal communication between the face model and the participant.

**Figure 1.** *The setup for the experiment: participant and face model are divided by a 44cm x 53cm liquid crystal screen that can turn either opaque or transparent within 1ms. During the actual experiment lights were turned off on the participant's side.*

Research assistants, located in another room, used a microphone to ask the face model and participant if they were ready to begin. Once readiness was confirmed, resting state data was

collected by turning the liquid crystal screen transparent for 60 seconds. During this stage, the face model maintained a neutral facial expression and avoided blinking. The participant was tasked to passively observe the model's face. Next the screen turned opaque for 60 seconds. After resting state data collection, the participant and face model were asked if they were ready to continue. The following condition would then continue for approximately 20 minutes, with a one-minute break in the middle. During this condition, the participant was tasked to passively observe the face model as the screen would turn transparent for 5 seconds, with 15-40 second inter-stimulus intervals. Inter-stimulus interval length was determined as sufficient, once the participants EDA-level had returned to baseline. During the 5 second stimuli presentations, the face model presented either neutral, sad, or angry faces in a randomized order, with 10 presentations of each facial expression in total. All facial expressions were communicated to the face model during the inter-stimulus intervals with small blinking lights in such a manner that the participant was unaware of the lights. The experimental procedure is illustrated in a conceptual diagram in Figure 2.

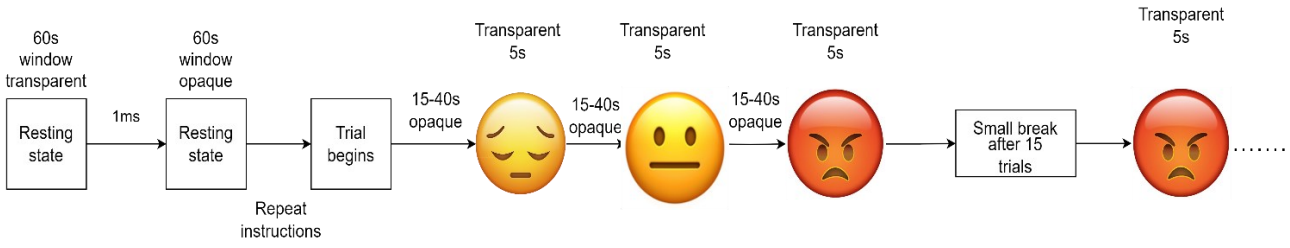


**Figure 2.** *Illustration of the experimental procedure. Facial expressions in randomized order. Each of the three facial expressions were presented 10 times (30 facial expressions in total). Resting state data were not used in statistical analyses, rather, resting state measurement was conducted to allow for the participant's arousal level to decrease and acclimate to the situation.*

After the experiment was concluded, all the sensors used in the psychophysiological measurements were removed, the participant was guided to another room to continue another experiment as part of the larger study, where participants were asked to view a video recording of the face model that was filmed during the previous procedure. Participants were asked to provide their estimation about what facial expression (e.g., sad, neutral, angry, surprised) they saw and how intense (clear, if the face was deemed neutral) the facial expression was. This task was conducted alone on a computer,

where the keyboard had stickers on buttons with emotional expressions written on them (e.g., sad or disgusted). Participants were informed that all emotional expressions on the keyboard would not necessarily be present on the video, but that they should answer intuitively and not think about their answers for too long. This task provided reliability and validity data of the facial expressions presented by the face models. Finally, the participant was informed of the true purpose of the EMG sensors, thanked, and compensated with a package of either coffee or tea.

### 2.4. Measures and pre-processing of psychophysiological data

#### 2.4.1. Beck Depression Inventory (BDI-II)

In assessing pretrial symptom levels of depression, the Beck Depression Inventory II (BDI-II) was used. The BDI is a self-reporting questionnaire for the evaluation of depressive symptom severity in both normal and psychiatric populations. It was first developed by Beck, Steer & Brown in 1961 (BDI) and has been since revised in 1978 (BDI-IA) and in 1996 (BDI-II) (Beck et al., 1996). The BDI is grounded on Beck's theory of depression as a negative distortion of cognitive processing.

The BDI has twenty-one items on a 4-point scale from 0 (no symptoms) to 3 (severe symptoms). The minimum total score is 0 and the maximum total score is 63. With those who have a pre-existing diagnosis of depression, scores of 0-13 indicate minimal depression, 14-19 mild depression, 20-28 moderate depression and 29-63 severe depression (Beck et al., 1996). In non-clinical populations, scores above 20 have been interpretated as indicating depression (Kendall et al., 1987). In a study of the adaptability of the BDI-II in the Finnish adult population Nuevo and colleagues (2008) suggested a cut-off-score of 17 or higher to be optimal for screening for depression in non-clinical settings.

Construct validity for the BDI-II is high, with a Cronbach's alpha rating of 0.92 for psychiatric patients and an alpha rating of 0.93 for college students (Beck et al., 1987). The internal consistency for our sample was $\alpha = 0.95$ (Sorsa, 2024). Even though several studies have mapped out country-specific cut-off-points for the BDI-II and the questionnaire has thus been well customised for different populations, a recent cross-cultural study (Seppänen et al., 2022) found that some item

scores differed significantly between different countries, indicating that the BDI does not take cultural differences into account as well as it should.

In the current study participants were asked to fill out the BDI-II before arriving to the experiment. The questionnaires were collected in the beginning of the experiment.

### 2.4.2. State and Trait Anxiety Inventory (STAI)

In assessing pretrial symptom levels of anxiety and mid-trial symptom levels of anxiety, the State and Trait Anxiety Inventory (STAI-Y) was used. The STAI is a self-reporting questionnaire for the evaluation of state anxiety (how one feels in the moment) and trait anxiety (how one generally feels). The STAI was first developed by Spielberger, Gorsuch and Lushene in 1970. Later a revised version, STAI Form X, was introduced, and later still a re-revised version, STAI Form Y. The STAI consists of two separate questionnaires for state and trait symptoms, consisting of 20-items each. The State Inventory (Form Y1) consists of 20 statements which ask participants to describe how they feel. The essential qualities assessed are the participants feelings of tension, nervousness, worry and apprehension. The Trait Inventory (Form Y2) consists of 20 statements to which the participant is asked to respond by indicating, on a four-point rating scale, the frequency that they experience specific anxiety symptoms.

The trait scale of STAI-Y2 (also referred to as STAI-T) has been reported to have very good to excellent internal consistency (.92-.95) and adequate test-retest reliability during a seven-week testing period (.85) (Elwood et al., 2012). The internal consistency for the current sample is $\alpha$ = 0.94 (Sorsa, 2024).

The STAI is widely used worldwide but it has also been criticized, especially for its ability to differentiate between anxious and depressive symptoms. In a recent meta-analysis by Knowles and Olatunji (2020) 388 published studies ($N$ = 31 021) on the trait scale of STAI (STAI-T) were examined. In the analysis anxious and depressive symptoms were found to correlate significantly (mean $r$ = .59) and individuals with depressive disorder had significantly higher STAI-T scores than individuals with anxiety disorder (Hedges's $g$ = 0.27). Because of these findings Knowles and Olatunji propose that the STAI-T should rather be considered as a non-specific measure for negative affectivity rather than trait anxiety.

In the current study participants were asked to fill out the State Anxiety Inventory (Form Y2) before arriving to the experiment. The questionnaire was collected in the beginning of the experiment.

### 2.4.3. Facial muscle activity

Facial muscle activity was measured by attaching two disposable electrode pairs (Ag/AgC1) with 0,5 cm of space between the electrodes: one pair over the zygomaticus major region and the other over the corrugator supercilii region. The data was measured and amplified using a NeurOne system. Next, the raw EMG data was filtered with a 20-400 Hz bandpass filter and a 50-Hz notch filter using BrainVision Analyzer software. The data was then segmented into 5500ms epochs, from 500ms before stimulus onset (baseline) to 5,000ms after stimulus onset. Artifact rejection was conducted with minimal allowed amplitude set to -250 μV and maximum allowed amplitude at 250 μV. The processed EMG data was then exported to Matlab, where mean EMG responses were calculated for each epoch in each emotional condition. Finally, the means of each epoch were averaged together to represent mean EMG activity for each emotional condition.

### 2.4.4. Electrodermal activity

Electrodermal activity was measured with two electrodes (Ag/AgC1, EL507, Biopac Systems, INC) coated with isotonic paste. The EDA electrodes were attached to the palmar surface on the participant's nondominant hand. One electrode was attached beneath the index finger (thenar eminence on the palm) while the other was attached below the fourth digit on the same horizontal level (hypothenar eminence on the palm). A NeurOne system was used to measure and amplify a continuous EDA level at a sampling rate of 1,000Hz (Bittium Biosignals Ltd, Kuopio, Finland). The raw EDA data of each participant was then segmented into 5500 ms epochs, from 500ms before stimulus onset (baseline) to 5,000ms after stimulus onset for each of the three emotional conditions using BrainVision Analyzer software. Data was then exported to Matlab, where the data

was resampled to 10 Hz, pre-processed with adaptive smoothing, and analysed with Continuous Decomposition Analysis. Descriptive statistics (i.e., means, minimums, maximums, and standard deviations) were extracted from all emotional conditions. The mean EDA levels were used for the statistical analyses.

### 2.5. Statistical analyses

Simple linear regressions were conducted with IBM SPSS version 29 to test the hypotheses of the present study. Trait anxiety and depressive symptoms (operationalized as scores on STAI-Y2 and BDI-II, respectively) were used as predictive variables, whereas EDA and EMG activity were used as outcome variables. The parametric assumption of normality was inspected with visual inspection of histograms. Visual inspection of the histograms showed that the assumption of normality was violated with multiple variables. Therefore, Spearman correlations were chosen for variable inspection. Descriptive statistics and correlations between study variables were calculated. Finally, three simple linear regression analyses were performed. Additionally, the same regression analyses were performed a second time with halved data, due to suspicions that participants had habituated to the study stimulus. To illustrate the habituation effect, we created line graphs (using Excel for Microsoft 365 version 2302) depicting averaged participant EDA levels during the viewing of sad and angry faces (see. figures 5 & 6).

## 3. RESULTS

Three simple linear regression analyses were employed to test our hypotheses. Visual inspection of variable histograms showed that the parametric assumption of normality was violated with multiple variables. As such, Spearman correlations were chosen for variable inspection. Means, standard deviations, minimum and maximus values for BDI-II, STAI-Y2, EDA and EMG are found in Appendix A. Distribution of anxious and depressive symptoms are illustrated in Figures 3. Spearman correlations for mean values of EDA and EMG are found in Tables 1 & 2. Notably, anxious and depressive symptoms were not normally distributed in our sample. Also, we found that the Spearman correlations for STAI-Y2 and BDI-II were very high ($r = .85$, $p < 0.001$).

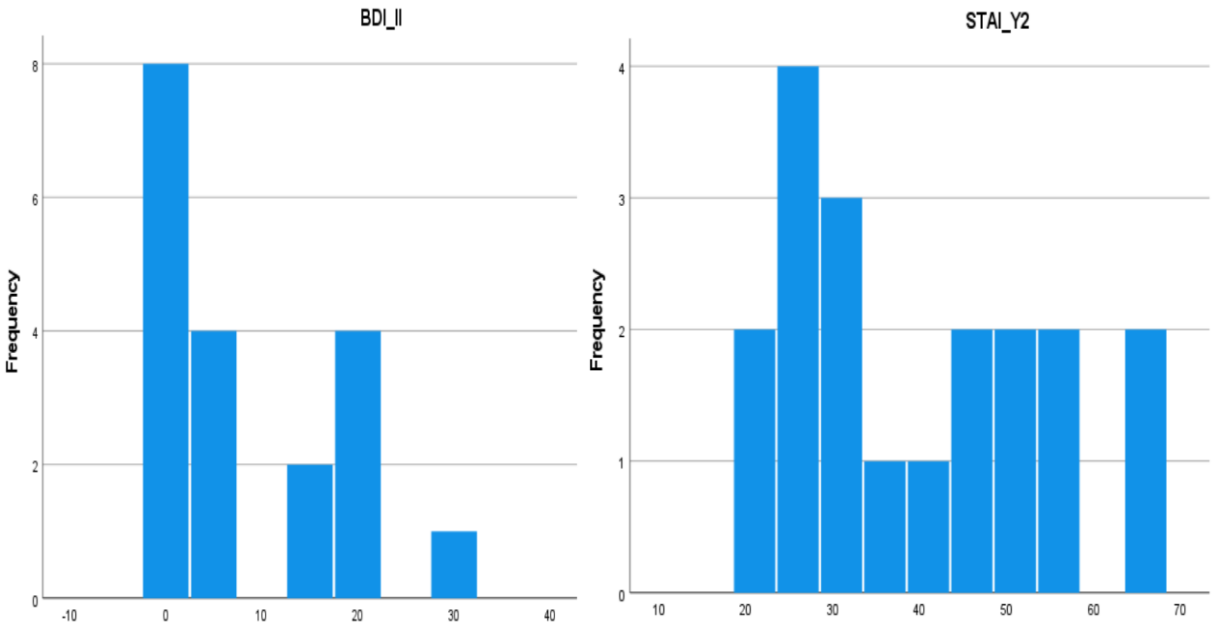


***Figure 3.*** *Distribution of the number of anxious and depressive symptoms within our sample (N = 19).*

***Table 1.*** *Spearman correlations for STAI-Y2, BDI-II and all conditions of EDA.*

*Spearman correlations for STAI-Y2, BDI-II and all conditions of EDA.*

| | | | STAI_Y2 | BDI_II | EDA_Ang_Mean | EDA_Sad_Mean | EDA_Neu_Mean |
|---|---|---|---|---|---|---|---|
| Spearman's rho | STAI_Y2 | Correlation Coefficient | -- | | | | |
| | | *p* | . | | | | |
| | | *n* | 19 | | | | |
| | BDI_II | Correlation Coefficient | .85** | -- | | | |
| | | *p* | .000 | . | | | |
| | | *n* | 19 | 19 | | | |
| | EDA_Ang_Mean | Correlation Coefficient | -.32 | -.17 | -- | | |
| | | *p* | .18 | .48 | . | | |
| | | *n* | 19 | 19 | 20 | | |
| | EDA_Sad_Mean | Correlation Coefficient | -.25 | -.07 | .74** | -- | |
| | | *p* | .31 | .76 | .000 | . | |
| | | *n* | 19 | 19 | 20 | 20 | |
| | EDA_Neu_Mean | Correlation Coefficient | -.28 | -.05 | .84** | .79** | -- |
| | | *p* | .24 | .83 | .000 | .000 | . |
| | | *n* | 19 | 19 | 20 | 20 | 20 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Notes: EDA_Ang_Mean = Mean values for EDA amplitude while viewing angry facial expressions.*

*EDA_Sad_Mean = Mean values for EDA amplitude while viewing sad facial expressions.*

*EDA_Mean_Neu= Mean values for EDA amplitude while viewing neutral facial expressions.*

***Table 2.*** *Spearman correlations for STAI-Y2, BDI-II and all conditions of EMG.*

*Spearman correlations for STAI-Y2, BDI-II and all conditions of EMG.*

| | | STAI_Y2 | BDI_II | EMG_Cor_Ang | EMG_Cor_Sad | EMG_Cor_Neu | EMG_Zyg_Ang | EMG_Zyg_Sad | EMG_Zyg_Neu |
|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | STAI_Y2 | Correlation Coefficient | -- | | | | | | |
| | *p* | . | | | | | | | |
| | *n* | 19 | | | | | | | |
| | BDI_II | Correlation Coefficient | .85** | -- | | | | | |
| | *p* | .000 | . | | | | | | |
| | *n* | 19 | 19 | | | | | | |
| | EMG_Cor_Ang | Correlation Coefficient | -.37 | -.35 | -- | | | | |
| | *p* | .12 | .14 | . | | | | | |
| | *n* | 19 | 19 | 20 | | | | | |
| | EMG_Cor_Sad | Correlation Coefficient | -.40 | -.40 | .99** | -- | | | |
| | *p* | .09 | .09 | .000 | . | | | | |
| | *n* | 19 | 19 | 20 | 20 | | | | |
| | EMG_Cor_Neu | Correlation Coefficient | -.38 | -.38 | 1.00** | .99** | -- | | |
| | *p* | .11 | .11 | .000 | .00 | . | | | |
| | *n* | 19 | 19 | 20 | 20 | 20 | | | |
| | EMG_Zyg_Ang | Correlation Coefficient | .14 | -.07 | .37 | .36 | .37 | -- | |
| | *p* | .57 | .79 | .11 | .12 | .11 | . | | |
| | *n* | 19 | 19 | 20 | 20 | 20 | 20 | | |
| | EMG_Zyg_Sad | Correlation Coefficient | .16 | -.03 | .39 | .39 | .39 | .99** | -- |
| | *p* | .50 | .91 | .09 | .09 | .09 | .00 | . | |
| | *n* | 19 | 19 | 20 | 20 | 20 | 20 | 20 | |
| | EMG_Zyg_Neu | Correlation Coefficient | .12 | -.07 | .39 | .38 | .38 | 1.00** | .99** | -- |
| | *p* | .63 | .78 | .09 | .09 | .10 | .00 | .00 | . |
| | *n* | 19 | 19 | 20 | 20 | 20 | 20 | 20 | 20 |

**. Correlation is significant at the 0.01 level (2-tailed).

*Notes: values titled with ''EMG'' denote EMG amplitudes of either zygomaticus major (Zyg) or corrugator supercilia (Cor) while viewing angry (Ang), sad (Sad) or neutral (Neu) faces.*

For hypothesis 1, we expected BDI-II scores to positively explain variance in corrugator supercilii activation, while viewing sad facial expressions. A significant relationship was not found: $F(1, 17) = 2.09$, $p = .167$. Thus, hypothesis 1 was not supported, and the null hypothesis must be accepted.

For hypothesis 2, we expected STAI-Y2 scores to positively explain variance in EDA activity while viewing angry facial expressions. A significant explanatory relationship was not found: $F(1,17) = 1.27$, $p = .275$. As such, hypothesis 2 was not supported, and the null hypothesis must be accepted.

For hypothesis 3, we expected BDI-II scores to positively explain variance in EDA activity during the viewing of sad facial expressions. Again, a significant explanatory relationship was not found: $F(1,17) = 0.05$, $p = .828$. Therefore, hypothesis 3 did not receive support, and the null hypothesis must be accepted.

Notably, visual inspection of histograms showed that the standardized residuals for all three regression analyses were not normally distributed. This was to be expected as assumption checking revealed the data to not be normally distributed. However, it suggests that regression analysis may not be appropriate for the analysis of this sample.

After the first regression analyses were conducted, we noted habituation effects in the EDA and EMG data. It was suspected that this habituation might hide variation in the first trials of the experimental procedure when averaged together. Therefore, we created an averaged line graph of the EDA data of all participants for the angry and sad conditions to illustrate the habituation (see. Figures 5 & 6).

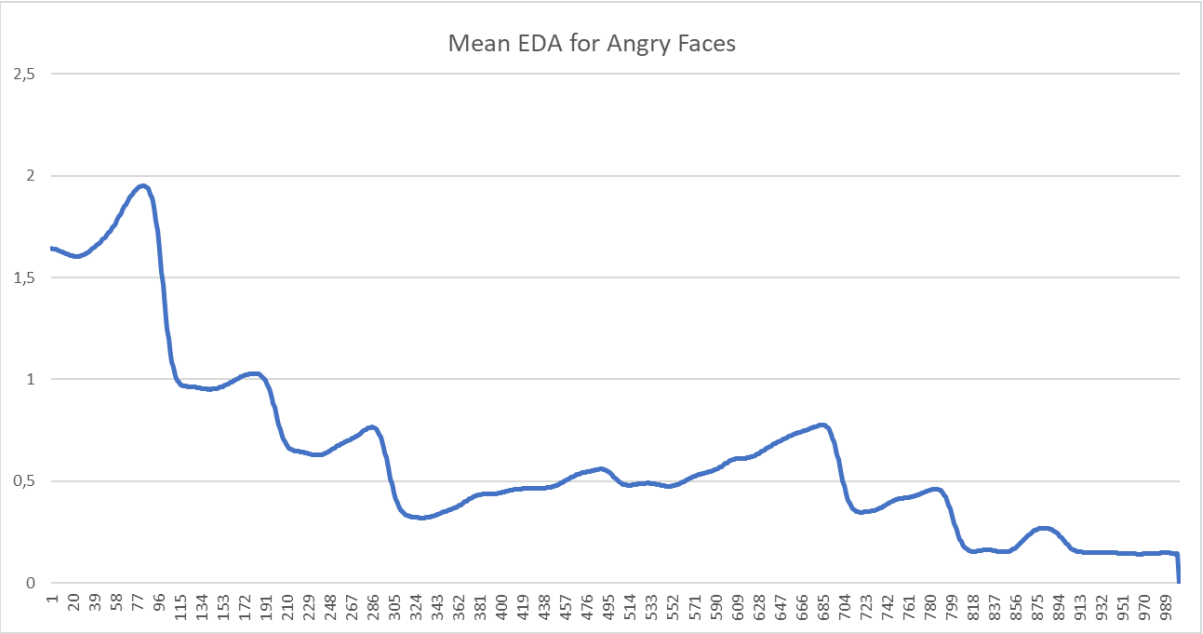


***Figure 5***. *Mean EDA activity of all participants (group average) during the viewing of angry faces. Note: Y-axis represents microvolts, whereas the X-axis represents time-points. Reactions for sad and neutral faces have been excluded from this data during the segmentation pre-processing phase of analysis.*

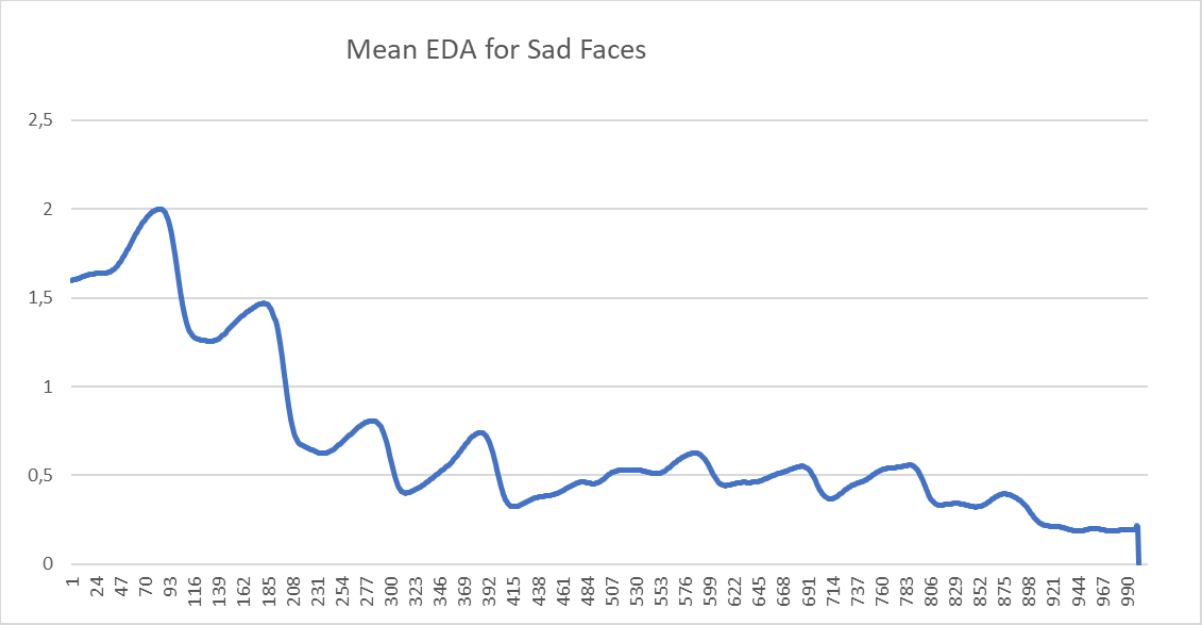


***Figure 6.*** *Mean EDA activity of all participants during the viewing of sad faces. Note: Y-axis represents microvolts, whereas the X-axis represents time-points. Reactions for sad and neutral faces have been excluded from this data during the segmentation pre-processing phase of analysis.*

Similar habituation patterns were detected in the EMG data. Therefore, we attempted to account for habituation effects by only including EDA and EMG data from the first five (of ten) trials, as visual inspection of the line graphs (Figures 5 & 6) suggested that this was when habituation became most apparent. Means and standard deviations for the first five trials of the EDA and EMG data can be found in Appendix B. Hypotheses 1 and 3 were not supported even when controlling for habituation effects. For results of these regression analyses, see Appendix C. For hypothesis 2, a significant explanatory relationship was found: $F(1,17) = 4.74$, $p = .044$. Unexpectedly, however, the directionality of the relationship was negative. The $R^2$ value was .22, indicating that trait anxiety explained 22% of the variance in EDA during the first half of viewing angry faces. The regression equation was:

$$\text{EDA score} = 1.55 - 0.02(\text{STAI-Y2 score}).$$

That is, for each one-point increase in the participants STAI-Y2 scores, EDA decreased by approximately .02 percentage points while viewing angry faces in the first half of the experiment. The results of the other regression analyses are visible in Appendix C.

## 4. DISCUSSION

The aim of this thesis was to examine whether depressive and anxious symptoms explain variance in emotional arousal and emotional mimicry. A novel study design utilizing live face models was introduced and psychophysiological measurements (EDA & EMG) were taken to investigate emotional arousal and emotional mimicry while viewing emotional facial expressions. Initial regression analyses did not support our hypotheses. However, when accounting for habituation effects, we found a significant explanatory relationship between trait anxiety and EDA. However, contrary to our hypothesis, this relationship was negative. Implications and possible explanations for these findings are discussed below.

### 4.1. Findings regarding anxiety and threat-related bias

We expected to find a positive explanatory relationship between trait anxiety and electrodermal activity during the viewing of angry facial expressions. Such findings were expected because of the threat-related bias that has shown to be a robust phenomenon in individuals with anxiety disorders and those with high trait anxiety (Bar-Haim et al., 2007). That is, we expected that individuals with high trait anxiety would experience heightened emotional arousal while watching a real person looking at them with an angry face, as the literature on threat related bias suggests that disengagement from threatening stimuli may be more difficult for such individuals (Bar-Haim et al., 2007; Fox et al., 2010). However, our initial regression analysis suggested that there was no significant relationship between trait anxiety and EDA while viewing angry facial expressions. Subsequently, further regression analyses were conducted to account for habituation effects, as it was suspected that participants were becoming habituated to the stimuli during the experiment. These subsequent analyses indicated a negative relationship between trait anxiety and EDA during the viewing of angry facial expressions.

One potential explanation for why our hypothesis regarding threat-related bias was not supported could be that our facial stimuli may have been too intensive for the bias to become visible. For example, Torro-Alves and colleagues (2016) found that individuals with high social anxiety were more likely to correctly judge a picture of a face as angry when the stimulus used was less intense when compared to individuals with low social anxiety. However, this difference disappeared with more intense facial expressions. The authors reason that individuals with high social anxiety have a small advantage in facial emotion recognition accuracy, however, this advantage disappears when the stimulus presented is less vague, or more ecologically valid. Notably, the study by Torro-Alves and colleagues (2016) investigated facial emotion recognition, whereas our study was interested in the psychophysiological effects elicited by facial expressions. However, it may be that in our study—which used an intensive, pseudo-dynamic stimulus—cognitive biases may not be visible because participants have little question as to what facial expression is being presented to them. That is, if the presented facial expressions had been vaguer, it could be that individuals with high

trait anxiety could have shown higher electrodermal activity as they may have been more likely to correctly identify a face as angry and thus be more emotionally aroused than individuals with low trait anxiety.

On the other hand, as mean EDA values were highly similar (See Appendices A and B) through each emotional condition, it is also possible that using a living face model as a stimulus was generally too arousing for the entire sample to reveal the presence of a threat related bias in the participants with high trait anxiety. Therefore, if the experimental situation was arousing to the extent that neutral facial expressions elicited similar emotional arousal as angry facial expressions, it stands to reason that more subtle cognitive biases might not become apparent from such conditions.

The single most puzzling result in our study arose from the halved data. Contrary to all expectations we saw signs that STAI-Y2 scores negatively explain electrodermal activity in the free viewing of angry faces. That means that angry facial expressions elicited less autonomic nervous responses in anxious participants than in non-anxious participants. This finding may be due to our small effect size or problems with the STAI-Y2 form. It is possible, that the surprising result may be because of the potentially poor construct validity of the STAI-Y2 (Knowles & Olatunji, 2020). Knowles and Olatunji, in their meta-analysis, found that the trait scale of STAI was more highly correlated with depressive symptoms than measures of anxiety. Therefore, they reason that STAI-Y2 might measure general negative affectivity more than trait anxiety. Indeed, in the present study, STAI-Y2 and BDI-II scores were highly correlated ($r$ = .85), which might support the notion that the trait scale of the STAI may not have sufficient construct validity. From this perspective, if the construct measured was not the intended psychological construct, it follows that the observed findings would also be surprising. However, if the effect were to be true, it would raise serious questions about our views regarding the threat-related bias associated with anxiety.

### 4.2. Findings regarding depression and negative bias

As the cognitive negative bias theory suggests that depressed individuals pay more attention to negative facial stimuli, we expected to find a positive explanatory relationship between depressive

symptoms and CS activity during the viewing of sad facial expressions (hypothesis 1). In line with the same paradigm, we expected to find a positive explanatory relationship between depressive symptoms and electrodermal activity during the viewing of sad facial expressions (hypothesis 3). Neither of the hypotheses were supported in this preliminary study.

It may be possible that the cognitive negative bias does not function as expected in facial emotion viewing. Even though previous studies have demonstrated ample evidence for a negative bias in face perception (Bourke et al., 2010; Gur et al., 1992; Krause et al., 2019; Leppänen et al., 2004; Persad and Polivy, 1993; Rubinow & Post, 1992; Surguladze et al., 2002), most of these studies have been conducted with static facial stimuli.

Notably, our findings are in line with other studies utilizing dynamic stimuli in facial emotion recognition experiments. For instance, Kan and colleagues (2004) and Schaefer and colleagues (2019) found no significant relationship between depressive symptoms and facial emotion recognition competency when using dynamic stimuli. Zwick and Wolkenstein (2017) have argued that the new, still rarely adopted test paradigms utilizing dynamic stimuli may eventually lead in the challenging of previous findings of the cognitive negative bias all together, as previous results may be due to the low ecological validity of static facial stimuli. Similar suggestions have been made in the study of facial emotion recognition and social anxiety (Torro-Alves et al., 2016). Zwick and Wolkenstein's assumption is supported by some studies that have found no evidence of depressive symptoms causing significant impairments in social cognition (Air et al., 2015). It is a well-documented fact that stimulus type serves as a significant moderator in facial emotion interpretation (Krause et al., 2019). Therefore, it may be that the findings of the current study are a result of stimulus type as well. Even though our stimulus was only pseudo-dynamic, the use of a live person in a social interaction experiment is arguably a significant upgrade in ecological validity, and future studies may prove ecological validity to be a key area of interest in social cognition research. However, the complete number of studies using dynamic stimuli in facial emotion viewing tasks is still very low (Krause et al., 2019) and therefore future studies are needed to clarify the relationship between stimulus type and the cognitive negative bias in studies of emotional facial expressions.

Regarding the EMG results, it may also be that motivation for facial mimicry does not work as hypothesized. In line with Hess (2021), we assumed that facial mimicry would be goal-dependent and following social tuning theory (Valdesolo & DeSteno, 2011), we expected people with depressive symptoms to have higher motivation to engage in social interaction with sad facial expressions. This motivation, in turn, we assumed to be detectable in the automatic mimicry of sad facial expressions. However, our results do not support this hypothesis. It has been argued that

mimicry of positively valanced facial expressions is more common than mimicry of sad facial expressions (Hess, 2021; Kraft-Feil et al., 2023). Thus, it is possible that the positively valanced nature of facial mimicry outweighs the social tuning aspect in individuals with depressive symptoms.

Regarding the EDA results, the hypodermal activity associated with depression may have been a contributing factor in the current study. In a systematic review of 77 relevant studies Sarchiapone and colleagues (2018) found hypodermal EDA activity to be a consistent factor in depression and suicidal behaviour, even to the effect that it could be considered a viable candidate as a biomarker for depression and suicidality. The research regarding these findings is ongoing but it seems apparent that people with depressive symptoms may differ from non-depressive participants at EDA baseline. This, in turn, may have implications not considered in the current study.

Another contributing factor in all results of the current study may be gender. Our sample was not evenly distributed between males and females (15 f, 4 m). In a meta-analysis of 23 studies concerning facial emotion recognition and depression, Krause and colleagues (2019) noted that the possibility of gender as a moderator in facial emotion recognition has been rarely examined even though gender differences regarding depression have been widely documented. This amounts to a severe gap in literature as there is no information available on how gender differences may translate to differences in facial emotion interpretation. Thus, it may be possible that the cognitive negative bias associated with depression has differing effects on the social cognition of males and females.

### 4.3. Limitations

The present study has limitations to consider. First, our sample was quite small. As indicated by Khamis and Kepler (2010), at least 25 participants would have been necessary to reliably discover a medium effect size. As such, it is possible that our sample did not have enough participants with high trait anxiety or high depressive symptoms to capture the effects of their associated cognitive biases in our analyses. Second, it is possible that the measure we used to quantify trait anxiety, the STAI-Y2, may not be a valid measure for the trait, as it has shown considerably high correlations with measures of depression in previous studies (for a meta-analysis, see. Knowles and Olatunji,

2020) as well as in the present study. On the other hand, measures of anxiety and depression might be expected to correlate with each other, due to their similar characteristics in negative affect. However, considering how strongly BDI-II scores and STAI-Y2 scores were associated in our analyses, further evidence is provided here to support the argument of Knowles and Olatunji (2020) that the STAI-Y2 may be a nonspecific measure of negative affect.

### 4.4. Future research

Our research findings are in line with the assumption that the use of dynamic stimulus in facial emotion interpretation experiments may prove paradigm changing and have a severe impact on how we understand cognitive biases in relation to social cognition (Zwick & Wolkenstein, 2017; Torro-Alves, 2016; Kan et al., 2004; Schaefer et al., 2019). Future research using dynamic stimuli is still needed to further explore these questions. In the current study, only a pseudo-dynamic stimulus was employed. The next logical step would be to use a fully dynamic stimulus paradigm where the face model would form facial expressions from neutral to sad or angry while being observed, rather than having the facial expressions ready as the screen turns transparent. Also, natural movements of the face model could be allowed during viewing sections to further imitate real-life circumstances. Another variation of dynamic stimulus use would be to also include low-intensity facial expressions. In real-life scenarios people often encounter both high-intensive and low-intensive facial expressions. This natural fluctuation could be adopted into experiment paradigms by introducing a grading system from neutral to 100 % intensity of any facial emotion expression.

Future research would do well in considering the high comorbidity of depressive and anxious symptoms. For instance, the STAI has been criticized for its ability to differentiate between anxious and depressive symptoms (Knowles & Olatunji, 2020). In our sample, we found that the Spearman correlations for STAI-Y2 and BDI-II were very high (.85, $p < 0.001$). This level of correlation brings into doubt the ability of these instruments to differentiate between depressive and anxious psychopathologies. These findings, taken together with several findings of the very high comorbidity of depressive and anxious symptoms in patient samples (e.g. Olfson et al., 2017),

highlight the need to be very careful when addressing the effect of depressive and anxious psychopathologies in social cognition.

### 4.5. Conclusions

The current study has been a preliminary investigation into the possibilities of dynamic stimulus use in social cognition and facial emotion perception studies regarding anxious and depressive symptoms. Contrary to previous research, our preliminary findings did not reveal a negative bias or a threat-related bias in our small sample of participants with varying levels of anxiety and depressive symptoms. That is, anxiety and depressive symptoms were not associated with reactions or behaviors (emotional arousal and emotional mimicry, respectively) that may be attributable to such biases.

Our findings are in line with other studies utilizing dynamic stimuli in social cognition research and raise interesting questions about the ecological validity of previous studies performed mainly with photographs of emotional faces as static stimuli. A question to be answered by future research is whether traditional conceptions of attentional cognitive biases regarding anxious and depressive psychopathologies are justly founded. This question holds within it several implications for clinical interventions and therapeutic work done with anxious and depressed patients. For instance, the branch of Cognitive psychotherapy for depression is based on Beck's notion of depression as a malfunction of information processing where the depressed individual perceives the world around them through unnecessarily negative expectations – i.e. the negative cognitive bias (Beck, 2002). If future research using dynamic stimuli were to continue to not replicate such fundamental notions of the negative cognitive bias, it would eventually necessitate a re-evaluation of the entire cognitive treatment approach for depression. Similarly, if the unexpected effect observed in the current study – where anxious symptomology explained negatively the activation of autonomic nervous responses – were to be replicated in future studies, this would warrant a serious re-evaluation of the way in which research has viewed the threat-related bias associated with anxiety and the way clinicians treat anxious patients.

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## APPENDICES

## APPENDIX A

*Means, standard deviations, minimum and maximum values for BDI-II and STAI-Y2.*

*Statistics*

| | | BDI_II | STAI_Y2 |
|---|---|---|---|
| N | Valid | 19 | 19 |
| | Missing | 1 | 1 |
| *Mean* | | 8.4 | 39.8 |
| *Std. Deviation* | | 9.36 | 14.68 |
| *Minimum* | | 0 | 21 |
| *Maximum* | | 28 | 67 |

*Means and standard deviations of psychophysiological measures.*

*Means & Standard deviations of psychophysiological measures*

| | *N* | *Mean* | *Std. Deviation* |
|---|---|---|---|
| EDA_Ang_Mean | 20 | ,63 | ,42 |
| EDA_Sad_Mean | 20 | ,69 | ,48 |
| EDA_Neu_Mean | 20 | ,66 | ,55 |
| EMG_Cor_Ang | 20 | 4,21 | 3,14 |
| EMG_Cor_Sad | 20 | 4,16 | 3,18 |
| EMG_Cor_Neu | 20 | 4,18 | 3,06 |
| EMG_Zyg_Ang | 20 | 1,47 | 1,27 |
| EMG_Zyg_Sad | 20 | 1,44 | 1,25 |
| EMG_Zyg_Neu | 20 | 1,51 | 1,29 |

**APPENDIX B**

*Means and standard deviations of halved psychophysiological data.*

*Means and standard deviations of halved psychophysiological data.*

| | *N* | *Mean* | *Std. Deviation* |
|---|---|---|---|
| Half_EDA_Ang_mean | 20 | ,86 | ,52 |
| Half_EDA_Sad_mean | 20 | ,96 | ,74 |
| Half_EMG_Cor_Ang | 20 | 4,17 | 3,09 |
| Half_EMG_Cor_Sad | 20 | 4,07 | 3,05 |
| Half_EMG_Zyg_Ang | 20 | 1,42 | 1,20 |
| Half_EMG_Zyg_Sad | 20 | 1,39 | 1,12 |

*Note: Data from neutral facial expressions were not halved, as that data was not used for hypothesis testing.*

**Appendix C**

*Regression for hypothesis 1, when controlling for habituation.*

*ANOVA*[a]

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 18,68 | 1 | 18,68 | 2,01 | ,174[b] |
| | Residual | 157,80 | 17 | 9,28 | | |
| | Total | 176,48 | 18 | | | |

[a] Dependent Variable: Half_EMG_Cor_Sad

[b] Predictors: (Constant), BDI_II

*Regression for hypothesis 3, when controlling for habituation.*

*ANOVA*[a]

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | ,13 | 1 | ,13 | ,22 | ,646[b] |
| | Residual | 9,84 | 17 | ,58 | | |
| | Total | 9,97 | 18 | | | |

[a] Dependent Variable: Half_EDA_Sad_mean

[b] Predictors: (Constant), BDI_II