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Rapid Facial Reactions of Emotional Expressions as a Function of Trait Sadism

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A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in Neuroscience
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Abstract

Using electromyography (EMG), it has been shown that facial muscles imperceptibly mirror the facial expressions of others, a phenomenon referred to as rapid facial reactions (RFRs). It was previously believed to follow the direct-matching hypothesis, however several recent studies have demonstrated that context and individual differences may be influencing factors on RFRs. At the present, it is unclear to what extent RFRs can be modulated. In the present study, we propose to determine the effects of facial stimuli versus non-facial stimuli on RFRs through measuring the EMG response of participants with trait sadism. The participants observed dynamic facial expressions as well as images of limbs in painful situations to assess the specificity of this effect. We found that facial stimuli elicited congruent RFRs whereas the non-facial stimuli did not. This study will allow for a better understanding of the mechanisms of RFRs, which may inform further research on empathy.

Keywords

Summary for Lay Audience

Rapid facial reactions (RFRs), the experience of replicating others' facial expressions with your own facial movements, occur in different situations. RFRs occur swiftly, without conscious attention, and are often not visible to the naked eye. Using a technique called electromyography (EMG), facial movements can be measured through electrical currents generated by muscle contraction. While much is still unknown about what can change RFRs, and to what extent, it has been shown that those higher in empathy tend to express RFRs to a higher degree. RFRs are therefore key to understanding the mechanisms behind empathy, and thus are important to study to understand this trait better. Currently, it is unknown if internal emotions are capable of changing these RFRs, and what is capable of eliciting them.

In this study, we attempt to answer these questions. First, to determine if internal emotions are capable of changing RFRs, we aimed to elicit internal emotions that would be different from the observed expressions. If the observed emotion was replicated, then internal emotions could not change RFRs. However, if the internal emotion was displayed instead, this would be called an incongruent emotion, proving that internal emotions could change RFRs. For this purpose, we tested everyday sadism, a trait similar to *Schadenfreude* in which people high in sadism find pleasure in other's distress. Second, to determine if faces cause RFRs regardless of internal feelings, we showed participants both facial and non-facial stimuli. The facial stimuli displayed expressions of pain to elicit incongruent reactions in sadistic individuals, and the non-facial stimuli were limbs in pain. If the same RFRs were expressed to the limbs as they were to the faces, then internal feelings likely caused both, but if they are different it may mean that faces have a unique effect on RFRs. We found that there were no incongruent RFRs to pain. The face stimuli elicited a different response than the limbs stimuli, implying that facial stimuli do have a unique effect on RFRs and are not modulated by internal emotions. Overall, this allows us to better understand the nature of RFRs, thereby aiding our understanding of empathy.

Co-Authorship Statement

I, Cathleen Fleury, completed all experimental and written work for this thesis project. The designing of the current study, recruitment of participants, completion of all data collection, data processing, data analysis, and writing of the work was all my own work.

My supervisor, Dr. Derek Mitchell, contributed to all aspects of this thesis project including the formulation of the research question, consultation with task design, data analysis, interpretation, and editing of the written work.

Acknowledgments

Though this work is my own, the completion of it would have been far from possible without the help of so many people who have supported me in my time here at Western University. First and foremost I would like to thank my supervisor, Dr. Derek Mitchell, for helping me through every aspect of this project. You have always pushed me to be my best, and never gave up on me. In the most discouraging of times, your kind words always got me through.

To my labmates, for being the best, most supportive people I could have asked for to be on this journey with me. Tamara Tavares, for being my fountain of wisdom in all things, and my go-to person for the best advice. Shannon Compton, for always being able to make me laugh, and for being the most reliable source for current events and movie recommendations. Hilary Dagg, for being one of the most genuine people I know, as well as being the pet guru. Mary Ritchie, for all of your abundant stats knowledge, and letting me use you for free therapy sessions. And finally Emma Stewart, to whom at least half of this thesis should belong to, as without you talking me through all the bad times, both personally and with data, I probably would have given up a long time ago. Thank you so much for answering my calls at all hours of the night, and for making this year a thousand times more fun than it otherwise would have been. The Nook will always be in my heart. All of you are some of my closest friends, and I will deeply miss our lab outings and book club meetings!

I would like to thank my volunteers, Matt DiNunzio, Ishita Sharma, Adham Saad, and Muhammad Faran, who all tirelessly worked to get the data collected and then processed. Your cheerful attitudes always brightened my day, and without you this thesis definitely would have taken five years instead of two.

I would also like to thank my Advisory Committee members, Arthur Brown, Elizabeth Finger, and Erin Heerey, for their expert guidance throughout this project. Your feedback and ideas were invaluable to making this project what it is today.

Finally, I would like to thank my family and friends for always supporting me no matter what. Your love and encouragement have always kept me going, and made my time at Western some of the best years of my life.

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Chapter 1

1   Introduction

Imagine that you are enjoying yourself at a party one day, and are speaking with a friend. You suddenly feel compelled to tuck your hair behind your ear, and realize that your friend has just done the same thing. You then become more aware of the similarities between your behaviours – you have both adopted the same posture, are using similar hand gestures, and are both absent-mindedly tapping your feet. Why might this be? Nonconscious mimicry occurs when one unintentionally imitates the actions of another (Chartrand & Bargh, 1999). Mimicking is a universal trait, seen in every human society across the globe (Chartrand, Maddux, & Lakin, 2005). It has been described as the "social glue" of societies (Lakin, Jefferis, Cheng, & Chartrand, 2003), aiding in the facilitation and maintenance of social connections. Mimicry has become an unconscious, nonverbal technique that aids in communicating various messages to others. Evolutionarily, maintaining strong social bonds and working well within larger groups often determined how long one would survive, and as such, behaviours that facilitated strong social connections evolved through processes associated with natural selection (Lakin et al., 2003). The natural selection of stronger social bonds (de Waal, 1989; Lakin et al., 2003) resulted in these nonverbal techniques being rewarded in social settings.

Unconscious mimicry is one technique that has been shown to increase rapport with others and enhance social connections. Increased mimicry is shown when there is enhanced liking of another, and being mimicked increases the subjective sense of a harmonious interaction, as well as increasing liking of the mimicking partner (Lakin et al., 2003; Van Baaren, Janssen, Chartrand, & Dijksterhuis, 2009). Unconscious mimicry has been linked to prosocial behaviour, with increased mimicking predicting more generosity and altruism (Van Baaren et al., 2009). Observing the mimicry patterns of others interacting can also subconsciously inform a bystander of several social metrics, such as the trustworthiness and competence of the interaction participants (Kavanagh, Suhler, Churchland, & Winkielman, 2011).

1.1   Facial Mimicry

Consider a time when you have walked down the street and passed by a stranger. They flash you a smile, and without thinking you find yourself smiling in return. Replicating the emotional facial expressions of others has been a way of communicating for humans for nearly as long as humans have needed to communicate. It evolved as a means of social interaction, and thus it is no surprise that it still plays a major role in the social lives of humans today. Mimicking can occur in several different ways, through gestures, posture, mannerisms, and more. However there is one specific form of mimicry that adds some interesting dimensions to this phenomenon, and that is facial mimicry. Facial mimicry is different from other mimicry in that it is inherently imbued with meaning, something that a foot tap or face touch would not necessarily have.

Facial expressions can be used to communicate in several different ways, and the processes and motivations behind them are often unclear. When viewing one individual smiling in response to a partner's smile, it is hard to say whether that individual is unconsciously mimicking the expression, or if they are expressing their own endogenous emotion in response to their partner's expressed emotion. These two scenarios demonstrate some of the difficulties found in conceptualizing facial mimicry. In the former scenario, the observer may be demonstrating what is known as the perception-behaviour link (Chartrand & Bargh, 1999), which is when an individual instantly and unconsciously recreates an observed reaction exactly as they saw it. Consequently, this reaction is context-independent. Alternatively, the latter scenario results in the same expression being performed, but the internal mechanisms are different. The expression instead is merely a reflection of what the individual is feeling, and thus could be modulated by context, intentions, or various other processes. For this reason, we will not be referring to this phenomenon as facial mimicry, but instead as rapid facial reactions (RFRs; Dimberg & Thunberg, 1998; Moody, McIntosh, Mann, & Weisser, 2007).

1.2   Rapid Facial Reactions (RFRs)

RFRs have been studied extensively, and several aspects of this phenomenon have become clear. RFRs occur very quickly, with the onset beginning as soon as 300ms after

observing a stimulus (Dimberg & Thunberg, 1998). RFRs are often an unconscious process, with neither the one displaying the reaction nor the one observing it being aware of the RFR occurring (Chartrand & Bargh, 1999; Dimberg, Thunberg, & Elmehed, 2000). Additionally they seem to be involuntary, as participants are unable to prevent it when asked to inhibit their expressions (Dimberg, Thunberg, & Grunedal, 2002), and an attempt to display a different emotion results in a significant delay in the reaction (Korb, Grandjean, & Scherer, 2010).

1.3   Emotion Contagion

It is thought that RFRs may have an affective component to them, with many studies showing that the motor response being displayed is often accompanied by an emotion that is related to that expression, an experience termed emotion contagion (Hatfield, Cacioppo, & Rapson, 1992; Hsee, Hatfield, Carlson, & Chemtob, 1990; Lundqvist & Dimberg, 1995). Emotion contagion is a temporary phenomenon, with effects no longer present 5 minutes after the presentation of the stimulus (Söderkvist, Ohlén, & Dimberg, 2018). Even still, through experiencing a similar emotion to the observed partner, it is possible that emotion contagion through RFRs enhances emotional empathy. It is difficult, however, to show that the felt emotion is derived from the RFR experience, rather than merely co-occurring with it, and thus this phenomenon is still under investigation (Hess & Blairy, 2001; Olszanowski, Wróbel, & Hess, 2020; van der Schalk et al., 2011).

1.4   Empathy

Facial mimicry has extensively been studied in relation to empathy. Empathy can be defined in at least two facets – cognitive and emotional empathy. Cognitive empathy is the ability to understand the feelings of the other, whereas emotional empathy is the ability to feel what another person is feeling (Sonnby-Borgström, 2002). Studies have shown that as both emotional and cognitive empathy increase, the intensity of RFRs increases as well (Chartrand & Bargh, 1999; Dimberg, Andréasson, & Thunberg, 2011; Drimalla, Landwehr, Hess, & Dziobek, 2019; Sonnby-Borgström, 2002). However, for tasks that involve emotional empathy compared to tasks that involve cognitive empathy,

RFRs are more intense during the emotional empathy tasks to the point where the type of task could be determined based on the examination of the RFRs (Drimalla et al., 2019). This seems to suggest that there may be a relationship between RFRs and emotional empathy.

1.5   Emotion Recognition

Another potential outcome of the RFR phenomenon is enhanced emotion recognition. Emotion recognition seems to scale with RFRs, wherein blocking the RFRs - either through physical obstruction of muscle movement or the injection of botulinum-toxin – reliably reduces emotion recognition (Hennenlotter et al., 2009; Lewis, 2018; Oberman, Winkielman, & Ramachandran, 2007; Wingenbach, Brosnan, Pfaltz, Plichta, & Ashwin, 2018). This relationship has been contested, however, as this effect has failed to replicate in certain studies (Hess & Blairy, 2001; Niedenthal, Mermillod, Maringer, & Hess, 2010). Furthermore, individuals with moebius syndrome – a condition of face paralysis from birth – do not seem to have any trouble with emotion recognition (Calder, Keane, Campbell, & Young, 2000; Keillor, Barrett, Crucian, Kortenkamp, & Heilman, 2002).

1.6   Theories of Motor-Matched Mimicry

One theory behind the potential relationship of emotion recognition and RFRs is the direct-matching hypothesis (Rizzolatti, Fogassi, & Gallese, 2001). This theory was formulated after the discovery of the mirror neuron system (MNS) in macaque monkeys (Rizzolatti et al., 2001). The MNS involves a process by which observing an action activates the same premotor neurons in the monkey that would be recruited if the monkey were to perform that action themselves. The direct-matching hypothesis proposes a similar process in humans, and suggests that this may increase the likelihood of the observed action being replicated by the observer in an unconscious and unintentional fashion, with the purpose of enhancing understanding of the observed action. Other theories have developed that propose a similar process and purpose, including the matched-motor hypothesis (Chartrand & Bargh, 1999; Preston & de Waal, 2002), the embodied cognition theory (Goldman & Sripada, 2005; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005) and the facial feedback theory (Buck, 1980;

Dimberg & Thunberg, 1998). These theories postulate that RFRs aid in emotion recognition through using the motor movement as a way to internally simulate and understand the perceived emotion. Through recreating the expression that is observed, one can in theory better identify what emotion they themselves are now expressing, and then assign that emotion to what is being expressed by their partner. This theory positions RFRs as an uncontrollable, non-affective process, that is the result of low-level mechanisms (Niedenthal et al., 2010; Oberman et al., 2007). Similar theories include the associative sequence learning account (Cook et al., 2013), the perception–action model (Preston & de Waal, 2002), and the affect-matching account (Dimberg et al., 2000), which all consider RFRs to be an automatic process in every social situation. Due to the tendency to react with the same emotion as perceived, the RFRs' involuntary and unconscious nature, as well as evidence for neonates replicating facial expressions (Meltzoff & Moore, 1977), these theories consider RFRs to be a memetic, biological process.

1.7   Context Dependent

However, additional aspects of RFRs are not accounted for when assuming that they are a purely motor-matching process, and thus an opposing theory must be examined. The appraisal theory posits that RFRs occur due to an individual's evaluation of a situation that concludes in an emotional response (Lazarus, 1991). Several different examples have shown support for this theory, demonstrating that RFRs are highly context-dependent, and can be modulated by various factors. As mentioned previously, RFRs increase rapport with others, in that more mimicry enhances liking. Thus, it makes sense that as the desire for individual or group affiliation increases, so too do RFRs and other mimicry behaviour (Lakin & Chartrand, 2003). Studies have shown that socially excluded individuals mimic more than those who are socially included, presumably because their affiliation motivation is stronger and more salient (Kawamoto, Nittono, & Ura, 2014; Lakin, Chartrand, & Arkin, 2008). To maintain a strong affiliative bond to one's ingroup, it can be seen as important to reduce affiliation with the outgroup, and as such RFRs seem to be reduced in response to outgroup members (Bourgeois & Hess, 2007). However, if social settings are negative environments rather than positive ones, as is the

case for those with social anxiety, reduced affiliative behaviour is displayed, as is evidenced with reduced smiling to strangers' smiles (Dimberg & Thunberg, 2007). Additional goal-driven modification can be seen when participants are motivated to understand another's emotional state. By being given tasks to identify individuals' expressions, they will display more RFRs than if they are asked an expression-irrelevant question, such as about a physical trait or the colour tint of the photo (Cannon, Hayes, & Tipper, 2009; Murata, Saito, Schug, Ogawa, & Kameda, 2016). Modulation of RFRs can be attributed to various other contexts. A sad mood can reduce one's willingness to participate in social experiences, and this can be seen in a concurrent reduction in RFRs when individuals are in sad compared to happy moods (Likowski et al., 2011). Using operant conditioning, it is also possible to train participants to attenuate smile responses to specific smiling individuals (Korb, Goldman, Davidson, & Niedenthal, 2019).

1.8 Incongruent Reactions

RFRs can be modulated to complex and specific dynamics as well, as can be seen through interactions of those with varying power statuses. One study primed participants to view themselves and other individuals as being in positions of either high or low power, and then measured their levels of RFRs. They found that people who saw themselves as being in a position of low power smiled at all other individuals, regardless of their expression. In contrast, participants who were high power mimicked the low power individuals while smiling at the anger of other high power individuals (Carr, Winkielman, & Oveis, 2014). This shows that RFRs can be not only modulated to various degrees, but even to a point of expressing an emotion that is incongruent with the perceived emotion. Incongruent reactions provide significant issues for a motor-matching theory of RFRs. Incongruent reactions can occur in situations where the context is incongruent with the facial expression being observed. An example of this can be seen in a study where participants were primed with cooperation or competition before viewing a facial expression (Seibt et al., 2013). For the conditions where cooperation was subliminally displayed, congruent RFRs were seen to all but anger expressions. However when competition was primed, incongruent RFRs were seen. Another study looked at the effect of context in the form of opinions of the people displaying the facial expressions, if

these opinions were shaped from second-hand accounts. Again, incongruent RFRs were seen in participants who had had no personal interactions with the target individual, but had their attitude changed through reading brief descriptions of the perceived individual (Likowski et al., 2008). Furthermore, with no manipulation of the participants' relationship to the observed individual, individual traits may influence the likelihood of an incongruent reaction, as one study found that those who tested low on empathy had a greater chance of expressing incongruent RFRs to angry faces (Sonnby-Borgström, 2002). As proposed by Hess and Fischer (2014), it would seem that this evidence would indicate that direct mimicry only occurs in instances where it would promote an affiliation goal, but reactions are otherwise context-dependent.

1.9   Measures of RFRs

In order to index facial reactions, two methods are commonly used. These include the Facial Action Coding System (FACS), and facial electromyography (EMG). FACS is a method developed by Carl-Herman Hjortsjö (1969) and later adopted and published by Paul Ekman and Wallace V. Friesen (1978). FACS is a system by which facial expressions are identified by visually coding muscle movements. Those trained in this technique can score participants' observable facial muscle movements by analyzing a video recording of the participant reacting to a stimulus. Any changes in intensity or expression is documented as an "Action Unit". Due to its unobtrusive nature, the FACS method of measuring changes in facial movement can be especially useful in studying subjects in natural settings, as opposed to experimental conditions, which may allow for more complex conditions of various contexts to be observed. In experimental conditions, this method also allows for the possibility of participants being kept ignorant of having their facial movements be the subject of investigation. This is more difficult to achieve with EMG, as the attachment of electrodes to subjects' faces inherently becomes more obtrusive. However, FACS can only measure observable muscle changes, and becomes less accurate with more subtle changes (Graham, 1980). For example, in one study testing the sensitivity of an automated facial coding program (Facereader; Noldus Information Technology), the Facereader struggled to differentiate between neutral and negative expressions (Höfling, Gerdes, Föhl, & Alpers, 2020). Thus, although effective for more

overt expressions, FACS is not as well-suited for studies involving expressions that are especially quick or subtle.

The second method, EMG, uses electrodes that are placed above specific muscles to measure the electrical currents generated in those muscles during contraction. Two Ag-AgCl electrodes are placed in a bipolar configuration on the surface of the skin, over whichever muscle is being measured. The electrodes are attached with adhesive collars around them, and a conductive gel fills each electrode to amplify the electrical signal. Each electrode measures the electrical current produced by the action potentials of the neurons in the muscles as the muscle contracts. The arrangement of the electrodes allows for the potential difference to be reported as an EMG signal. Studies will often record from the left side of the face, as bidirectional differences may be seen in individual subjects, and the left side has shown to be more expressive than the right (Indersmitten & Gur, 2003; Sackeim, Gur, & Saucy, 1978). However, when analyzing participants as a group, these differences tend to be non-significant (Boxtel, 2010; Ekman, Hager, & Friesen, 1981). There are two muscles of note which are most commonly used. Corrugator supercilii is a muscle at the inner corner of the eyebrow and is responsible for furrowing the eyebrow. This can occur in many different situations, such as concentration (Kaiser & Wehrle, 2001; Rozin & Cohen, 2003), but is most often associated with negative affect, such as sadness, pain, or anger (Dimberg et al., 2002). Zygomaticus major is a long muscle that stretches from the corner of the mouth to the top of the ear, and is responsible for pulling the corners of the mouth up into a smile, which is most often associated with happiness.

The disadvantages of facial EMG stem primarily from its physical and obtrusive nature. Attaching objects to subjects' faces is inherently more distracting than simply observing the individual. Wires hanging from an individual's face are cumbersome and make it difficult to ignore the experimental conditions the participant is in. Thus, there is always a risk that the participant may alter their behaviours from their natural state, and it is impossible to observe participants in their natural social environments. However, this technique is invaluable for its ability to detect even the weakest of facial movements, and can measure responses that are below the visual detection threshold (Boxtel, 2010). In

studies that have compared the utility of both the FACS and EMG methods, EMG has proved to be the superior method in identifying and measuring RFRs, due to their tendency to be below the visual detection threshold (Cacioppo, Bush, & Tassinary, 1992; Graham, 1980; Hazlett, Hopkins, & Research, 1999; Tassinary & Cacioppo, 1992; Wolf, 2015).

1.10   Gap in Knowledge

RFRs thus appear to be more sensitive to context than was once thought. However, it is still unknown which mechanisms are at play behind this phenomenon. Besides the trait empathy study (Sonnby-Borgström, 2002), little research has been done into the impact of individual traits on incongruent expressions, and on RFRs in general. Additionally, for what has been studied, the emotion of anger was the perceived expression, which introduces issues of a dominance hierarchy (Cabral, Tavares, & de Almeida, 2016; Carr et al., 2014), in which the response to an anger expression differs depending on one's power dynamic with the other person. For example, one may react with fear to the anger expression of someone who has more power, but may react with anger or laughter to the anger expression of someone who is lower in the dominance hierarchy. Thus, there is potential variance in what response can be expected from the viewer, and an emotion that may have less variance in the expected response would be valuable to test. Insight into the effect of individual trait differences on RFRs may shed some light on the process through which this phenomenon comes about. Furthermore, incongruent responses have been seen as by-products of initial studies, but few have studied these responses directly. In order to determine the effect of facial stimuli on incongruent responses, it may be valuable to observe the effect of other stimuli to see if incongruent responses could be elicited in various situations. One population of interest, everyday sadists, experiences incongruent responses as a consistent personality trait, and may help uncover these mechanisms.

1.10.1   Faces versus Limbs Stimuli

There is lack of clarity in the literature concerning the extent to which RFRs to facial stimuli have unique properties versus RFRs generated from other stimuli. In order to

explore this, Dimberg et al. (2002) compared the EMG signal of participants who observed positive or negative facial expressions, to participants who observed positive or negative non-facial stimuli. They observed that the effects were the same for those who viewed happy and angry faces as those who viewed images of snakes and flowers; zygomaticus activity increased rapidly and involuntarily to both happy faces and flowers, and corrugator activity increased rapidly and involuntarily to both angry faces and snakes. As the snakes and flowers could not invoke a mimicry effect, the facial expressions must be a reflection of the participants' endogenous emotions. Therefore there is at least a possibility that the facial stimuli were inducing an emotional expression as well, rather than eliciting mimicry. Similarly, we were interested in whether incongruent emotions could be expressed independent of a facial stimulus if one's endogenous emotional state was incongruent with the valence of the perceived stimulus. To this end, participants were shown images of hands and feet in positions of pain, or in similar, non-painful positions. If an incongruent emotion was felt towards the facial stimuli, then the same emotion should be felt towards non-facial stimuli. Thus, if the EMG pattern shows a significant difference between the two stimuli types, then RFRs to facial stimuli may not be a mere reflection of internal emotions to the perceived emotion. While Dimberg et al. tested this possibility using snakes and flowers, it may be beneficial to explore the effects of individual traits on this relationship. As such, in the present study we use non-facial stimuli that display distress cues, and have the potential to elicit empathy, or alternatively, an incongruent response.

1.10.2   Everyday Sadism

In addition to the potential unique effect of facial stimuli on RFRs, we were interested in the potential interaction of individual traits on this relationship. In order to fully explore these questions, we used trait sadism as a measure of the effect of individual differences, while also testing the experience of incongruent emotions on facial stimuli. Everyday sadism manifests in the pleasure taken at another person's distress. It differs from sexual and criminal sadism in that it is a subclinical form of sadism that is found normally distributed throughout a community sample (Buckels, Jones, & Paulhus, 2013). Similar to the concept of *Schadenfreude*, examples of the social acceptance of everyday sadism

can be seen in the popularity of violence in sports and video games, the common experience of bullying in school, or the infamous "trolls" on the Internet. Sadism has recently been added to a group that consists of a constellation of traits that predict antisocial behaviour. Initially called the Dark Triad (Paulhus & Williams, 2002), the renamed Dark Tetrad (Chabrol, Van Leeuwen, Rodgers, & Séjourné, 2009) includes narcissism, Machiavellianism, psychopathy, and now sadism. Inclusion into this group acknowledges sadism's relation to the other traits in the common propensity for callous exploitation, yet each trait predicts a specific kind of antisocial behaviour independently from the others. Everyday sadism is a prime example of experiencing incongruent emotions to those observed in others. As opposed to those high in emotional empathy, who would experience emotion contagion upon viewing others in pain (Hatfield, Rapson, & Le, 2009), everyday sadists feel positive affect upon observing others in pain. Everyday sadists are defined by their very incongruence, and thus present a distinctly unique opportunity to investigate RFRs in the presence of endogenous incongruent emotions.

Pain is integral to the study of sadism, as it is the pain response that elicits a reaction in individuals with high trait sadism. Pain has been used in interesting ways to detect emotional and empathic reactions (Akitsuki & Decety, 2009; Decety, Chen, Harenski, Kiehl, & Parvizi, 2013; Jackson, Meltzoff, & Decety, 2005; Lamm, Batson, & Decety, 2007). Through using pain stimuli in this study in both limbs and faces, we are able to measure the RFRs to stimuli that may theoretically have a negative valence to those low in trait sadism, but will induce a pleasure experience in those who are high in trait sadism. This uniquely allows for the measurement of the impact that individual trait differences have on the relationship between facial stimuli and RFRs.

1.11   Dynamic versus Static Stimuli

While studying the RFRs in response to experimentally controlled stimuli, past studies have presented the stimuli as either static (Dimberg & Thunberg, 1998; Philip, Martin, & Clavel, 2018; Tassinary & Cacioppo, 1992) or dynamic (Drimalla et al., 2019; Krumhuber, Likowski, & Weyers, 2014; Moody & McIntosh, 2011) images. There are benefits and drawbacks to each kind of stimulus, which should be considered in relation

to the goals of each study when choosing a stimulus type. Static images were used for a long time with RFR studies due to the technological limitations of early studies in producing and presenting realistic and reliable dynamic stimuli (Dimberg, 1982; Dimberg & Lundqvist, 1990; Lundqvist & Dimberg, 1995). Another benefit to using static emotional images is the clear onset of the stimuli, thus providing an unambiguous time course for the EMG signal. In contrast, dynamic stimuli transition through many degrees of the target expression. Decisions must be made about whether to consider the initial transition away from a neutral expression as the onset of the stimulus, or to rather consider the peak of the expression the stimulus onset. Due to the spontaneous and rapid nature of RFRs, being measured to the magnitude of hundreds of milliseconds (Dimberg & Thunberg, 1998), this decision can be crucial to the analysis of the results. The variability of these decisions by studies results in potentially less consistent results between studies.

Past studies have compared the difference seen in EMG signal when observing dynamic versus static stimuli. While there have been varying conclusions regarding which emotions show the greatest differences, every study has shown more exaggerated EMG responses to dynamic stimuli compared to static stimuli for some emotions (Rymarczyk, Biele, Grabowska, & Majczynski, 2011; Sato & Yoshikawa, 2007; Weyers, Mühlberger, Hefele, & Pauli, 2006). Dynamic expressions have also been shown to improve emotion recognition, and show higher intensity and realism ratings compared to static images (Rymarczyk et al., 2011; Weyers et al., 2006). Additionally, brain regions that are involved in emotion perception are more widely activated while observing dynamic facial expressions compared to static ones (Trautmann, Fehr, & Herrmann, 2009). It is important to note, however, that while each stimulus type have their own benefits and drawbacks, both static and dynamic stimuli reliably elicit RFRs (Rymarczyk et al., 2011; Rymarczyk, Żurawski, Jankowiak-Siuda, & Szatkowska, 2016), and are thus both valid types of stimuli to use.

1.12   Present Study

Rather than exploring incongruent expressions elicited by experimental manipulations, everyday sadists present an opportunity to investigate the effects of individual trait

differences on the mechanisms of RFRs. To show this, we used pictures of faces and limbs in pain or non-pain to distinguish between the effect faces have on eliciting RFRs, and whether that produces a significant effect on displaying endogenous emotions. Through using limbs as the non-facial stimuli, we can assess participants' reactions to stimuli that can elicit empathy separate from a response to a facial expression. We measured participants' facial activity through electromyography (EMG) to allow the rapid and subtle muscle movements to be recorded as accurately as possible. Through our study, we hypothesize that RFRs to emotional stimuli do not always match the expression directly, but instead are modulated by the emotional trait of the observer in response to perceived emotion. We predict that sadistic traits will be associated with a reduction in emotion-congruent RFRs, and an increase in emotion-incongruent RFRs. We also predict that RFRs in response to limbs in pain will match the congruency of RFRs to pain faces.

Chapter 2

2 Methods

2.1 Participants

Eighty-one participants (25 males, 56 females) took part in this study. All participants were in good physical health and reported having no history of psychiatric or neurological diagnoses. Participants also had normal or corrected-to-normal vision, and had never used Botox. Flyers were used for participant recruitment. Data from one participant had to be excluded due to technical malfunctions. Thus, EMG analyses were conducted with eighty participants aged 18 to 45 (mean age = 24.75, SD = 6.25). Informed consent was obtained from all participants, and they were compensated $15/hour for their participation. This study was approved by the Health Sciences Research Ethics Board at the University of Western Ontario, London, Ontario, Canada.

2.2 Stimuli and Procedures

EMG recordings were collected while the participants viewed the stimuli, using bipolar placement of 4mm shielded Ag/Ag-Cl surface electrodes (EL254S, BIOPAC Systems, Inc.). Electrodes were placed above the corrugator supercilii and zygomaticus major muscles according to guidelines (Fridlund & Cacioppo, 1986). Prior to electrode placement, the surface of the skin at each location was cleaned with an alcohol wipe, followed by an abrasive Nuprep gel to remove any dead skin cells and excess oils. The electrodes were then filled with conductive gel (GEL100, BIOPAC Systems, Inc.) and placed on the skin. Data were bandpass filtered with a frequency range of 20-500 Hz using an EMG100C module. The signals were integrated and rectified using the root mean squared (rms) technique, then averaged across 100ms intervals from 1000ms pre-stimulus onset to the end of the 2000ms stimulus.

Participants were seated in a dimly lit room, and were instructed to keep movement to a minimum and to refrain from speaking, so as to avoid introducing artefacts into the EMG data. Participants then began a computerized task which was displayed on a PC using the

E-Prime 3.0 software (Psychology Software Tools, Pittsburgh, USA). One of two tasks would begin, the order of which was counterbalanced.

Task 1 – Painful Facial Expressions Task (Decety, Skelly, Yoder, & Kiehl, 2014): Participants would first review instructions explaining the upcoming task, and then completed one practice run to ensure complete understanding of the task. Once ready to begin, participants were shown a 2000ms fixation cross, followed by a 2000ms video of an actor displaying either an expression of pain or happiness. The videos were comprised of 3 male and 3 female actors, each displaying each emotion once as used in prior research (Decety et al., 2014). Participants were then asked 3 questions, the order of which was counterbalanced. Using the numbers on the keyboard to indicate their answers, the participants were asked to identify which emotion they had just seen, how genuine the emotion was on a scale of 1 to 9, and how intense the emotion was on a scale of 1 to 9. The order of each corresponding number to each answer was counterbalanced across participants. This repeated 36 times until every video was displayed once.

Task 2 – Painful Limbs Task (Decety, Michalska, Akitsuki, & Lahey, 2009): Participants would first review instructions explaining the upcoming task, and then completed one practice run to ensure complete understanding of the task. The stimuli in this task were comprised of static images of 3 hands in positions of pain (e.g. hand stuck in door), 3 hands in similar, but neutral positions (e.g. hand on door handle), 3 feet in positions of pain (e.g. stepping on glass), and 3 feet in similar but neutral positions (e.g. foot beside a glass cup) (Decety et al., 2009). All images were of situations that a participant could relate to their own lives, as they were everyday situations. Once ready to begin, participants were shown a 2000ms fixation cross, followed by a 2000ms image of a limb in a painful or neutral situation (Decety et al., 2009). Participants were then asked 3 questions, the order of which was counterbalanced. Using the numbers on the keyboard to indicate their answers, the participants were asked to identify whether the limb they viewed was in pain or no pain, how realistic the situation was on a scale of 1 to 9, and how intense the pain was on a scale of 1 to 9. The order of each number corresponding to each answer was counterbalanced across participants. This repeated 24 times until every image was displayed once.
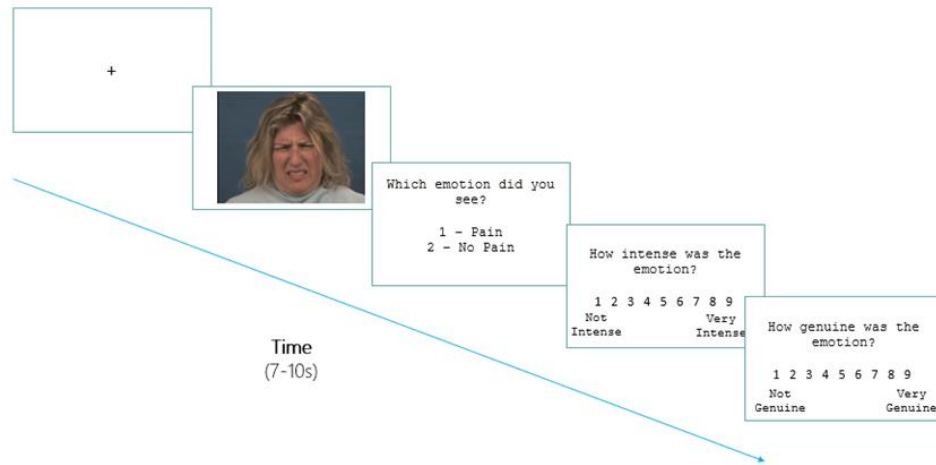
Figure 1: Example of Painful Facial Expressions Task
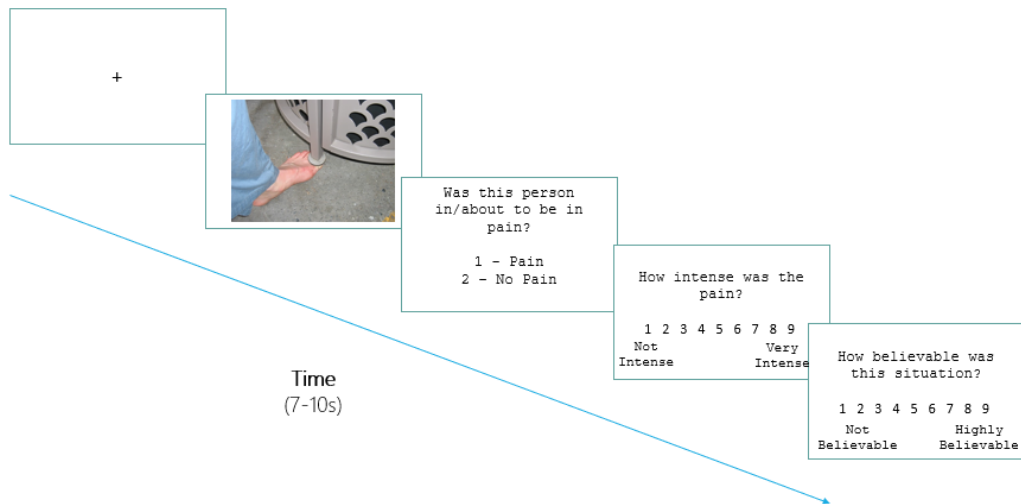
Figure 2: Example of Painful Limbs Task

2.3   Measures

2.3.1   Comprehensive Assessment of Sadistic Traits (CAST)

The CAST (Buckels & Paulhus, 2013) was administered to participants in order to assess their levels of trait sadism. The CAST is an 18 item self-report scale that was designed for a subclinical population, and thus is most appropriate to assess our community sample. Subjects are given a total score ($\alpha = 0.89$) by calculating the mean of the 18 items, as well as a score on three subscales: verbal direct sadism (e.g. "I was purposely mean to some people in high school"; $\alpha = 0.81$), physical direct sadism (e.g. "I enjoy physically hurting people"; $\alpha = 0.83$), and vicarious sadism (e.g. "I enjoy playing the villain in games and torturing other characters"; $\alpha = 0.82$). The verbal direct subscale assesses an individual's enjoyment of causing verbal harm to others in person, whereas the physical direct subscale assesses an individual's enjoyment of causing physical harm to others in person. In contrast, the vicarious subscale assesses an individual's enjoyment of causing harm to others through simulated and/or fantasized means. Responses are made on a 7-point scale ranging from "Strongly Disagree" to "Strongly Agree". This measure was validated through the administration of this measure to samples of university students and community adults (N = 5,553) (Buckels, 2018).

2.4   Data Analysis

Data were analyzed separately for each task using IBM Statistical Package for Social Sciences version 26. In order to standardize results, the EMG signals were transformed to be a percentage of baseline, in accordance with suggestions from Boxtel (2010). To obtain the percentage of baseline values, each EMG signal value was divided by the mean of 1000ms pre-stimulus. To reduce variability within participant data, Z-normalized scores were obtained per participant, within muscle sites and stimulus type. Thus, since participants viewed the same type of stimulus multiple times across various actors and limbs, any significant within-subject outliers could be excluded. Trials that exceeded 2 SD were excluded, resulting in 4.4% of trials being excluded for corrugator; 4.9% for zygomaticus for Task 1, and 5% for corrugator; 5.2% for zygomaticus for Task 2. Data

were then averaged for each participant by muscle site and stimulus type, and then segmented into 500ms bins, resulting in Bin 1 (0-500ms), Bin 2 (500-1000ms), Bin 3 (1000-1500ms), and Bin 4 (1500-2000ms). These were then tested between-subjects for multivariate outliers using Mahalanobis Distances, resulting in the exclusion of 7 participants from Task 1 and 9 participants from Task 2.

For each task, a repeated measures ANOVA was conducted to compare mean differences in EMG activation for corrugator and zygomaticus to painful and non-painful stimuli. The threshold for significance was set at $p < 0.05$ for planned comparisons and post-hoc tests. Using an approach employed in previous work to examine the interaction between trait empathy and EMG response (Harrison, Morgan, & Critchley, 2010), we included CAST as a continuous between-subjects variable to determine the interaction of each of these factors with everyday sadism, and repeated this analysis. A Greenhouse-Geisser correction was used for all main effects and interactions that had a significant Mauchly's Test of Sphericity ($p > 0.05$).
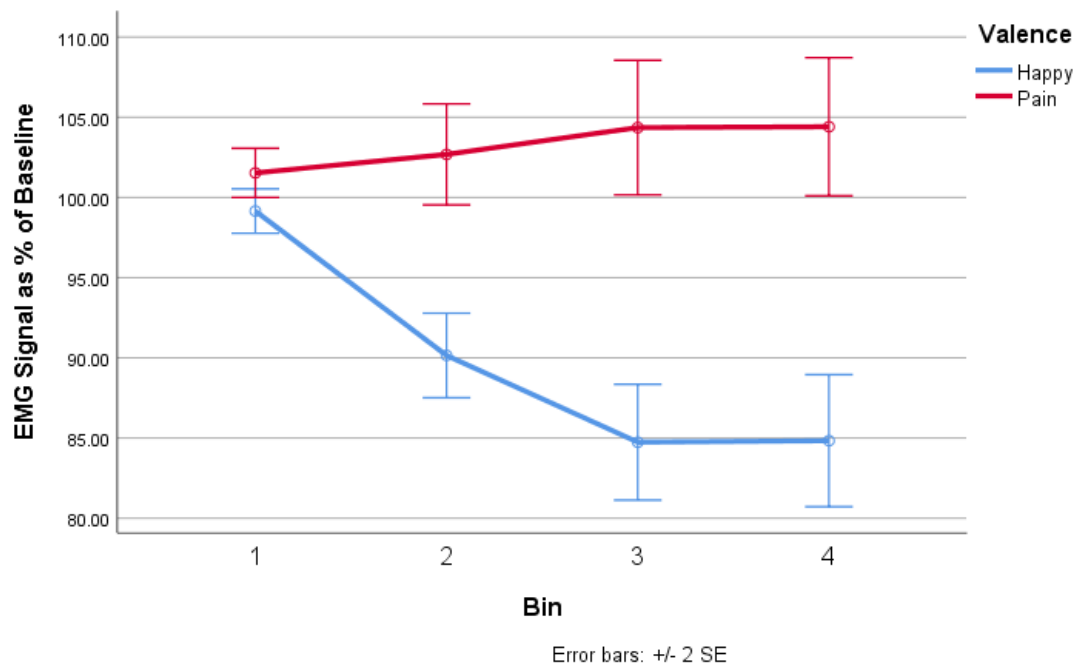
Chapter 3

3   Results
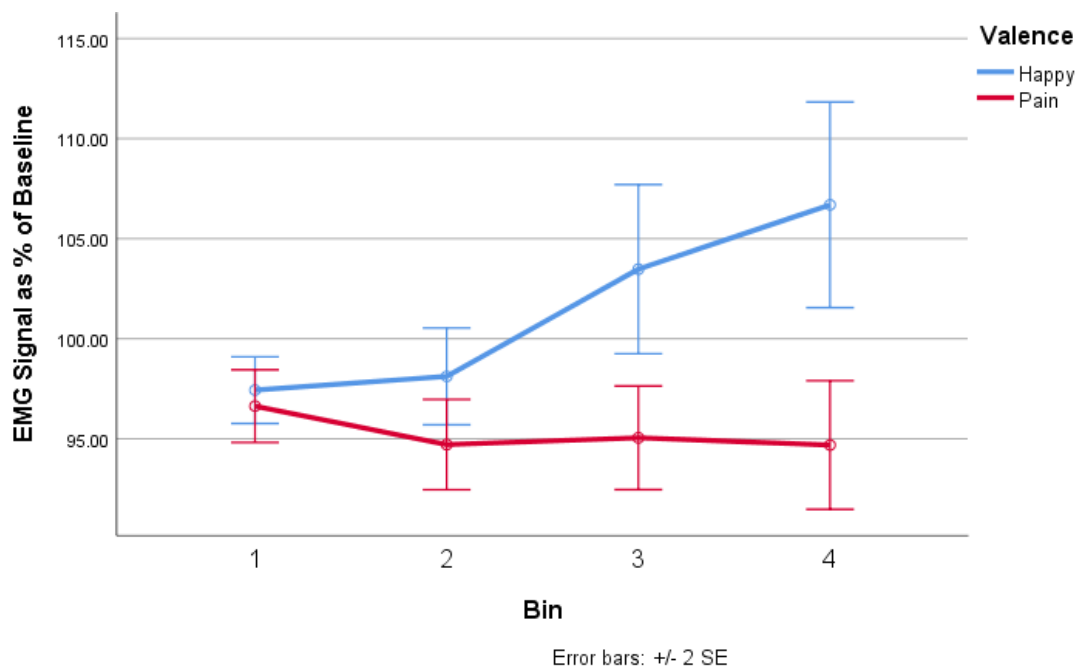
3.1   Painful Facial Expressions

First, we conducted a 2 (Valence pain, happy) x 2 (Muscle: corrugator, zygomaticus) x 4 (Temporal windows Bin: 1-4) repeated measures ANOVA using the EMG response as the outcome of interest. There was a significant main effect of valence ($F(1,72) = 13.320$, $p < 0.001$), but no significant effect of muscle ($F(1,72) = 1.113$, $p = 0.295$) or bin ($F(1.671,120.28) = 2.986$, $p = 0.063$). We found a significant interaction between valence x muscle ($F(1, 72) = 84.036$, $p < .001$), valence x bin ($F(1.832, 131.880) = 5.627$, $p = 0.006$), and muscle x bin ($F(1.625, 117.021) = 16.909$, $p < .001$). All effects were qualified by a significant 3-way interaction, valence x muscle x bin ($F(1.552, 111.726) = 46.856$, $p < .001$).

To characterize the nature of this interaction, we conducted separate 2 (Valence) x 4 (Bin) ANOVAs for each muscle. For corrugator, these analyses showed a significant main effect of valence ($F(1,72) = 73.725$, $p < 0.001$) and bin ($F(1.508,108.587) = 11.290$, $p < 0.001$), as well as a significant interaction between valence and bin ($F(1.626,117.075) = 41.553$, $p < 0.001$). A series of paired t-tests were then conducted to further characterize the interaction. For all bins, corrugator had greater activation to pain faces than to happy faces, with the greatest difference found at bins 3 ($t(72) = 8.445$, $p < 0.001$) and 2 ($t(72) = 8.193$, $p < 0.001$). For zygomaticus, these analyses showed a significant main effect of valence ($F(1,72) = 20.398$, $p < 0.001$) and bin ($F(1.714,123.438) = 7.083$, $p = 0.002$). There was a significant interaction between valence and bin ($F(1.639,117.993) = 14.886$, $p < 0.001$). However, zygomaticus showed significantly greater activity to happy relative to pain expressions for bins 2-4, with the greatest difference found at bin 4 ($t(72) = -4.684$, $p < 0.001$) and bin 3 ($t(72) = -4.441$, $p < 0.001$). Thus, the interaction was generally characterized by: increased corrugator activity to painful relative to happy expressions in all bins, particularly at bins 2 and 3; in contrast, zygomaticus showed increased activity to happy relative to painful expressions in bins 2-4.

Additionally, corrugator EMG response to pain faces were found to be significantly greater than baseline at bin 1 ($t(72) = 1.998$, $p = 0.049$), bin 3 ($t(72) = 2.073$, $p = 0.042$, and bin 4 ($t(72) = 2.047$, $p = 0.044$, but not significantly different from baseline at bin 2 ($t(72) = 1.707$, $p = 0.092$). Corrugator EMG response to happy faces were found to be significantly lower than baseline at bin 2 ($t(72) = -7.469$, $p < 0.001$), bin 3 ($t(72) = -8.447$, $p < 0.001$), and bin 4 ($t(72) = -7.369$, $p < 0.001$), but not significantly different from baseline at bin 1 ($t(72) = -1.230$, $p = 0.223$). Zygomaticus EMG response to pain faces were found to be significantly lower than baseline at bin 1 ($t(72) = -3.717$, $p < 0.001$), bin 2 ($t(72) = -4.689$, $p < 0.001$), bin 3 ($t(72) = -3.823$, $p < 0.001$), and bin 4 ($t(72) = -3.307$, $p < 0.001$). Zygomaticus EMG response to happy faces were found to be significantly lower than baseline at bin 1 ($t(72) = -3.086$, $p = 0.003$), then significantly greater than baseline at bin 4 ($t(72) = 2.605$, $p = 0.011$), but were not significantly different from baseline at bin 2 ($t(72) = -1.557$, $p = 0.124$), and bin 3 ($t(72) = 1.645$, $p = 0.104$).

Figure 3: EMG response as a function of time since stimulus onset and the emotional valence of facial expressions for corrugator supercilii

Figure 4: EMG response as a function of time since stimulus onset and the emotional valence of facial expression stimuli for zygomaticus major

3.2   Painful Limbs

We conducted a 2 (Valence: pain, neutral) x 2 (Muscle: corrugator, zygomaticus) x 4 (Bin: 1-4) repeated measures ANOVA using the EMG response as the outcome of interest. There was a significant main effect of muscle ($F(1,66) = 13.423$, $p < .001$), but no main effect of valence ($F(1,66) = 3.298$, $p = 0.074$) or bin ($F(1.805,119.145) = 2.984$, $p = 0.060$). We found a significant valence x muscle interaction ($F(1,66) = 8.355$, $p = 0.005$), but no significant interactions between valence x bin ($F(2.088,137.775) = 1.870$, $p = 0.156$), nor muscle x bin ($F(1.813,119.635) = 0.105$, $p = 0.884$). However, a significant 3-way valence x muscle x bin interaction emerged ($F(1.867,123.253) = 8.435$, $p = .001$).

To characterize the nature of this 3-way interaction, we conducted separate 2 (Valence) x 4 (Bin) ANOVAs for each muscle. For zygomaticus, these analyses showed a significant main effect of valence ($F(1,66) = 8.768$, $p = 0.004$) but not bin ($F(1.957,129.163) =$

2.317, p = 0.104). There was a significant valence x bin interaction (F(1.970,130.022) = 6.689, p = 0.002). A series of paired t-tests were then conducted to further characterize the interaction. Zygomaticus showed significantly greater activity to limbs in pain relative to neutral limbs for bins 2-4, with the greatest difference found at bin 3 (t(66) = 3.568, p = 0.001). For corrugator, there was no significant main effect of valence (F(1,66) = 0.230, p = 0.633) nor bin (F(1.709,112.763) = 1.421, p = 0.246). There was no significant interaction between valence x bin (F(2.071,136.716) = 1.487, p = 0.229). Thus for zygomaticus, but not corrugator, significantly more activity to pain versus neutral limbs emerges over time.

Additionally, corrugator EMG response to limbs in pain were found to be significantly greater than baseline at bin 1 (t(66) = 2.501, p = 0.015), but not significantly different from baseline at bin 2 (t(66) = 0.194, p = 0.847), bin 3 (t(66) = 0.882, p = 0.381) and bin 4 (t(66) = 1.082, p = 0.283). Corrugator EMG response to neutral limbs were found to be significantly greater than baseline at bin 4 (t(66) = 2.452, p = 0.017), but not significantly different from baseline at bin 1 (t(66) = 1.481, p = 0.143), bin 2 (t(66) = 1.028, p = 0.308), nor bin 3 (t(66) = 1.630, p = 0.108). Zygomaticus EMG response to limbs in pain were found to be significantly lower than baseline at bin 1 (t(66) = -3.688, p < 0.001), and bin 2 (t(66) = -2.763, p = 0.007), but not significantly different from baseline at bin 3 (t(66) = -0.256, p = 0.799), and bin 4 (t(66) = -0.72, p = 0.943). Zygomaticus EMG response to neutral limbs were found to be significantly lower than baseline at bin 1 (t(66) = -3.133, p = 0.003), bin 2 (t(66) = -5.246, p < 0.001), bin 3 (t(66) = -5.428, p < 0.001), and bin 4 (t(66) = -4.333, p < 0.001).

Figure 5: EMG response as a function of time since stimulus onset and the emotional valence of limb stimuli for corrugator supercilii

Figure 6: EMG response as a function of time since stimulus onset and the emotional valence of limb stimuli for zygomaticus major
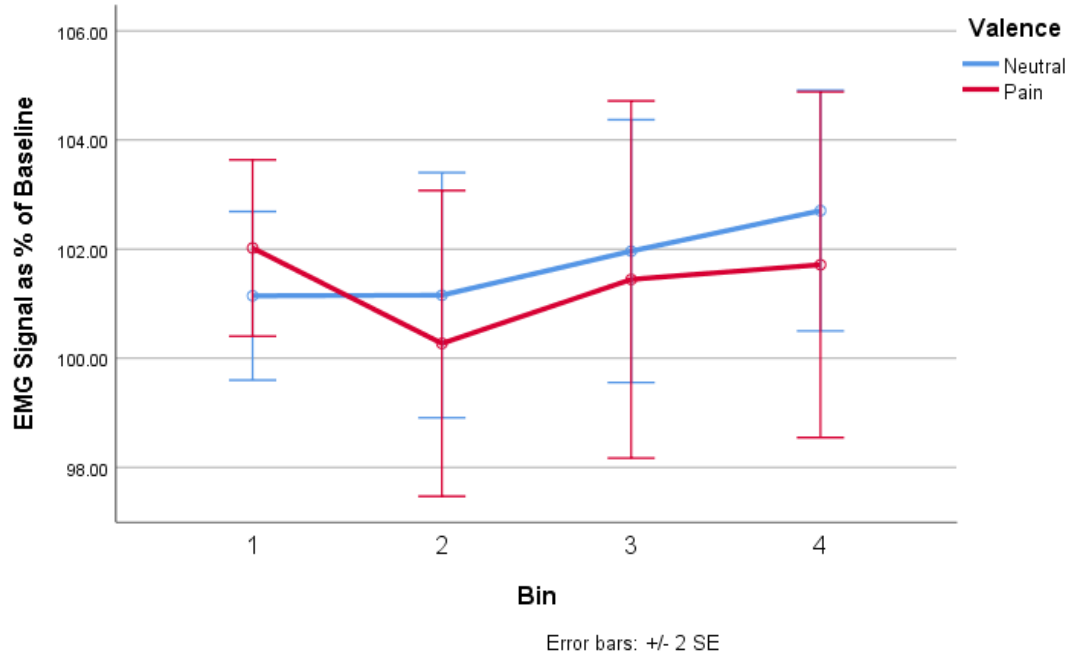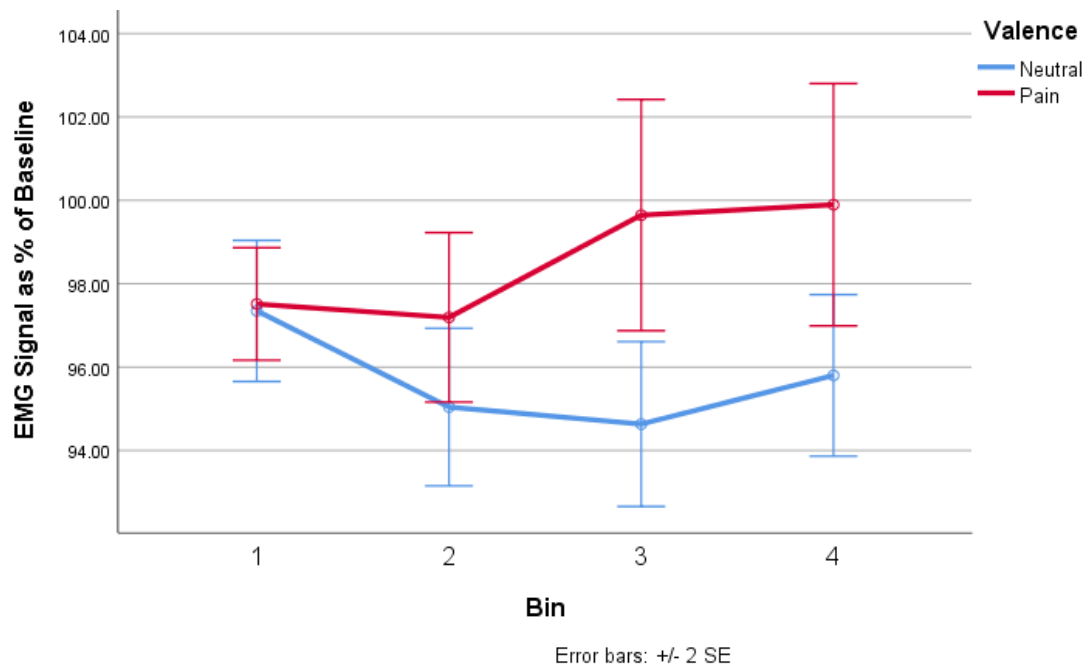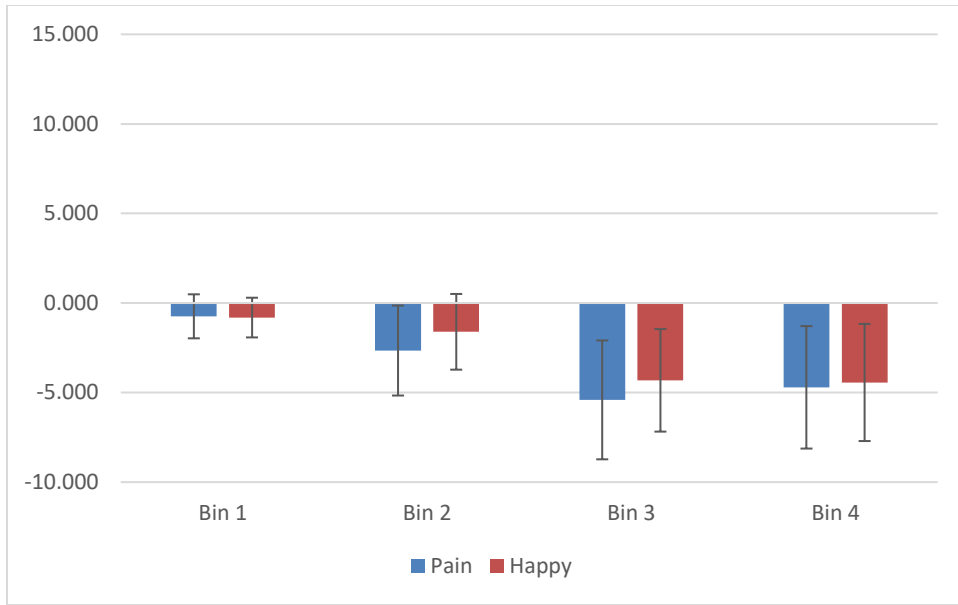
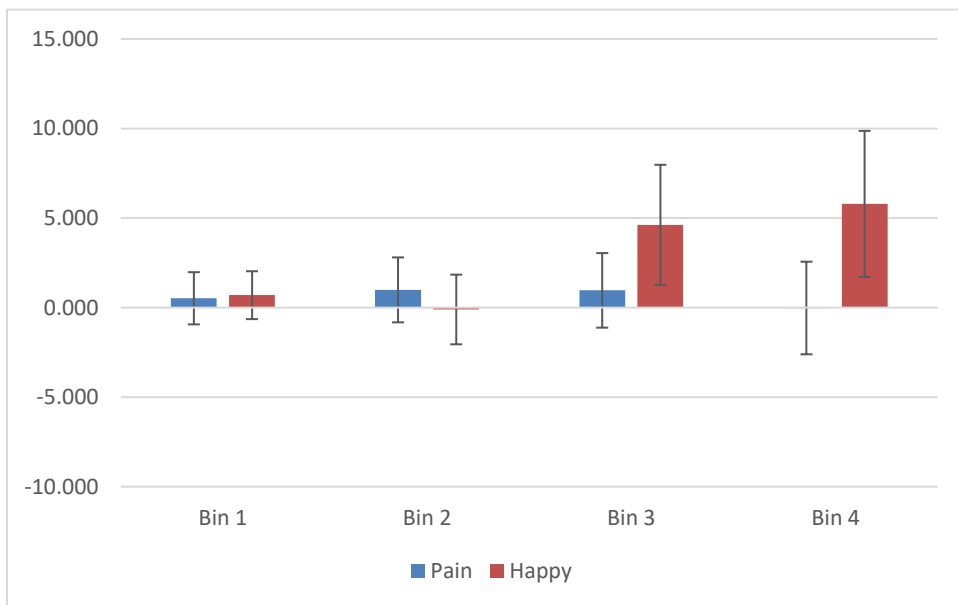## 3.3 Everyday Sadism and Painful Facial Expressions

In order to delineate the potential impact of everyday sadism on the RFRs in reaction to viewing happy and painful faces, we included CAST as a continuous between-subjects variable in our previous 2 (Valence: pain, happy) x 2 (Muscle: corrugator, zygomaticus) x 4 (Bin: 1-4) repeated measures ANOVA and focussed on effects involving CAST. There was no significant main effect of CAST as a continuous between-subjects factor $(F(1,71) = 0.384, p = 0.538)$. However there was a significant 3-way interaction, muscle x bin x CAST $(F(1.650, 117.161) = 3.911, p = 0.030)$. In order to delineate the nature of this interaction, a series of regression analyses were performed, followed by a comparison of the beta weights associated with factors identified in the 3-way interaction. The regression analyses revealed that CAST was not a significant independent predictor of EMG responses to any stimuli. To compare the beta weights, the 95% confidence intervals of the unstandardized beta weights were estimated via bias corrected bootstrap (1000 re-samples). In the event that the confidence intervals overlapped by less than 50%, the beta weights would be considered statistically significantly different from each other $(p < 0.05;$ Cumming, 2009). The confidence intervals of happiness at bin 4 was compared between the corrugator and zygomaticus, and found to be significantly different $(\Delta\beta = 10.23)$. Higher CAST scores were associated with more zygomaticus activity and lower corrugator activity to happy faces. Thus, the association between CAST and EMG activity is significantly higher for zygomaticus than corrugator at bins 3 and 4.

Figure 7: Unstandardized beta weights for CAST and corrugator to faces across 2000ms

Figure 8: Unstandardized beta weights for CAST and zygomaticus to faces across 2000ms

3.4   Everyday Sadism and Painful Limbs

In order to delineate the potential impact of everyday sadism on the RFRs in reaction to viewing limbs in pain and neutral limbs, we included CAST as a continuous between-subjects factor in our previous 2 (Valence: pain, neutral) x 2 (Muscle: corrugator, zygomaticus) x 4 (Bin: 1-4) repeated measures ANOVA. There was no significant main effect of CAST as a continuous between-subjects factor ($F(1,65) = 0.199$, $p = 0.657$). Nor were there any significant interactions. Thus, CAST did not have a significant impact on EMG outcome measures regardless of valence, muscle, or timepoint

3.5   Subjective Ratings

Out of a maximum score of 9, the average ratings were as follows: genuineness for limbs in pain was 5.88 (SD = 1.33), genuineness for faces in pain was 5.36 (SD = 1.47), genuineness for neutral limbs was 7.28 (1.27), genuineness for happy faces was 6.52 (SD = 1.13), intensity for limbs in pain was 6.88 (SD = 1.16), intensity for faces in pain was 6.27 (SD = 1.28), intensity for neutral limbs was 1.69 (SD = 0.69), intensity for happy faces was 6.19 (SD = 1.11). The genuineness ratings of limbs in pain were not significantly different from the genuineness ratings of faces in pain ($t(167) = 0.921$, $p = 0.358$), nor were the genuineness ratings of neutral limbs significantly different from the genuineness ratings of happy faces ($t(185) = 0.254$, $p = 0.800$). However, the intensity ratings of limbs in pain were significantly greater than the intensity ratings of faces in pain ($t(179) = 3.52$, $p < 0.001$), and the intensity ratings of neutral limbs were significantly less than the intensity ratings of happy faces ($t(176) = 17.947$, $p < 0.001$). Neither the genuineness nor intensity ratings for limbs nor faces correlated with CAST scores. CAST scores were not significantly correlated with genuineness ratings for limbs in pain ($r = 0.052$, $p = 0.650$), neutral limbs ($r = 0.054$, $p = 0.639$), pain faces ($r = 0.036$, $p = 0.750$), happy faces ($r = 0.066$, $p = 562$). CAST scores were not significantly correlated with intensity ratings for limbs in pain ($r = 0.120$, $p = 0.294$), neural limbs ($r = 0.097$, $p = 0.394$), pain faces ($r = 0.102$, $p = 0.369$), nor happy faces ($r = 0.135$, $p = 0.237$).

Chapter 4

4   Discussion

4.1 Study Results

RFRs are a key component in social communication (Lakin et al., 2003), and are already being used as a measure of empathy (Harrison et al., 2010; Hermans, Putman, & Van Honk, 2006), yet the mechanisms behind them are still not well understood. The directionality of emotional facial expressions and internal emotional feelings is still unclear. The motor-matching theories position RFRs as a rigid phenomenon, resistant to contextual modulation. More recent evidence has shown that RFRs are able to be modulated by context, though the extent to which this is possible is still unclear. Through using incongruent responses and individual trait differences, this study aimed to determine whether RFRs are a function of motor-matching mimicry or endogenous emotions. Additionally, there has been a lack of clarity in the literature concerning the unique effects of facial stimuli on RFRs compared to other stimuli. This study uses facial stimuli and non-facial stimuli so as to elucidate the extent of the impact that facial stimuli may have on the modulation of RFRs by internal emotions and individual traits. This study is the first to examine the effects of incongruent endogenous emotions through everyday sadism on RFRs in response to painful facial and non-facial stimuli. Through examining any differences in RFRs between facial and non-facial stimuli, we hoped to determine if there was a unique effect of facial stimuli on eliciting motor-matching RFRs.

We hypothesized that RFRs to emotional stimuli do not always match the expression directly, but instead are modulated by the emotional trait of the observer in response to perceived emotion. Specifically, we predicted that sadistic traits would be associated with a reduction in emotion-congruent RFRs, and an increase in emotion-incongruent RFRs. We also predicted that RFRs in response to limbs in pain will match the congruency of RFRs to pain faces. Contrary to our first prediction, we found that sadistic traits were associated with an increase in emotion-congruent RFRs to faces. Contrary to our second prediction, we found that RFRs in response to limbs in pain were not significantly different from baseline, while faces in pain elicited congruent RFRs. Interestingly, RFRs

to neutral limbs produced an increase in corrugator activity and a decrease in zygomaticus activity. Together, these results are consistent with the suggestion that facial stimuli do in fact have a specific effect that can elicit RFRs independent of endogenous emotions. From our results, we can see that this relationship between individual sadistic traits and RFRs is much less straightforward than we originally thought.

4.2 RFRs to facial expressions of pain and limbs in painful situations

In this study we aimed to determine if facial stimuli had a unique ability to elicit RFRs independently of endogenous emotions. If participant RFRs to both facial and non-facial stimuli were in the same direction, then endogenous emotions would likely be driving the RFRs. However, results showed that there were some interesting differences between the facial stimuli and limbs stimuli. For facial expressions, congruent RFRs were seen in response to both valences. For pain expressions, the corrugator EMG signal was elevated and the zygomaticus EMG signal was depressed. Whereas for the happy expressions, the zygomaticus EMG signal was eventually elevated and the corrugator EMG signal was depressed. Non-facial stimuli elicited a more complicated relationship. Limbs in pain elicited corrugator and zygomaticus EMG signals that did not significantly differ from baseline. However, neutral limbs elicited increased corrugator and decreased zygomaticus. When adding everyday sadism as a continuous between-subjects factor of interest, sadism had no significant impact on EMG response to facial nor non-facial stimuli, regardless of valence. However, we found that zygomaticus EMG responses were significantly more associated with sadism than corrugator.

4.3 Interpretation

In our first analysis, we were interested in determining if there were any significant differences between RFRs in response to facial versus non-facial stimuli. Significant differences were found, with congruent RFRs found in response to both pain and happy facial stimuli, and baseline signal in response to limbs in pain and increased corrugator to neutral limbs. These results seem to suggest that facial stimuli do in fact have a unique effect on RFRs compared to non-facial stimuli. One's response to pain, be it facial or

non-facial, should in theory remain consistent. This difference between the types of stimuli indicates that the internal emotions were displayed in relation to the limbs stimuli, but facial stimuli elicited RFRs regardless of endogenous emotions.

Another reason for the difference found between facial and non-facial stimuli may be due to the dynamic nature of the facial stimuli as opposed to the static images of the limbs. Studies have shown larger effects for dynamic stimuli than static (Rymarczyk et al., 2011; Sato & Yoshikawa, 2007; Weyers et al., 2006). However static images do consistently elicit significant responses (Dimberg, 1982; Rymarczyk et al., 2011), so this would not account for the lack of response to the limbs in pain. The increased corrugator and decreased zygomaticus activity in response to neutral limbs relative to limbs in pain was an unexpected result.

In our second analysis, we were interested in testing our prediction; that sadistic traits would be associated with a reduction in emotion-congruent RFRs, and an increase in emotion-incongruent RFRs. Again, the effects found were different from what we expected, seeing instead no significant relationship between sadism and EMG response to facial and non-facial stimuli in positions of pain or no pain. Sadism was, however, significantly more associated with zygomaticus EMG activity than corrugator EMG activity at later timepoints, indicating a potential increase in congruent RFRs in response to facial stimuli. A number of possible explanations can be speculated for this result. In regard to the trend of a potential increase in congruent RFRs to facial stimuli, it may be that, similar to highly empathic individuals, emotional expressions in others are more salient than it would be to someone of average to low empathy (Preston & de Waal, 2002). However for the highly empathic individual, the salience is due to helping or compassion motivations, whereas the highly sadistic individual is motivated by pleasure. If this is the case, then displaying congruent RFRs to limbs would not enhance the pleasure experience for sadism, as there is no emotion visible to recognize, and thus the limbs would not be as salient as the facial stimuli. Therefore, we do not see any effect of everyday sadism on limbs.

Another interpretation may be that sadism and masochism are more closely linked than once thought (Fedoroff, 2008; World Health Organization, 1992). It may be that when an increase in congruent RFRs facilitates an increase in emotion contagion, the pleasure that is derived from seeing others in pain is actually rooted in pleasure felt at experiencing pain oneself. Consider the phenomenon of the horror movie as a common example of this. Though the goal of the horror film is to induce fear, and at times disgust, in the viewer - emotions that are commonly considered to be of a negative valence - many revel in this feeling and return to this experience repeatedly (Martin, 2019).

4.4   Limitations and Future Directions

One limitation of this study was that, subjective ratings of their endogenous emotions were not collected from participants, and as such we cannot be sure whether the expressions towards limbs were a true representation of their emotions or not. Additionally, genuineness and intensity ratings were collected, and though genuineness ratings were not significantly different between the limbs and faces stimuli, limbs in pain were rated as being significantly more intense than faces in pain, while happy faces were rated as more intense than neutral faces. Ideally, future studies would acquire stimuli that were matched in both dimensions. Furthermore, as previously mentioned, there was a difference in the presentation of stimuli between facial and non-facial stimuli. Facial stimuli were presented as dynamic videos, whereas the limbs were static images. The discrepancy between these methods of presentation could account for some differences observed in the EMG signal activity, but it is difficult to know exactly how much of that difference should be attributed to that discrepancy.

Future studies may want to assess participants' sadistic trait levels through other means than those used in the present study. Using a different or additional questionnaire measures may give a more complete picture of each individual's propensity towards everyday sadism. Alternatively, a behavioural study may corroborate questionnaire results, and circumvent issues that may arise from self-report measures. Buckels et. al (2013) conducted a study that elicited sadistic behaviours by giving participants an optional work task that rewarded participants with the supposed ability to blast an innocent opponent with a loud sound. Adding an element such as this to RFR studies may

provide interesting results. Future studies may also benefit from using fMRI to investigate these relationships. In doing so, the neural correlates of sadistic traits in relation to others' pain may become more apparent, and thus aid in elucidating the complexities of everyday sadism in relation to empathy.

4.5   Conclusion

Overall, these results seem to suggest that RFRs are even more nuanced than originally thought. This study aimed to determine the extent to which individual traits and endogenous emotions could modulate RFRs. This was done by examining the differential effects of facial stimuli, compared to non-facial stimuli, on eliciting RFRs. As effect sizes were relatively small, any interpretation should be treated with caution, but it appears as though facial stimuli elicit a response that may not be the same as participants' endogenous feelings towards pain, as is evidenced by the differences between facial and non-facial stimuli. Everyday sadism did not prove to be a significant predictor of EMG response to facial nor non-facial stimuli. In light of these results, there may be implications in support of the facial feedback theory. Facial feedback may be a means by which RFRs increase the effects of emotion contagion or emotion recognition, due to the pleasing nature of distress cues. Future studies may help in clarifying this relationship further. Ultimately this novel study will help shed light on the intricate mechanisms of the physiology of empathy. In identifying how each population differs in the ability to empathize, this important trait can be understood better.

References

Akitsuki, Y., & Decety, J. (2009). Social context and perceived agency affects empathy for pain: An event-related fMRI investigation. *NeuroImage*, *47*, 722–734. https://doi.org/10.1016/j.neuroimage.2009.04.091

Bourgeois, P., & Hess, U. (2007). The impact of social context on mimicry. *Biological Psychology*, *77*, 343–352. https://doi.org/10.1016/j.biopsycho.2007.11.008

Boxtel, A. Van. (2010). Facial EMG as a tool for inferring affective states. *Proceedings of Measuring Behavior*, *2010*(August 24-27), 104–108.

Buck, R. (1980). Nonverbal Behavior and the Theory of Emotion: The Facial Feedback Hypothesis. In *Journal of Personality and Social Psychology* (Vol. 38).

Buckels, E. E. (2018). *The Psychology of Everyday Sadism* (Unpublished doctoral dissertation) University of British Columbia, BC, Canada. https://doi.org/10.1038/109368a0

Buckels, E. E., Jones, D. N., & Paulhus, D. L. (2013). Behavioral Confirmation of Everyday Sadism. *Psychological Science*, *24*(11), 2201–2209. https://doi.org/10.1177/0956797613490749

Buckels, E. E., & Paulhus, D. L. (2013). *Comprehensive Assessment of Sadistic Tendencies (CAST)*.

Cabral, J. C. C., Tavares, P. de S., & de Almeida, R. M. M. (2016). Reciprocal effects between dominance and anger: A systematic review. *Neuroscience and Biobehavioral Reviews*, *71*, 761–771. https://doi.org/10.1016/j.neubiorev.2016.10.021

Cacioppo, J. T., Bush, L. K., & Tassinary, L. G. (1992). Microexpressive Facial Actions as a Function of Affective Stimuli: Replication and Extension. *Personality and Social Psychology Bulletin*, *18*(5), 515–526.

Calder, A. J., Keane, J., Campbell, R., & Young, A. W. (2000). Facial Expression Recognition By People With Mobius Syndrome. *Psychology*, *17*(1976), 73–87.

Cannon, P. R., Hayes, A. E., & Tipper, S. P. (2009). An electromyographic investigation of the impact of task relevance on facial mimicry. *Cognition and Emotion*, *23*(5), 918–929. https://doi.org/10.1080/02699930802234864

Carr, E. W., Winkielman, P., & Oveis, C. (2014). Transforming the mirror: Power fundamentally changes facial responding to emotional expressions. *Journal of Experimental Psychology: General*, *143*(3), 997–1003. https://doi.org/10.1037/a0034972

Chabrol, H., Van Leeuwen, N., Rodgers, R., & Séjourné, N. (2009). Contributions of psychopathic, narcissistic, Machiavellian, and sadistic personality traits to juvenile delinquency. *Personality and Individual Differences*, *47*(7), 734–739. https://doi.org/10.1016/j.paid.2009.06.020

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality and Social Psychology*, *76*(6), 893–910. https://doi.org/10.1037//0022-3514.76.6.893

Chartrand, T. L., Maddux, W. W., & Lakin, J. L. (2005). Beyond the Perception-Behavior Link: The Ubiquitous Utility and Motivational Moderators of Nonconscious Mimicry. In *The New Unconscious* (pp. 334–361).

de Waal, F. B. M. (1989). *Peacemaking among primates*. Cambridge, Mass. : Harvard University Press.

Decety, J., Chen, C., Harenski, C., Kiehl, K. A., & Parvizi, J. (2013). An fMRI study of affective perspective taking in individuals with psychopathy: Imagining another in pain does not evoke empathy. *Frontiers in Human Neuroscience*, *7*, 1–12. https://doi.org/10.3389/fnhum.2013.00489

Decety, J., Michalska, K. J., Akitsuki, Y., & Lahey, B. B. (2009). Atypical empathic responses in adolescents with aggressive conduct disorder: A functional MRI

investigation. *Biological Psychology*, *80*(2), 203–211.
https://doi.org/10.1016/j.biopsycho.2008.09.004

Decety, J., Skelly, L., Yoder, K. J., & Kiehl, K. A. (2014). Neural processing of dynamic emotional facial expressions in psychopaths. *Social Neuroscience*, *9*(1), 36–49. https://doi.org/10.1080/17470919.2013.866905

Dimberg, U. (1982). Facial Reactions to Facial Expressions. *Psychophysiology*, *19*(6), 643–647. https://doi.org/10.1111/j.1469-8986.1982.tb02516.x

Dimberg, U., Andréasson, P., & Thunberg, M. (2011). Emotional empathy and facial reactions to facial expressions. *Journal of Psychophysiology*, *25*(1), 26–31. https://doi.org/10.1027/0269-8803/a000029

Dimberg, U., & Lundqvist, L.-O. (1990). Gender Differences in Facial Reactions to Facial Expressions. *Biological Psychology*, *30*, 151–159.

Dimberg, U., & Thunberg, M. (1998). Rapid facial reactions to emotional facial expressions. *Scandinavian Journal of Psychology*, *39*, 39–45.

Dimberg, U., & Thunberg, M. (2007). Speech anxiety and rapid emotional reactions to angry and happy facial expressions: Personality and Social Sciences. *Scandinavian Journal of Psychology*, *48*(4), 321–328. https://doi.org/10.1111/j.1467-9450.2007.00586.x

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious Facial Reactions to Emotional Facial Expressions. *Psychological Science*, *11*(1), 86–89.

Dimberg, U., Thunberg, M., & Grunedal, S. (2002). Facial reactions to emotional stimuli: Automatically controlled emotional responses. *Cognition and Emotion*, *16*(4), 449–471. https://doi.org/10.1080/02699930143000356

Drimalla, H., Landwehr, N., Hess, U., & Dziobek, I. (2019). From face to face: the contribution of facial mimicry to cognitive and emotional empathy. *Cognition and Emotion*, *33*(8), 1672–1686. https://doi.org/10.1080/02699931.2019.1596068

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system: a technique for the measurement of facial movement*. Palo Alto: Consulting Psychologists Press.

Ekman, P., Hager, J. C., & Friesen, W. V. (1981). The Symmetry of Emotional and Deliberate Facial Actions. *Psychophysiology*, *18*(2), 101–106.

Fridlund, A. J., & Cacioppo, J. T. (1986). Guidelines for Human Electromyographic Research. *Psychophysiology*, *23*(5), 567–590.

Goldman, A. I., & Sripada, C. S. (2005). Simulationist models of face-based emotion recognition. *Cognition*, *94*, 193–213. https://doi.org/10.1016/j.cognition.2004.01.005

Graham, J. L. (1980). A new system for measuring nonverbal responses to marketing appeals. *AMA Educator's Conference*, 340–343.

Harrison, N. A., Morgan, R., & Critchley, H. D. (2010). From facial mimicry to emotional empathy: A role for norepinephrine? *Social Neuroscience*, *5*(4), 393–400. https://doi.org/10.1080/17470911003656330

Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1992). Primitive emotional contagion. *Emotion and Social Behavior*, *14*(3), 151–177.

Hatfield, E., Rapson, R., & Le, Y.-C. L. (2009). Emotional Contagion and Empathy. *The Corsini Encyclopedia of Psychology and Behavioral Science*. https://doi.org/10.7551/mitpress/9780262012973.003.0003

Hazlett, R. L., Hopkins, J., & Research, H. (1999). Emotional Response to Television Commercials: Facial EMG vs. Self-Report. *Journal of Advirtising Research*, *39*(2), 7–23.

Hennenlotter, A., Dresel, C., Castrop, F., Ceballos-Baumann, A. O., Wohlschla¨gerwohlschla¨ger, A. M., & Haslinger, B. (2009). The Link between Facial Feedback and Neural Activity within Central Circuitries of Emotion-New Insights from Botulinum Toxin-Induced Denervation of Frown Muscles. *Cerebral*

Cortex March, *19*, 537–542. https://doi.org/10.1093/cercor/bhn104

Hermans, E. J., Putman, P., & Van Honk, J. (2006). Testosterone administration reduces empathetic behavior: A facial mimicry study. *Psychoneuroendocrinology*, *31*, 859–866. https://doi.org/10.1016/j.psyneuen.2006.04.002

Hess, U., & Blairy, S. (2001). Facial mimicry and emotional contagion to dynamic emotional facial expressions and their influence on decoding accuracy. *International Journal of Psychophysiology*, *40*(2), 129–141. https://doi.org/10.1016/S0167-8760(00)00161-6

Hess, U., & Fischer, A. (2014). Emotional mimicry: Why and when we mimic emotions. *Social and Personality Psychology Compass*, *8*(2), 45–57. https://doi.org/10.1111/spc3.12083

Hess, U., Philippot, P., & Blairy, S. (1998). Facial Reactions to Emotional Facial Expressions: Affect or Cognition? *Cognition and Emotion*, *12*(4), 509–531. https://doi.org/10.1080/026999398379547

Hjortsjö, C.-H. (1969). *Man's face and mimic language*. Lund, Sweden: Studentlitteratur.

Höfling, T. T. A., Gerdes, A. B. M., Föhl, U., & Alpers, G. W. (2020). Read My Face: Automatic Facial Coding Versus Psychophysiological Indicators of Emotional Valence and Arousal. *Frontiers in Psychology*, *11*(June), 1–15. https://doi.org/10.3389/fpsyg.2020.01388

Hsee, C. K., Hatfield, E., Carlson, J. G., & Chemtob, C. (1990). The Effect of Power on Susceptibility to Emotional Contagion. *Cognition and Emotion*, *4*(4), 327–340. https://doi.org/10.1080/02699939008408081

Indersmitten, T., & Gur, R. C. (2003). Emotion Processing in Chimeric Faces: Hemispheric Asymmetries in Expression and Recognition of Emotions. *The Journal of Neuroscience*, *23*(9), 3820–3825.

Jackson, P. L., Meltzoff, A. N., & Decety, J. (2005). How do we perceive the pain of

others? A window into the neural processes involved in empathy. *NeuroImage*, *24*(3), 771–779. https://doi.org/10.1016/j.neuroimage.2004.09.006

Kaiser, S., & Wehrle, T. (2001). Facial expressions as indicators of appraisal processes. In *Appraisal theories of emotions: Theories, methods, research* (pp. 285–300). New York: Oxford University Press.

Kavanagh, L. C., Suhler, C. L., Churchland, P. S., & Winkielman, P. (2011). When it's an error to mirror: The surprising reputational costs of mimicry. *Psychological Science*, *22*(10), 1274–1276. https://doi.org/10.1177/0956797611418678

Kawamoto, T., Nittono, H., & Ura, M. (2014). Social exclusion induces early-stage perceptual and behavioral changes in response to social cues. *Social Neuroscience*, *9*(2), 174–185. https://doi.org/10.1080/17470919.2014.883325

Keillor, J. M., Barrett, A. M., Crucian, G. P., Kortenkamp, S., & Heilman, K. M. (2002). Emotional experience and perception in the absence of facial feedback. *Journal of the International Neuropsychological Society*, *8*(1), 130–135. https://doi.org/10.1017/s1355617701020136

Korb, S., Goldman, R., Davidson, R. J., & Niedenthal, P. M. (2019). Increased medial prefrontal cortex and decreased zygomaticus activation in response to disliked smiles suggest top-down inhibition of facial mimicry. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.01715

Korb, S., Grandjean, D., & Scherer, K. R. (2010). Timing and voluntary suppression of facial mimicry to smiling faces in a Go/NoGo task - An EMG study. *Biological Psychology*, *85*, 347–349. https://doi.org/10.1016/j.biopsycho.2010.07.012

Krumhuber, E. G., Likowski, K. U., & Weyers, P. (2014). Facial Mimicry of Spontaneous and Deliberate Duchenne and Non-Duchenne Smiles. *Journal of Nonverbal Behavior*, *38*(1), 1–11. https://doi.org/10.1007/s10919-013-0167-8

Lakin, J. L., & Chartrand, T. L. (2003). Using Nonconscious Behavioural Mimicry to Create Affiliation and Rapport. *Psychological Science*, *14*(4), 334–339.

Lakin, J. L., Chartrand, T. L., & Arkin, R. M. (2008). I am too just like you: Nonconscious mimicry as an automatic behavioral response to social exclusion. *Psychological Science*, *19*(8), 816–822. https://doi.org/10.1111/j.1467-9280.2008.02162.x

Lakin, J. L., Jefferis, V. E., Cheng, C. M., & Chartrand, T. L. (2003). The Chameleon Effect as Social Glue: Evidence for the Evolutionary Significance of Nonconscious Mimicry. *Journal of Nonverbal Behavior*, *27*(3), 145–162.

Lamm, C., Batson, C. D., & Decety, J. (2007). The Neural Substrate of Human Empathy: Effects of Perspective-taking and Cognitive Appraisal. *Journal of Cognitive Neuroscience*, *19*(1), 42–58. https://doi.org/http://dx.doi.org/10.1162/jocn.2007.19.1.42

Lazarus, R. S. (1991). *Emotion and adaptation*. New York, NY: Oxford University Press.

Lewis, M. B. (2018). The interactions between botulinum-toxin-based facial treatments and embodied emotions. *Nature*, *8*, 14720. https://doi.org/10.1038/s41598-018-33119-1

Likowski, K. U., Mü, A., Seibt, B., Pauli, P., & Weyers, P. (2008). Modulation of facial mimicry by attitudes. *Journal of Experimental Social Psychology*, *44*, 1065–1072. https://doi.org/10.1016/j.jesp.2007.10.007

Likowski, K. U., Weyers, P., Seibt, B., Stöhr, C., Pauli, P., & Mü, A. (2011). Sad and Lonely? Sad Mood Suppresses Facial Mimicry. *Journal of Nonverbal Behavior*, *35*, 101–117. https://doi.org/10.1007/s10919-011-0107-4

Lundqvist, L. O., & Dimberg, U. (1995). Facial expressions are contagious. *Journal of Psychophysiology*, *9*(3), 203–211.

Martin, G. N. (2019). (Why) do you like scary movies? a review of the empirical research on psychological responses to horror films. *Frontiers in Psychology*, *10*(OCT). https://doi.org/10.3389/fpsyg.2019.02298

Meltzoff, A. N., & Moore, M. K. (1977). Imitation of Facial and Manual Gestures by Human Neonates. In *New Series* (Vol. 198).

Moody, E. J., & McIntosh, D. N. (2011). Mimicry of dynamic emotional and motor-only stimuli. *Social Psychological and Personality Science*, *2*(6), 679–686. https://doi.org/10.1177/1948550611406741

Moody, E. J., McIntosh, D. N., Mann, L. J., & Weisser, K. R. (2007). More than mere mimicry? The influence of emotion on rapid facial reactions to faces. *Emotion*, *7*(2), 447–457. https://doi.org/10.1037/1528-3542.7.2.447

Murata, A., Saito, H., Schug, J., Ogawa, K., & Kameda, T. (2016). Spontaneous facial mimicry is enhanced by the goal of inferring emotional states: Evidence for moderation of "automatic" mimicry by higher cognitive processes. *PLoS ONE*, *11*(4), 1–15. https://doi.org/10.1371/journal.pone.0153128

Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in Attitudes, Social Perception, and Emotion. *Personality and Social Psychology Review*, *9*(3), 184–211. https://doi.org/10.1207/s15327957pspr0903

Niedenthal, P. M., Mermillod, M., Maringer, M., & Hess, U. (2010). The Simulation of Smiles (SIMS) model: Embodied simulation and the meaning of facial expression. *Behavioral and Brain Sciences*, *33*, 417–480. https://doi.org/10.1017/S0140525X10000865

Oberman, L. M., Winkielman, P., & Ramachandran, V. S. (2007). Social Neuroscience Face to face: Blocking facial mimicry can selectively impair recognition of emotional expressions. *Social Neuroscience*, *2*(3–4), 167–178. https://doi.org/10.1080/17470910701391943

Olszanowski, M., Wróbel, M., & Hess, U. (2020). Mimicking and sharing emotions: a re-examination of the link between facial mimicry and emotional contagion. *Cognition and Emotion*, *34*(2), 367–376. https://doi.org/10.1080/02699931.2019.1611543

Paulhus, D. L., & Williams, K. M. (2002). The Dark Triad of personality: Narcissism,

Machiavellianism, and psychopathy. *Journal of Research in Personality*, *36*(6), 556–563. Retrieved from www.academicpress.com

Philip, L., Martin, J. C., & Clavel, C. (2018). Suppression of Facial Mimicry of Negative Facial Expressions in an Incongruent Context. *Journal of Psychophysiology*, *32*(4), 160–171. https://doi.org/10.1027/0269-8803/a000191

Preston, S. D., & de Waal, F. B. M. (2002). Empathy: Its ultimate and proximate bases. *Behavioral and Brain Sciences*, *25*, 1–72.

Rizzolatti, G., Fogassi, L., & Gallese, V. (2001). Neurophysiological mechanisms underlying the understanding and imitation of action. *Nature Neuroscience*, *2*(September), 1–10. https://doi.org/10.1038/35090060

Rozin, P., & Cohen, A. B. (2003). High Frequency of Facial Expressions Corresponding to Confusion, Concentration, and Worry in an Analysis of Naturally Occurring Facial Expressions of Americans. *Emotion*, *3*(1), 68–75. https://doi.org/10.1037/1528-3542.3.1.68

Rymarczyk, K., Biele, C., Grabowska, A., & Majczynski, H. (2011). EMG activity in response to static and dynamic facial expressions. *International Journal of Psychophysiology*, *79*(2), 330–333. https://doi.org/10.1016/j.ijpsycho.2010.11.001

Rymarczyk, K., Żurawski, Ł., Jankowiak-Siuda, K., & Szatkowska, I. (2016). Do Dynamic Compared to Static Facial Expressions of Happiness and Anger Reveal Enhanced Facial Mimicry? *PLOS ONE*, *11*(7), e0158534. https://doi.org/10.1371/journal.pone.0158534

Sackeim, H. A., Gur, R. C., & Saucy, M. C. (1978). Emotions Are Expressed More Intensely on the Left Side of the Face. *Science*, *202*(4366), 434–436.

Sato, W., & Yoshikawa, S. (2007). Spontaneous facial mimicry in response to dynamic facial expressions. *Cognition*, *104*(2), 1–18. https://doi.org/10.1016/j.cognition.2006.05.001

Seibt, B., Weyers, P., Likowski, K. U., Pauli, P., Mühlberger, A., & Hess, U. (2013). Subliminal interdependence priming modulates congruent and incongruent facial reactions to emotional displays. *Social Cognition*, *31*(5), 613–631. https://doi.org/10.1521/soco.2013.31.5.613

Söderkvist, S., Ohlén, K., & Dimberg, U. (2018). How the Experience of Emotion is Modulated by Facial Feedback. *Journal of Nonverbal Behavior*, *42*(1), 129–151. https://doi.org/10.1007/s10919-017-0264-1

Sonnby-Borgström, M. (2002). Automatic mimicry reactions as related to differences in emotional empathy. *Scandinavian Journal of Psychology*, *43*(5), 433–443. https://doi.org/10.1111/1467-9450.00312

Tassinary, L. G., & Cacioppo, J. T. (1992). Unobservable Facial Actions and Emotion. *Psychological Science*, *3*(1), 28–34.

Trautmann, S. A., Fehr, T., & Herrmann, M. (2009). Emotions in motion: Dynamic compared to static facial expressions of disgust and happiness reveal more widespread emotion-specific activations. *Brain Research*, *1284*, 100–115. https://doi.org/10.1016/j.brainres.2009.05.075

Van Baaren, R., Janssen, L., Chartrand, T. L., Dijksterhuis, A., Baaren, R. Van, Janssen, L., … Chartrand, T. L. (2009). Where Is the Love? The Social Aspects of Mimicry. *Philosophical Transactions: Biological Sciences*, *364*(1528), 2381–2389.

van der Schalk, J., Fischer, A., Doosje, B., Wigboldus, D., Hawk, S., Rotteveel, M., & Hess, U. (2011). Convergent and divergent responses to emotional displays of ingroup and outgroup. *Emotion*, *11*(2), 286–298. https://doi.org/10.1037/a0022582

Weyers, P., Mühlberger, A., Hefele, C., & Pauli, P. (2006). Electromyographic responses to static and dynamic avatar emotional facial expressions. *Psychophysiology*, *43*(5), 450–453. https://doi.org/10.1111/j.1469-8986.2006.00451.x

Wingenbach, T. S. H., Brosnan, M., Pfaltz, M. C., Plichta, M. M., & Ashwin, C. (2018). Incongruence between observers' and observed facial muscle activation reduces

recognition of emotional facial expressions from video stimuli. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.00864

Wolf, K. (2015). Measuring facial expression of emotion. *Dialogues Clinical Neuroscience*, *17*(4), 457–462.

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