IS IT CONTAGIOUS? AN EYE-MOVEMENT AND EMG STUDY OF SMILE AUTHENTICITY JUDGMENT

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Abstract

A smile is commonly used to mask negative emotions, yet those emotions are often leaked through microexpressions. These microexpressions act as brief displays of the individual's true emotion. Studies have indicated that participants often have difficulty judging the emotional expressions as truly happy or not truly happy, even when the leaked emotion is displayed for extended periods of time. The current study used a smile authenticity judgment task and sought to understand why individuals have difficulty with these non-authentic smiles (i.e. masking smiles; angry brow, angry mouth, disgust, fear, sad brow, and sad mouth). Various judgment strategies were evaluated, such as explicit knowledge, attentional limitations (eye-movement measures), emotional contagion (scale; ECS), and facial mimicry (electromyography; EMG). Accuracy results were observed to be a function of emotional expressions, where participants are more accurate with masking smiles containing fear and less accurate with masking smiles containing anger in the brows. In addition, judgment strategies appear to be a function of emotion. For instance, emotional contagion and facial mimicry were respectively significant predictors of fear and angry mouth masking smile judgment accuracy. Alternatively, attentional limitations were a significant predictor of angry brow masking smile judgment accuracy. In sum, smile authenticity judgment of masking smiles and their respective strategies appear to be as a function emotion.

1 Introduction

The face provides a great deal of information, where the ability to interpret emotional facial expressions allows an individual to adapt their behaviours during social interactions (Darwin, 1998). While these emotional facial expressions are often in response to a felt emotion, studies have shown that individuals are capable of voluntarily manipulating their facial expressions (e.g. Gosselin, Perron, & Beaupré, 2010). Of these voluntary expressions, the smile is one of the most frequently emitted (Abel, 2002). Individuals have displayed a degree of difficulty in the judgement of true and false smiles (Porter, ten Brinke, & Wallace, 2012). A recent study has explored perceptual-attentional factors to attempt to understand this difficulty, although results could not fully support this hypothesis (e.g. Perron & Roy-Charland, 2013; Perron, Roy-Charland, Chamberland, Bleach, & Pelot, 2016). The current study will be exploring this question with the use of an embodiment approach, to determine if mimicking and emotional contagion can explain factors important in the judgement of true and false smiles.

1.1 Production of Smiles

The Facial Action Coding System (*FACS*; Ekman, Friesen, & Hager, 2002) discerns 44 muscle contractions (i.e. action units or AUs) that correspond to overt changes in the face. According to the FACS, variations in AU activation are a function of emotion (e.g. Gosselin & Kirouac, 1995). It has been suggested that enjoyment smiles contain the co-activation of the *orbicularis oculi* and the *zygomaticus major* muscles, commonly referred to as the Cheek Raiser (i.e. AU6), or the Duchenne marker, and the Lip Corner Puller (i.e. AU12) by the FACS (Ekman, Friesen, & Hager, 2002; Krumhuber & Manstead, 2009; Thibault, Levesque, Gosselin, & Hess, 2012). These muscle activations move the skin of the face to create the appearance of enjoyment. The Cheek Raiser lifts the cheeks and narrows the eyes/brows apertures, creating the “crow’s feet” in the outer corners of the eyes, while the lip stretcher stretches the lips out and upward, creating the smile. These true displays of enjoyment are often referred to as Duchenne smiles.

Individuals display a certain aptitude to voluntarily manipulate their own facial expressions. It has been suggested that individuals can minimize or neutralize the expression of a felt emotion, simulate a facial expression without feeling said emotion (i.e. *simulated smiles; non-Duchenne smiles*), or mask an emotion with the display of another (i.e. *masking smiles*; Ekman & Friesen, 1975; Porter et al., 2012). With voluntary manipulation, a smile may serve to better coordinate a conversation (Ekman, 2001), to reduce conflicts (Ikuta, 1999), manipulate others (Keating & Heltman, 1994), or to conceal the expression of negative emotions (Ekman, Friesen, O’Sullivan, 1988).

1.1.1 Masking Smiles

When individuals attempt to mask their negative emotions with a smile, they must complete a dual task – concealing/inhibiting their true emotions, while displaying/activating a facial expression of happiness. In research concerning simulated smiles, it was originally suggested that only an approximate 20% of adults were able to voluntary manipulate their *orbicularis oculi* (Ekman, Roper, & Hager, 1980; Ekman & Friesen, 1982; Levenson, Ekman, & Friesen, 1990). This capability has recently been suggested to be as high as 60% (Gosselin et al., 2010). While the voluntary activation of a smile is already considered to be difficult (Duchenne, 1862/1990; Ekman et al., 1980; Gosselin, Maassarani, Younger, & Perron, 2011; Gosselin et al., 2010), the Inhibition hypothesis (Ekman, 2003) posits that it is also difficult to inhibit the muscle activation while trying to conceal felt emotions. This difficulty can lead to the manifestation of microexpressions (see Ekman 1985/2001; Ekman & O’Sullivan, 2006; Porter et al., 2012), displaying the true nature of the dissimulated emotion.

Microexpressions were originally described to be very brief (40 to 200 milliseconds; Ekman & O'Sullivan, 2006) full face displays of emotion. However, a recent study by Porter and colleagues (2012) has offered support against this. In their study, a group of individuals were recruited and instructed to produce expressions that were genuine (i.e. display true emotion), simulated (i.e. display emotion without feeling), masked (i.e. conceal true emotion with another), or neutralized (i.e. suppressed emotion with neutral face) in response to emotional stimuli. During this task, a video camera was used to record the individual's expressions. The FACS was then used to determine which muscles were activated. Microexpressions were observed in approximately 25% of the participants trying to falsify their facial expressions, offering support for the Inhibition hypothesis. In addition, results suggested that microexpressions may manifest for approximately a second in the upper or lower half of the face at any given time. While the longer duration may contribute to the detection of a deceptive expression, the fact that the microexpression can be either in the upper or lower portion of the face may add increased complexity (Porter et al., 2012).

While the use of deceitful smiles likely has facilitating effects on social interactions (DePaulo, Kashy, Kirkendol, Wyer, & Epstein, 1996), the detection of deceit is quite important during high stake situations where the wellbeing of others may be at risk (Porter & ten Brinke, 2010). A number of studies have suggested that individuals experience difficulty in the processing of these microexpressions, with success rates approaching 60% where the chance level is 50% (e.g. DePaulo, 1988; Ekman & O'Sullivan, 1991; Frank, Ekman, & Friesen, 1993; Mann, Vrij, & Bull, 2004; O'Sullivan, Ekman, Friesen, & Scherer, 1985; Porter et al., 2012; Warren, Schertler, & Bull, 2009; Zuckerman, Koestner, & Colella, 1985). For instance, Porter and colleagues (2012) recruited a second group of individuals to interpret the facial expressions produced by participants. These new participants were displayed the video recordings obtained in the first portion of the Porter et al. (2012) study, to determine if individuals could detect falsified emotions. Results were consistent with the above statement, yielding an accuracy of 55% that did not significantly differ from chance levels.

With such evident difficulty observed in the processing of deceptive smiles, studies have sought to determine some underlining factor that may explain this difficulty. There are currently inconsistencies in the research. For instance, difficulty has been suggested to be the result of error-inducing stereotypes, involving misleading preconceptions of sincerity indicators (DePaulo, Lindsay, Malone, Muhlenbruck, Charlton, & Cooper, 2003; Porter, England, Juodis, ten Brinke, & Wilson, 2008; Stromwall & Granhag, 2003; Vrij, 2000, 2004). In addition, it has been proposed to be due to an excessive amount of motivation directed toward the detection of deception, leading to “tunnel-vision” (Porter, McCabe, Woodworth, & Peace, 2007). The attractiveness of the individual displaying the expression has also been suggested to be a potential factor, where more attractive individuals are considered more sincere (Bull & Rumsey, 1988; Downs & Lyons, 1991).

In a recent study, Perron and colleagues (2016) attempted to determine if perceptual-attentional factors also contributed to the difficulty in judging masking smiles. These researchers sought to determine if individuals displayed a decreased amount of attention to, or had difficulty perceiving, the microexpressions. Using a smile judgment task to assess implicit knowledge, individuals were instructed to respond “truly happy” when they think that an enjoyment smile was displayed and “not truly happy” when they think that a non-enjoyment smile was displayed. The non-enjoyment smiles used in this study consisted of masking smiles, containing traces of other emotions (Angry Brows, Angry Mouth, Disgust, Fear, Sad Brows, and Sad Mouth). The researchers also examined explicit knowledge, individuals were asked if another emotion was present when they produced a “not truly happy” response. If they believed another emotion was present, they were asked to indicate which other emotion they believed it to be. Furthermore, eye-tracking measures were used to assess perceptual and attentional factors.

Results of Perron et al. (2016) posited two main contributions. First, there were variations in judgments as a function of the masked emotion, with fear being the most accurate and anger in the eyebrows being the least accurate. In addition, performance on the smile authenticity judgment task was influenced by the location of the microexpression (mouth or eyes/brows) as a function of masked emotion, with sad brows being greater than sad mouth and angry mouth being greater than angry brows. The second contribution of the Perron et al. (2016) study suggests that perceptual-attentional mechanisms and explicit knowledge about the masked emotion cannot explain the performance during the smile authenticity judgement task, because no link was apparent between the former two tests and the latter. The current study will explore another mechanism, embodied simulation, to determine if it contributes to the judgement of masking smiles.

1.2 Embodied Simulation

In an article by Goldman and Sripada (2005), embodied simulation is suggested as an alternative to what they refer to as theory-theory. While theory-theory may refer to the previously mentioned theories concerning error-inducing stereotypes, attractiveness, and perceptual-attentional factors, embodied simulation posits that we understand the affect in others by simulating the affect ourselves. In addition, Goldman and Sripada (2005) discuss three potential methods of embodied simulation: a generate-and-test model, a reverse simulation model, and a reverse simulation model with an ‘as if’ loop.

The generate-and-test model simply suggests that an individual will attempt to simulate/recreate the emotional facial expression presented to them by activating the facial expression associated with a certain emotion. The individual will then continue to attempt emotional facial expressions until the facial expression associated with a particular emotion matches the facial expression displayed to them. While this generate-and-test model is offered as a potential candidate, this trial and error method may take several attempts and impact affect processing (Goldman & Sripada, 2005).

As an alternative model, the reverse simulation model proposes that a tendency to recreate the emotional facial expressions of others (i.e. *facial mimicking*) may lead to the experience of that same emotion (i.e. *emotion contagion*), a process often referred to as the facial feedback (see Laird, 1984). The experienced emotion is then attributed to the individual making the expression, which in turn may contribute to the process of emotional facial expression recognition (Goldman & Sripada, 2005). In a similar fashion, the reverse simulation model with an 'as if' loop suggests that facial mimicking may lead to emotion contagion, which leads to the attribution of the emotional state generated to the individual displaying the facial expression. However, this latter model also suggests that individuals may be able to experience emotional contagion without facial mimicry (Goldman & Sripada, 2005). It is currently difficult to discern which of these two models is accurate, although the process of facial feedback has been studied (e.g. Ekman, Levenson, & Friesen, 1983).

In the Ekman et al. (1983) study, individuals were directed how to simulate expressions of surprise, disgust, sadness, anger, fear, and happiness, or asked to imagine an experience of those emotions. During this process, the researchers measured the participant's heart rate, left and right hand temperatures, skin resistance, and forearm muscle tension. Regardless of the manipulation, results suggested that anger and fear produced increased heart rates compared to happiness, and anger also produced increased skin temperatures in the left and right hands compared to happiness. Of greater importance, three subgroups were determined from the emotions when individuals simulated facial expressions. It was found that anger, fear, and sadness produced increased heart rates compared to happiness, disgust, and surprise. In addition, anger produced increased skin temperature compared to fear and sadness. Researchers discuss how this seems to coincide with previous research that suggests fear and anger to produce similar heart rate increases, but with anger producing increased skin temperatures compared to fear. The findings of Ekman and colleagues (1983) are very important in showing that the simple activation of muscles associated with emotions can produce differential autonomic activity, providing potential support for the facial feedback hypothesis.

1.3 Electromyography and Facial Mimicry

Facial mimicry consists of systematic muscle activations to mirror another's face. Electromyography, or EMG, is a tool used to measure bioelectric events that occur as a result of muscle contractions (Fridlund & Cacioppo, 1986; Tassinary, Cacioppo, & Vanman, 2000; Hess, 2009). Specifically, it measures action potentials that are generated along groups of muscle fibers, also referred to as motor unit action potentials (*MUAP*). While needle electrodes are often used in medical settings, surface electrodes provide a non-invasive measure of muscle activity. Measurements taken at the skin, with surface electrodes, represent the summation of several MUAPs from numerous muscle fiber groups in the selected region (Hess, 2009). With regards to facial EMG, it is common to use bipolar surface electrodes to measure a voltage difference between two electrodes placed in close proximity and parallel to the muscle fibers (Hess, 2009). A reference electrode is also used, often placed on the forehead (e.g. Fridlund & Cacioppo, 1986;

Hess, 2009), to filter out electrical signals that are not related to the muscle activity (i.e. noise). Mean amplitudes are often computed from the EMG signal, because linear covariance has been suggested to be apparent between mean amplitudes and muscle contractions (see Hess, 2009).

The measure of facial EMG activity is of particular interest because it provides a more sensitive measure of facial movement (Tassinary & Cacioppo, 1992). It has been suggested that there are two forms of facial expression movement: overt and covert. When muscles contract and result in the movement of facial skin, it is an overt facial expression. However, as discussed by Tassinary and Cacioppo (1992), MUAPs may occur independent of an overt facial expression and can be referred to as covert facial expressions. In 1982, Dimberg took advantage of EMG equipment to systematically show that individuals displayed elevated activity in *zygomaticus major* muscle when displayed happy facial expressions and elevated *corrugator supercilii* muscle activity for angry facial expressions. While the *zygomaticus major* is responsible for stretching the lips in the creation of a smile, the *corrugator supercilii* is responsible for lowering the brows in emotions such as fear, anger, and sadness (see Gosselin & Kirouac, 1995). Therefore, this study (Dimberg, 1982) suggests that individuals tend to mimic facial expressions while they examine them, by displaying increased *zygomaticus major* EMG activity when displayed happy expressions and increased *corrugator supercilii* EMG activity when displayed angry expressions.

Since this observation with happy and angry emotional expressions, further studies have investigated these mimicking effects with other emotional facial expressions (neutral, happy, angry, sad, fear, disgust, and surprise; Lundqvist & Dimberg, 1995). In a study by Lundqvist and Dimberg (1995), a set of expressions were displayed for each emotion as EMG data was recorded, and emotions were displayed in separate blocks. Following each block participants were asked to complete a questionnaire to measure their emotions at that time. This study yielded congruent results with the Dimberg (1982) study, happiness and anger displayed larger *zygomaticus major* and *corrugator supercilii* activity, respectively, in comparison to the EMG activity from neutral expression. In addition, elevated activity was observed in the *pars lateralis* muscle for expressions of surprise, and in the *levator labii* muscle for disgust and happiness. The *corrugator supercilii* also produced elevated activity for sad expressions and decreased activity for happy expressions (Lundqvist & Dimberg, 1995).

The observations obtained in the Lundqvist and Dimberg (1995) study seemed to be in conjunction with FACS prototypes (see Gosselin & Kirouac, 1995), where the presentation of an emotional facial expression resulted in corresponding facial activity in the viewer's face. An unexpected finding in this study was the *levator labii* activity for happiness, which Lundqvist and Dimberg (1995) interpreted as "cross talk", meaning it is likely the result of activity from the *zygomaticus major* that has been detected by the *levator labii* electrodes. The authors, however, concluded that previously observed mimicking by Dimberg (1995) tends to generalize to other emotional facial expressions.

A study by Dimberg, Thunberg, and Elmehed (2000) displayed how individuals appear to be quite sensitive to this mimicking effect. Participants were only shown emotional facial expressions for 30ms, which was immediately followed by a neutral facial expression. At this rate, the emotional facial expression was considered to be unconscious to the viewers. When individuals reported that they had not detected any motion or light phenomena, representing the detection of the emotional expression, larger *zygomaticus major* activity was observed when happy emotional facial expressions were displayed and larger *corrugator supercilii* activity was observed with angry emotional facial expressions. These results coincide with the previous reports of Dimberg (1982), suggesting that mimicking occurs quite rapidly and independent of conscious cognitive processes (Dimberg et al., 2000).

To determine if the activation of muscles during this mimicking contributes to emotion recognition, studies have blocked facial mimicry by asking participants to maintain a pen horizontally between their teeth/lips or to chew gum (eg. Oberman, Winkielman, & Ramachandran, 2007). A recent study has employed a mouthguard to block facial mimicry in three studies (Rychlowska et al., 2014). In their first study, Rychlowska and colleagues (2014) sought to determine if the mouthguard limited the amount of facial mimicry. Videos were used of true smiles (Duchenne Smiles) and false smiles (non-Duchenne Smiles). EMG activity was measured in the *zygomaticus major* muscle when they were wearing a mouthguard and when they were free to mimic (i.e. no mouthguard). Results from this first study showed that individuals displayed increased *zygomaticus major* activity for true smiles than false smiles when individuals were free to mimic. However, when mimicking was blocked with the mouthguard, no difference in *zygomaticus major* activity was found between true and false smiles (Rychlowska et al., 2014). This study also employed the Computer Expression Recognition Toolbox (CERT), which is essentially a computer program designed to detect 19 FACS muscle movements in a video. CERT was used to determine if the video stimuli correlated with EMG activity. When individuals were free to mimic, a positive correlation was reported between *zygomaticus major* activity in the video stimuli and *zygomaticus major* activity in the participant’s face. This is further support for Dimberg’s (1982) hypothesis that participants are mimicking the facial expression stimuli. More important, when mimicking was blocked, a correlation was not found between CERT and EMG activity, suggesting they did not mimic. This first study justifies the use of a mouthguard to block facial mimicry.

In a second and third experiment, Rychlowska and colleagues (2014) sought to determine if the blockage of facial mimicry had an impact on a smile judgement task. To do this, similar to their first study, some individuals were fitted with a mouthguard and others were not. In order to ensure that the distraction of biting down on the mouthguard was not solely responsible for any judgement impairments, some individuals were fitted with a heart rate monitor on their finger (third experiment) or asked to grasp a "stress ball" firmly (second experiment). While it is clear how a stress ball can be seen as a comparable distractor to the mouthguard, the heart rate monitor was hypothesized to make individuals more aware of their bodies and have an impact on attention during the task (Rychlowska et al., 2014). In both cases, results suggested that individuals capable of mimicking the facial expressions were better suited to distinguish between true and false smiles than individuals with blocked facial expressions. In addition, no difference was found between free to mimic and distracted (stress ball) individuals or between the individuals distracted by the heart rate monitor and those distracted by the stress ball. The former manipulations all significantly differed from the blocked mimicking (mouthguard) individuals. These findings suggest that the blockage of facial mimics is detrimental to the judgement of smile genuineness.

The effects of mimicry blockage on the recognition of happiness seems to be well documented (e.g. Oberman et al., 2007; Maringer, Krumhuber, Fischer, & Niedenthal, 2011; Rychlowska et al., 2014), but its effects on other emotional facial expressions appear to be less reported. However, a study by Ponari, Conson, D'Amico, Grossi, and Trojano (2012) has explored other emotions. In their study, individuals were instructed to either hold a Chinese chopstick horizontally between their teeth, to contract the inner portion of their brows together, or were free to mimic the emotional facial expression stimuli. While the Chinese chopstick was hypothesized to block mimicry in the lower portion of the individual's face, similar to the mouthguard previously discussed, the contraction of the brows was thought to block mimicry in the upper portion of the face. When asked to judge the emotional facial expressions, it was found that the blockage of mimicking in the mouth region resulted in interference with the recognition of happiness, disgust, and fear. On the other hand, the blockage of mimicking in the eye/brow region resulted in the interference of fear and anger recognition. With regards to the recognition of surprise and sadness, mimicry blockage of the eye/brow or mouth region was not found to have an impact. This study by Ponari and colleagues (2012) appears to suggest that the facilitating effects of mimicry may be as a function of muscle location (eyes/brows or mouth region).

1.4 Emotional Contagion

While facial mimicking has been well documented (e.g. Dimberg, 1982; Lundqvist & Dimberg, 1995), its interaction with emotional contagion has been inconsistent. In the Lundqvist and Dimberg (1995) study previously discussed, participants were asked to report their emotional states following the display of an emotional facial expression. Individuals reported increased feelings of the emotion corresponding to the emotional facial expression presented, for all except expressions of surprise. This was interpreted as a representation of emotional contagion, as a result of seeing the emotional facial expressions. Given the presence of facial mimicry and emotional contagion, it was hypothesized that mimicry contributed to emotional contagion (Lundqvist & Dimberg, 1995).

In a similar study by Hess and Blairy (2001), results contradicted the hypothesis of Lundqvist and Dimberg (1995). Participants were displayed videos of people imagining an emotional event (happy, anger, disgust, and sadness). These video stimuli were created in a laboratory prior to the experiment, by asking individuals to imagine an emotional event. All the stimuli used in this study contained at least one emotional facial expression. The task of the participant was to judge the emotions in the video, and they were also asked to complete a well-being questionnaire. This well-being questionnaire was supposed to measure their emotional state following the stimulus. Throughout the experiment, EMG activity was measured in the *orbicularis oculi* (associated with happiness), *corrugator supercilii* (anger, fear, and sadness), and *levator labii* (disgust). Analyses of EMG activity indicated that happy stimuli had elevated activity in the *orbicularis oculi*, when compared to the other two muscles. Sadness and anger both displayed more activity in the *levator labii* than the *orbicularis oculi* and *corrugator supercilii*. Furthermore, anger displayed marginally greater *levator labii* activity than sadness. Disgust did not display differences between the facial muscles.

With regards to their emotional states, individuals in the Hess and Blairy (2001) study reported to be more cheerful, sad/depressed, and repulsed when they were displayed expressions of happy, sad, and anger, respectively. While the results for happy and sad were anticipated, the responses for anger were not. Data for this study was collected from French individuals, and repulsed (repulsé) in French implies a desire to get away. Therefore, Hess and Blairy (2001) interpreted these results to potentially represent a fleeing response. Mediation analyses were used to determine if facial mimicry influences the degree of emotional contagion or recognition accuracy, and to determine if emotional contagion impacted the recognition accuracy. An important finding from this study was that facial mimicry likely did not have a mediational effect on the participant’s emotional state or recognition accuracy, nor did the emotional state have a mediational effect on recognition accuracy. While mimicry and emotional contagion are reported to have been observed in this study, Hess and Blairy (2001) suggested these results to potentially indicate that mimicry may not contribute to emotional contagion and emotion recognition. Therefore, even though mimicry blockage has recently been observed to negatively impact affect processing (Rychlowska et al., 2014), this study suggests that mimicking may not contribute to the recognition of affect.

Both the Lundqvist and Dimberg (1995) and Hess and Blairy (2001) study reported that individuals tended to feel the emotion displayed in the emotional facial expression. However, it has been suggested that individual differences with regards to emotional contagion would be expected due to genetics, the individual's gender, environmental factors, and personality characteristics (Doherty, 1997). Therefore, the Emotion Contagion Scale (*ECS*; Doherty, 1997) was developed to determine how susceptible an individual is to emotional contagion. It contains 15 questions, designed to test susceptibility to positive emotions (happiness and love) and negative emotions (fear, anger, and sadness). This scale includes three questions for each emotion, for which they are asked to provide their answer on a Likert scale. A test of the internal consistency within this scale provided a Cronbach α of .90, indicating excellent reliability (Doherty, 1997). When positive and negative emotions were examined separately, Cronbach's α were .82 and .80 respectively. In addition, differences between primary testing and retesting three weeks later did not reach significance, indicating good test-retest reliability.

The validity of the ECS was measured in many ways. For instance, Doherty (1997) refers to an article by Doherty, Orimoto, Singelis, Hebb, and Hatfield (1995) where participants were displayed videos of individuals recounting happy and sad memories. Following a video, participants were instructed to rate how happy and sad they felt during the experience. In addition, participants completed the ECS and were videotaped throughout the experiment. Judges then evaluated the videos of the participants and rated how happy or sad they appeared.

ECS scores were found to significantly interact with the ratings of emotion from the judges and from the participants. However, the emotional ratings from the judges did not significantly interact with the ratings of emotion from the participants. The ECS was, therefore, interpreted as a better predictor of emotional contagion than individuals (i.e. judges) watching participants react.

Using the ECS, Manera, Grandi, and Colle (2013) recently tested this embodied simulation hypothesis with the judgement of Duchenne smiles (enjoyment) and non-Duchenne smiles (non-enjoyment). The results of this study showed that individuals who reported greater susceptibility to the emotional contagion of negative emotions performed better at the judgement of authenticity of simulated smiles. In contrast, individuals with greater susceptibility to emotional contagion for positive emotions tended to rate non-Duchenne smiles as “truly happy”. With a greater sensitivity to negative emotions, individuals scoring higher for negative emotional contagion would be more fine-tuned to detect the non-genuine smiles.

1.5 Current Study

The embodied simulation hypothesis suggests that individuals mimic and feel the emotional facial expression displayed to them, and the attribution of that feeling to the other individual’s expression facilitates emotional judgement. While there are inconsistencies in the research as to whether mimicking does in fact lead to the experience of the emotion (Lundqvist & Dimberg, 1995; Wild, Erb, Eyb, Bartels, & Grodd, 2003; Hess & Blairy, 2001), the study by Ekman and colleagues (1983) suggests that the simulation of an emotional expression was linked to physiological responses associated with said emotion. In addition, a great deal of research has shown that the blocking of mimicking has detrimental effects on emotional facial expression processing (Oberman et al., 2007; Maringer et al., 2011; Ponari et al., 2012; Rychlowska et al., 2014). As a result, the current research focused on determining if there was a potential link between facial mimicry and the judgement of masking smiles, and also included the ECS to determine if there was a link between emotional contagion susceptibility scores and the judgement of masking smiles.

The current study determined facial mimicry by recording EMG activity. It has been suggested that the use of EMG measurements can record muscle action potentials that are absent of an actual facial movement, providing a more sensitive measure (Tassinary & Cacioppo, 1992). A link between facial mimicking and the ECS was also investigated. As previously discussed, the ECS represents a measurement of emotional contagion susceptibility. While a previous study by Hietanen, Surakka, and Linnankoski (1998) has proposed a correlation between EMG activity and the ECS, the stimuli did not include facial expressions. To the researcher's knowledge, previous studies had not yet investigated this relationship in this manner. Individuals with high emotional contagion susceptibility were hypothesized to mimic more than those with low susceptibility scores. Differential facial mimicry was also expected between individuals that scored high susceptibility to negative contagion on the ECS and those that scored high susceptibility to positive contagion. It was hypothesized that individuals with high susceptibility to negative contagion may mimic the negative microexpressions displayed in masking smiles more than those with high susceptibility to positive contagion.

Similar to Perron and colleagues (2016), this study also employed eye-tracking measures to determine if there was a potential link with facial mimicry. For instance, can eye-movements predict facial mimicry? A review of previous research did not reveal any studies that have tested for a link between facial mimicry and eye-movement patterns. It was, however, hypothesized that the amount of time spent gazing at an area would be able to predict the amount of mimicking displayed by the participant in said area. More specifically, more time looking at the eyes/brows would predict greater mimicry in muscles in that area.

While the current study will be examining many effects, its main purpose was to determine if facial mimicry and/or emotional contagion during a smile judgment task could be linked to the performances of individuals while categorizing enjoyment smiles and masking smiles, or during the explicit knowledge test (see Perron et al., 2016, for example). The masking smiles used were those of Perron and colleagues (2016), with traces of negative emotions (Angry Brows, Angry Mouth, Disgust, Fear, Sad Brows, and Sad Mouth). Applying the results of Manera and colleagues (2013) to the judgement of masking smiles, it was hypothesized that individuals that scored higher on the ECS for negative susceptibility would perform better on the judgement task. As discussed earlier, these individuals may be more fine-tuned to detect negative emotion. In addition, it was hypothesized that the mimicking behaviours of the negative emotion microexpressions may be positively correlated with smile judgements.

2 Methods and Materials

2.1 Participants

Forty-four undergraduate students initially took part in the current study, but only 40 were used for statistical analysis (36 women and 4 men; mean age = 23, SD = 6.54). All individuals reported normal or corrected-to-normal vision. In addition, individuals were initially told that the purpose of the EMG sensors was to measure skin temperature (e.g. Lundqvist & Dimberg, 1995). At the end of the experiment, all participants were asked if they knew that muscle activity was being measured. Anyone that indicated knowledge of the true purpose of the EMG sensors was excluded from the analyses; three participants were excluded as a result of this criterion. One participant was also excluded because of technical difficulties with the EMG system. All participants were required to sign an informed consent to participate in the current study.

2.2 Materials

2.2.1 Stimuli

All the emotional facial expression images were taken directly from the Perron et al. (2016) study. These images were established according to the FACS (Ekman, Friesen, & Hager, 2002).

As displayed in Figure 1, the current study took advantage of seven AU configurations to create smile stimuli. As previously discussed, a smile of true enjoyment has been suggested to contain the co-activation of the *orbicularis oculi* (Cheek Raiser; AU6) and the *zygomaticus major* (Lip Corner Puller; AU12). The remainder of the smiles in this study were intended to represent masking smiles. These latter smiles contained microexpressions of fear, disgust, sadness, and anger (e.g. Ekman, Friesen, & O'Sullivan, 1988; Perron et al., 2016). In addition to the muscles seen in enjoyment smiles, the Fear masking smiles contained the activation of the *corrugator supercilii* (Brow Lower; AU4), *frontalis, pars medialis* (Inner Brow Raiser; AU1), and *frontalis, pars lateralis* (Outer Brow Raiser; AU2). Disgust masking smiles contained additional activity in the *levator labii superioris alaquae nasi* (Nose Wrinkler; AU9). For anger and sadness, traces of negative emotions were displayed either in the eye/brow or mouth region. While the angry brow masking smile image contained the additional *corrugator supercilii* (Brow Lower; AU4) activity, the masking smile with anger in the mouth contained activity in the *orbicularis oris* (Lip Presser; AU24). For the images of sad brows, additional activity was displayed in the *corrugator supercilii* (Brow Lower; AU4) and the *frontalis, pars medialis* (Inner

Brow Raiser; AU1), while sad mouth contained activity in the *depressor anguli oris* (i.e. *triangularis*; Lip Corner Depressor; AU15).

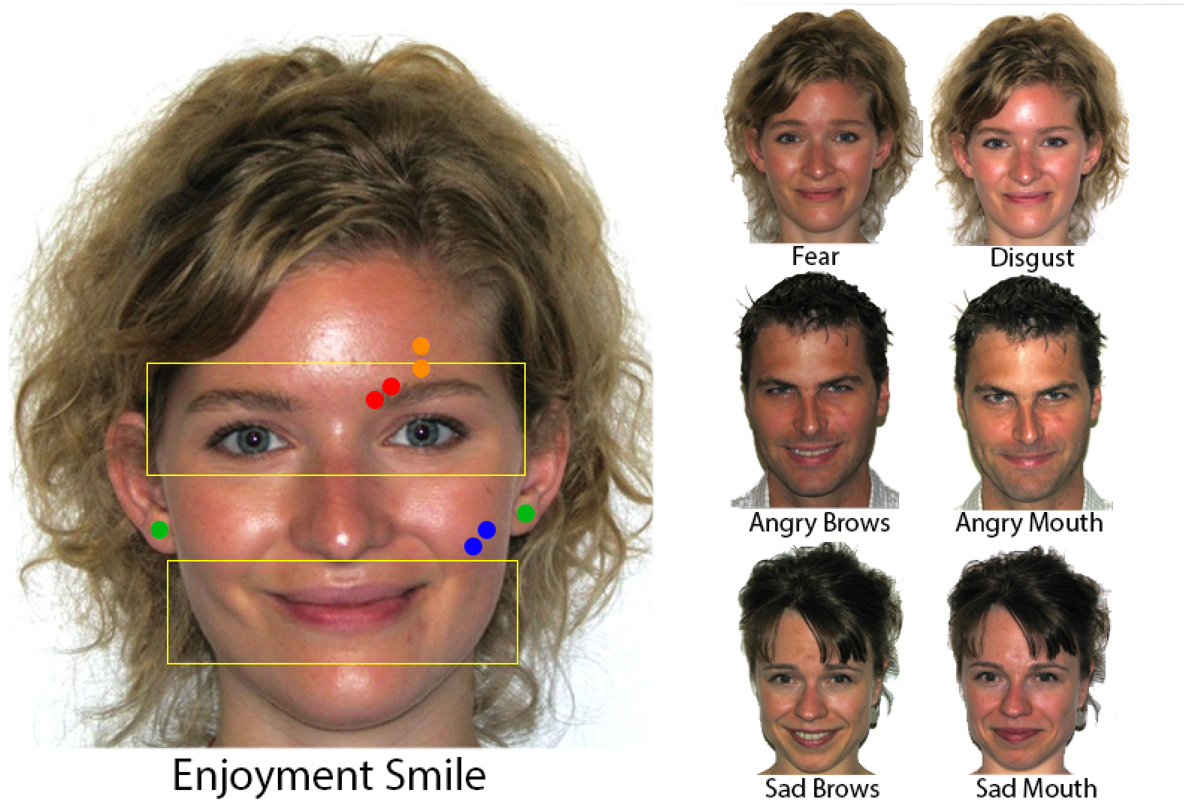

Figure 1. *Examples of the images used in this study. The six images on the right side (Fear, Disgust, Angry Brows, Angry Mouth, Sad Brows, and Sad Mouth) represent examples of the masking smiles. The electrode placements in the current study are presented on the Enjoyment Smile, as defined by Fridlund and Cacioppo (1986). Reference Sensors (green), Zygomaticus Major Sensors (blue), Corrugator Supercilii Sensors (red), and Frontalis Pars Lateralis Sensors (orange). The eyes/brows and mouth zones, used for eye-tracking measures, are presented with the yellow boxes.*

Each smile was originally produced by six encoders (3 men and 3 women), who were enlisted and instructed how to simulate the facial expressions. All images were evaluated by two independent FACS coders, to ensure the precision of the expressions, and an inter-rater agreement of 100% was required for use in the study. Due to these criteria and the difficulties in the production of these smiles, only four encoders were used in this study for each type of smile (see Perron et al., 2016). With four encoders for each of the seven expressions (see Figure 1), this resulted in a total of 28 images being used.

2.2.2 Emotional Contagion Scale

The ECS (Doherty, 1997) was administered following the task itself. The scale contains 15 questions; three for each emotion (happiness, love, fear, anger, and sadness). For instance, the individual may be asked "When someone smiles warmly at me, I smile back and feel warm inside" (see Appendix A). For each question, participants are asked to provide their answer on a four-point Likert scale for how likely the statement was to occur (1 = Never; 4 = Always). Individuals scoring higher on this scale are considered to be more susceptible to emotional contagion than those scoring lower. The scale can also be divided as a function of emotion type (positive emotion: happiness and love questions; negative emotion: fear, anger, and sadness questions). Therefore, susceptibility of emotional contagion toward positive and negative emotions can also be assessed (see Manera et al., 2013).

2.2.3 EMG Measures

Two PowerLab 4/25 (ADInstruments Pty Ltd., Bella Vista, Australia) were used to acquire EMG data. Three bipolar Ag/AgCl electrode pairs were used to collect voltage changes along the left side of the face at three muscle locations: the *corrugator supercilii,* the *frontalis, pars lateralis*, and the *zygomaticus major*. Covidien/Kendall Medi-Trace Foam electrodes were used, with a 1½" diameter pad and a sensor in the center that was 1cm in diameter. These pads were then cut so that there was an inter-electrode space of 1cm, removing some of the conductive material surrounding the sensor. The electrode placements were in accordance with the guidelines established by Fridlund and Cacioppo (1986). See Figure 2 for a display of the electrode placements.

EMG data was digitized with a sampling rate of 1000Hz, with the earlobes as the reference electrodes. EMG data was filtered with a bandpass filter between 20Hz and 400Hz. In addition, a 60Hz notch filter was used to account for the frequency of the connected power supply and external electrical activity (e.g. light sources). The data was then stored on a computer for off-line analysis. Initially, a 4th order zero-lag low-pass Butterworth filter was applied with a cut-off frequency of 10Hz.

2.2.4 Eye-Tracking Measures

The EyeLink II system was used to record eye-movements. With two cameras placed directly under the eyes, eye-movements are tracked with a high average accuracy (0.5˚) and a sampling rate of 500Hz. An infrared sensor was also located on the forehead to track head movement. Only one pupil was tracked, as determined by the most accurate calibration. For this process, a point originally begins in the center of the screen and participants are asked to follow the point as it moves. A nine-point calibration procedure was used to ensure a maximum deviation of 1˚ in visual angle.

2.3 Procedure

The procedures for this task were taken directly from the Perron et al. (2016) study. All images were randomly presented on a computer screen positioned 70 centimeters from the individual. Each encoder stimulus presented an enjoyment smile 12 times (4 encoders X 12 repetitions; 48 images of enjoyment smiles) and each of the six masking smiles twice (4 encoders X 6 types of smiles X 2 repetitions; 48 masking smiles). Participants were instructed to judge whether the smile presented was “truly happy” or “not truly happy” (*‘Truly Happy’ question*). Once a decision was made, they were instructed to click a computer mouse. Participants were then displayed a blank screen and asked to provide their response (“truly happy" or "not truly happy"). If the participant indicated that the image was "truly happy", the subsequent image was presented. However, the image would be presented again if the participant produced a "not truly happy" response, and the individual would be asked to indicate if another emotion was present in the image (*'Another Emotion' question*). If yes, then the individual would be asked to explicitly label which emotion was present from a given list (anger, fear, sadness, disgust, surprise, interest, guilt, shame, contempt, or other; *'What Emotion' question*). Following this procedure, the next image would be presented. The entire experiment was recorded using a Sony DCR-SR68 Handycam, which has Face Detection technology, making it easier to monitor the sensors on the individual's face.

2.4 Data Analysis

2.4.1 Behavioural

To determine how accurate individuals were when asked if the expression was 'truly happy' or 'not truly happy' ('Truly Happy' question), accuracy for enjoyment and non-enjoyment smiles were calculated separately. With the enjoyment smiles (Happy), the number of 'truly happy' responses was divided by the number occurrences of that expression. A similar procedure was performed with the non-enjoyment smiles (Masking smiles: Angry Brow, Angry Mouth, Disgust, Fear, Sad Brow, and Sad Mouth), where the number of 'not truly happy' responses was divided by the number of occurrences of the particular expression (e.g. Angry Brow). The 'Another Emotion' question was intended to determine if participants were aware of the presence of another emotion. Accuracy analyses were conducted separately for each of the masking smiles by dividing the number of 'yes' responses to the 'Another Emotion' question by the number of 'not truly happy' responses received during the 'Truly Happy' question. For instance, the number of times a participant responded 'yes' during the 'Another Emotion' question for the Angry Brow expression was divided by the number of times they said the Angry Brow expression was ‘not truly happy’ during the ‘Truly Happy’ question. For the ‘What Emotion’ question, participants were asked what the other emotion was. Therefore, for each masking smile, the number of expected responses was divided by the number of ‘yes’ responses during the ‘Another Emotion’ question. More specifically, when dealing with Angry Brow, the number of ‘anger’ responses for ‘What Emotion’ was divided by the number ‘yes’ responses for ‘Another Emotion’ when the Angry Brow image was displayed.

2.4.2 Eye-Movements

EyeLink Dataviewer was used to analyse the eye-movement data. This software allows the individuals fixations to be superimposed on the stimulus that was presented to them. Two measures of eye-movements were analysed, in accordance with the Perron et al. (2016) study: total dwell time and proportion of time in target regions. To compute the total dwell time, the sum of all time spent on the image was computed from the beginning of the trial until the participant pressed the mouse button. The proportion of time in a region (eyes/brows or mouth) was computed by dividing the dwell time in that region by the total dwell time on the image. This was done because dwell time in a region can be influenced by longer durations on the image (see Perron et al., 2016).

2.4.3 Electromyography

LabChart (ADInstruments Pty Ltd., Bella Vista, Australia) was used to examine the EMG data. The activity in each muscle was segmented into their respective trial windows. These trial windows were equal to the total viewing time of a stimulus; from stimulus onset to the button press. All trial windows were sorted by smile type. For each muscle, the mean absolute activity was collected across the trial windows. The mean activity for a muscle, in response to a smile type, was then calculated by dividing the sum of those mean activities across the trial windows by the number of occurrences of the smile type.

3 Results

3.1 Accuracy

3.1.1 Truly Happy Question

A Repeated-Measures ANOVA was run with Emotional Expression (Happy, Angry Brow, Angry Mouth, Disgust, Fear, Sad Brow, and Sad Mouth) as a within-subject factor. As presented in Figure 2, results indicated that the effect of Emotion was significant on the proportion of expected responses, $F(6,234) = 19.07$, $p < .05$, $\eta_p^2 = .33$. Post-hoc (LSD) tests indicated that participants were more accurate at labelling the Fear masking smile as the expected response (not truly happy) than all the other emotional expressions. Further, fewer expected responses were observed with the Angry Brow masking smile, than all of the remaining expressions. Finally, the Happy and Sad Brow expressions produced more expected responses than the Angry Mouth expression.

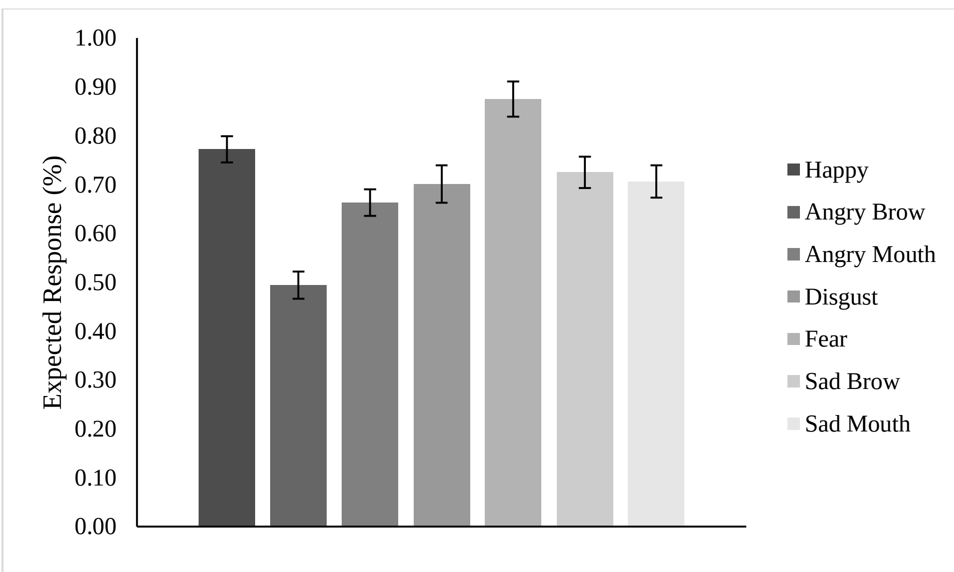

Figure 2.The proportion of expected responses for each of the emotional expressions during the 'Truly Happy' question. Standard error bars represent the standard error of the mean.

3.1.2 Another Emotion Question

A Repeated-Measures ANOVA was run with Emotion (Angry Brow, Angry Mouth, Disgust, Fear, Sad Brow, and Sad Mouth) as a within-subject factor. As evident in Figure 3, the effect of Emotion was observed to be significant on accuracy when participants were asked if there was another emotion in the expression, $F(5,185) = 4.01$, $p < .05$, $\eta_p^2 = .10$. Post-hoc (LSD) tests indicated that participants were more likely to indicate the presence of another emotion with the Fear masking smile, when compared to the remaining. No difference was found between the remaining expressions.

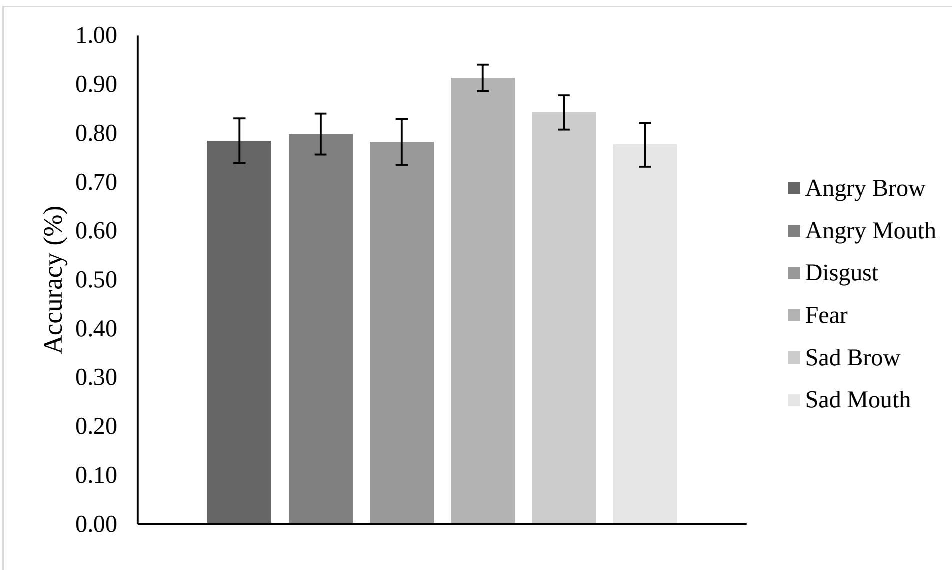

Figure 3.The proportion of accurate responses to the 'Another Emotion' question, as a function of masking smile. Standard error bars represent the standard error of the mean.

3.1.3 What Emotion Question

A Repeated-Measures ANOVA was run with Emotion (Angry Brow, Angry Mouth, Disgust, Fear, Sad Brow, and Sad Mouth) as a within-subject factor. As displayed in Figure 4, results indicated that the effect of Emotion was significant on accuracy when participants were asked to label the other emotion in the expression, $F(5,180) = 6.86$, $p < .05$, $\eta_p^2 = .16$. Post-hoc (LSD) tests suggested that participants were more accurate at labelling the other emotion in a masking smile expression with the Angry Mouth than all other emotional expressions, except Disgust. Further, Disgust accuracy was greater than Sad Mouth, Angry Brow, and Fear expressions. No other differences were observed.

The proportion of label responses (surprise, shame, sadness, other, interest, guilt, fear, disgust, contempt, and anger) were calculated for each emotional expression (Angry Brow, Angry Mouth, Disgust, Fear, Sad Brow, and Sad Mouth), and these values were also compared to chance. To compute these proportions, the number of times a label was used was divided by the number of total labels used for each expression, this is displayed in Figure 4. With ten label choices, chance was set at 10%. The purpose of this test was to determine if a label was used at a rate above chance level. With the number of tests performed, it was decided that p had to be less than .001 to be considered significant. Results indicated that no labels were indicated above chance level for the Angry Brow and Sad Mouth expressions, including their respective labels, $t(122) = 0.74$, $p = .46$ and $t(180) = 2.20$, $p = .03$. For the Angry Mouth, the anger label was used at a rate greater than chance, $t(170) = 5.79$, $p < .001$, $r^2 = .16$. When the Disgust expression was displayed, participants labeled it as disgust at a rate greater than chance, $t(175) = 4.86$, $p < .001$, $r^2 = .12$. For the Fear expressions, the sadness and surprise labels were used at rates greater than chance, $t(265) = 4.41$, $p < .001$, $r^2 = .07$ and $t(265) = 5.12$, $p < .001$, $r^2 = .09$ respectively. The fear label was not used at a rate greater than chance, $t(265) = 0.28$, $p = .78$. Finally, the Sad Brow expression resulted in surprise labels greater than chance, $t(197) = 4.67$, $p < .001$, $r^2 = .10$. The sadness label was not used at a rate greater than chance level, $t(197) = 2.83$, $p = .005$.

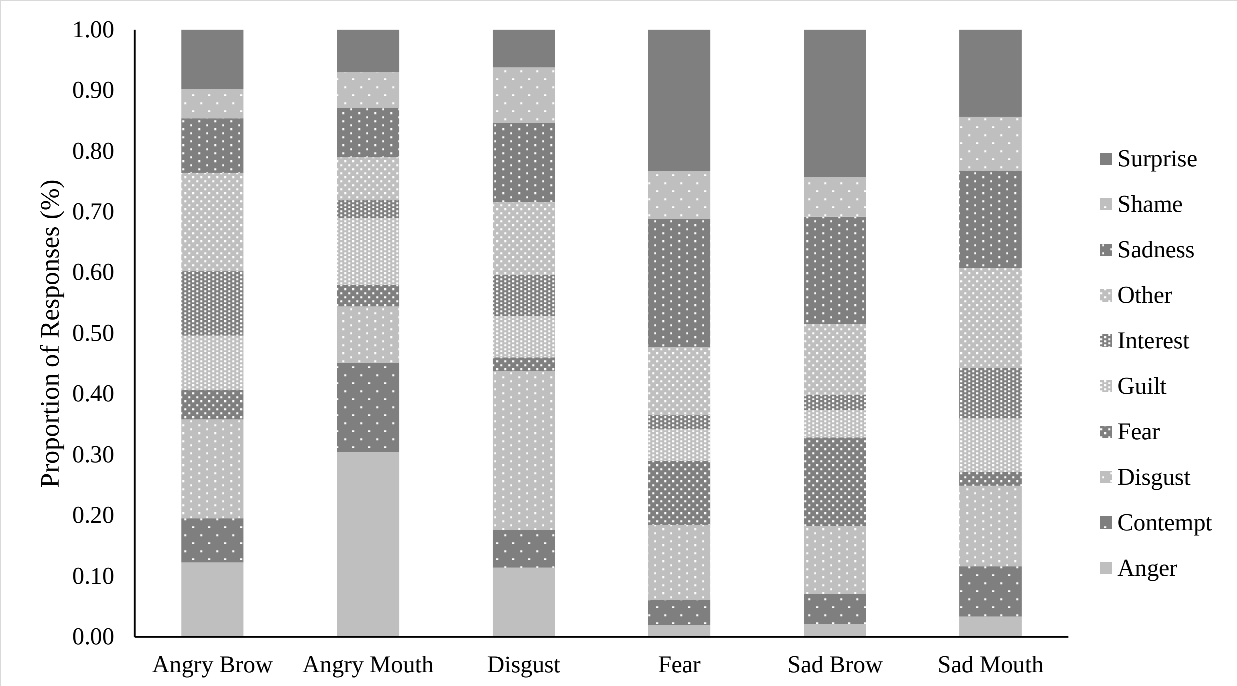

Figure 4. The proportion of times each label was used during the 'What Emotion' question, for each of the emotional expressions. Labels at the bottom of the figure represent the seven emotional expressions, while legend presents the label options presented to the participant.

3.2 Eye-Movements

3.2.1 Total Dwell Time

A Repeated-Measures ANOVA was then used with Emotion (Happy, Angry Brow, Angry Mouth, Disgust, Fear, Sad Brow, and Sad Mouth) as a within-subject factor. Results indicated that Emotion had a significant main effect on the total time spent on an image (total dwell time), $F(6,234) = 2.64$, $p < .05$, $\eta_p^2 = .06$. Post-hoc (LSD) tests indicated that participants spent more time on the image with Sad Mouth than Angry Mouth, Angry Brow, and Fear masking smiles. Further, longer total dwell times were obtained with Sad Brow expressions than Angry Brow and Fear, and more time with Disgust masking smiles than Fear. No other significant differences were obtained. These findings can be viewed in Figure 5.

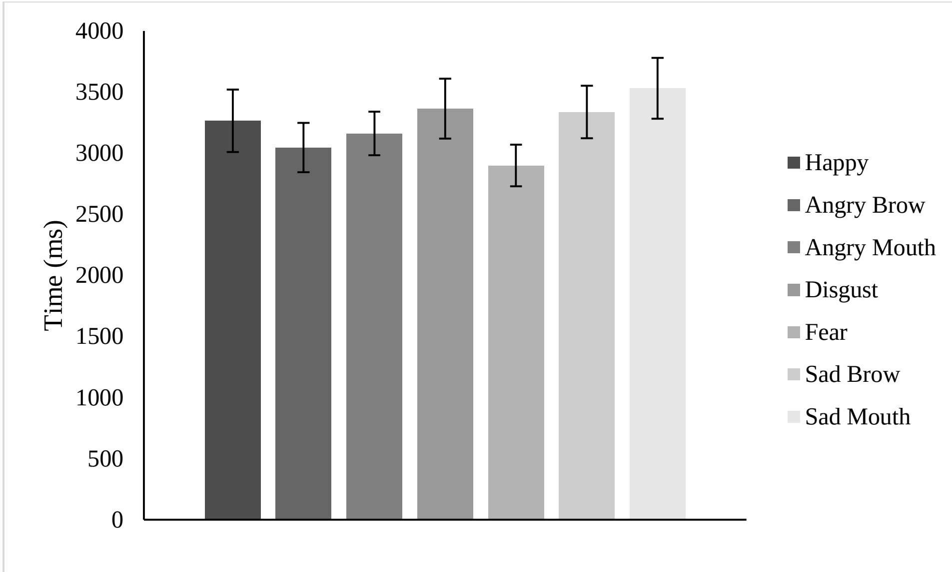

Figure 5. The amount of time spent on the emotional expression images. Standard error bars represent the standard error of the mean.

3.2.2 Proportion of Time

A 2 (Zone: Eyes/Brows and Mouth) x 7 (Emotion: Happy, Angry Brow, Angry Mouth, Disgust, Fear, Sad Brow, and Sad Mouth) Repeated-Measures ANOVA was used with Zone and Emotion as within-subject factors. Results suggested that there was a significant main effect for Zone, $F(1,39) = 52.33$, $p < .05$, $\eta_p^2 = .57$, and a significant interaction, $F(6,234) = 2.48$, $p < .05$, $\eta_p^2 = .06$. The main effect for Emotion did not reach significance, $F(6,234) = 1.02$, $p = .42$, $\eta_p^2 = .03$. Simple main effect tests were computed to further investigate the interaction, where the p-value needed to be less than .016 to be considered significant. The effect of zone was found to be significant with all the emotional expressions, all $F > 339.39$, $p < .01$. Post-hoc (LSD) tests indicated that participants spent more time in the Eyes/Brows region than the Mouth region for all emotional expressions. The effect of emotional expression within the Eyes/Brows and Mouth regions were not found to be significant, both $F < 1$. These findings can be viewed in Figure 6.

To account for the interaction, difference scores were computed between the proportion of time in the eyes/brows and the proportion of time in the mouth, for each emotional expression.

A repeated-measures ANOVA was used with these difference scores, with Emotion (Happy, Angry Brow, Angry Mouth, Disgust, Fear, Sad Brow, and Sad Mouth) as a within subject factor. Results indicated that there was a significant main effect for Emotion, $F(6,234) = 2.48$, $p < .05$, $\eta_p^2 = .06$. Post-hoc tests indicated that there was a greater difference between the proportion of time in the eyes/brows and mouth with the Fear masking smile than Angry Brow, Angry Mouth, Disgust, Happy, and Sad Mouth expressions. There was no significant difference between the Fear and Sad Brow masking smiles, and no other significant differences were observed.

3.3 EMG Activity

This data was analyzed using a 3 (Muscle: *zygomaticus major*, *corrugator supercilii*, and *frontalis, pars lateralis*) x 7 (Emotion: Happy, Angry Brow, Angry Mouth, Disgust, Fear, Sad Brow, and Sad Mouth) Repeated-Measures ANOVA, with Muscle and Emotion as within-subject factors. As displayed in Figure 7, results revealed no significant main effects for Muscle, $F(2,78) = 2.58$, $p = .08$, $\eta_p^2 = .06$, or Emotion, $F(6,234) = 0.45$, $p = .84$, nor was there a significant interaction, $F(12,468) = 0.30$, $p = .99$.

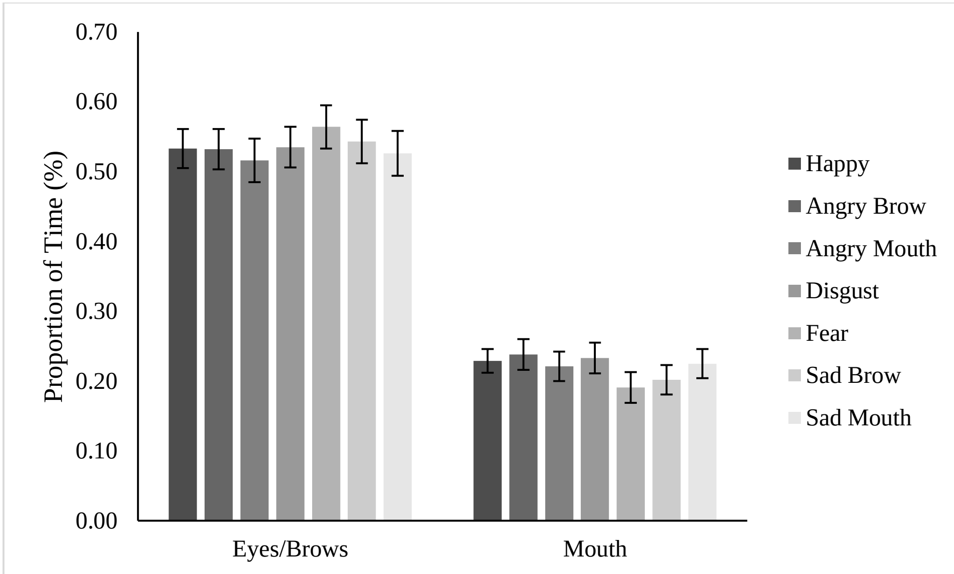

Figure 6. The proportion of time spent in either the eyes/brows or the mouth region, as a function of the emotional expression. Standard error bars represent the standard error of the mean.

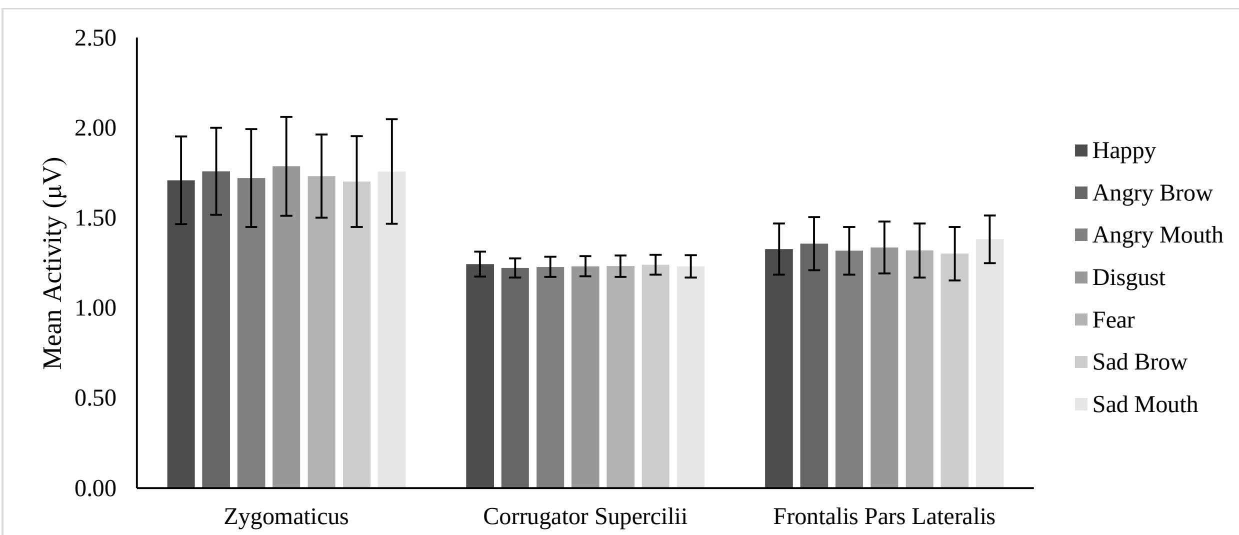

Figure 7. The average EMG activity (μV) for each emotional expression, as a function of muscle type. Standard error bars represent the standard error of the mean.

3.4 Regressions

3.4.1 Truly Happy Question

For each emotion, separate stepwise multiple regressions were performed to determine if explicit knowledge (‘Another Emotion’ or ‘What Emotion’), emotional contagion (positive ECS or negative ECS), facial mimicry (*zygomaticus major*, *corrugator supercilii*, or *frontalis, pars lateralis*), or eye-movements (total dwell time, proportion of time in eyes/brows region, or proportion of time in mouth region) could predict ‘Truly Happy’ judgment accuracies. In sum, four Multiple regressions were performed for each of the seven emotional expressions (total of 28). As displayed in Table 1, results suggested that explicit knowledge was not a significant predictor for any of the emotional expressions. Alternatively, emotional contagion was found to significantly predict Fear masking smile accuracies, where a decrease in sensitivity to positive emotional contagion was a predictor for increased accuracy. Emotional contagion was not found to predict accuracy for any of the remaining emotional expressions. Using the EMG activity to measure facial mimicry, the *zygomaticus major* activity was found to be a significant predictor for Angry Mouth accuracies ($p < .05$). Greater muscle activity predicted lower accuracy. Muscle activity was not found to predict judgment accuracy for any other emotional expressions. Finally, eye-movements presented significant predictors for the Angry Brow, Fear, and Disgust masking smiles ($p < .05$). Results indicated that an increased amount of time in the eyes/brows region was able to predict greater accuracies with the Angry Brow expression. Conversely, an increased amount of time on the Fear and Happy images predicted lower accuracies.

Significant correlations were also observed, excluding the already discussed significant predictors, as displayed in Table 2. Correlations between accuracy and eye-movements were examined. Results indicated with the Angry Brow expression: a positive correlation between dwell time and accuracy; and a negative correlation between the proportion of time in the mouth and accuracy. When the correlations between emotional contagion and accuracy were considered, a positive correlation was observed between the negative ECS and Happy accuracy. A negative correlation was also observed between the positive ECS and Sad Mouth accuracy. No other correlations were observed with accuracy.

3.4.2 Explicit Knowledge

Stepwise multiple repressions were used to determine if positive or negative ECS could predict accuracies during the ‘Another Emotion’ or ‘What Emotion’ questions, as function of emotional expression. Eye-movement and EMG data were not analyzed because it was only measured at the beginning of the trial, while participants were judging if the smile was truly happy or not truly happy. Results indicated that emotional contagion was not a significant predictor for either ‘Another Emotion’ or ‘What Emotion’. However, a significant positive correlation was observed between negative ECS scores and ‘Another Emotion’ accuracies with Angry Brow expressions. More specifically, increased accuracy with the Angry Brow expression was observed with increased negative ECS scores.

3.4.3 EMG Activity

Subsequent analyses were conducted to determine if emotional contagion (positive ECS or negative ECS) or eye-movements (proportion of time in eyes/brows region or proportion of time in mouth region) could predict EMG activity. Separate stepwise multiple regressions were conducted for each emotional expression and each muscle. Results indicated that eye-movements provided a significant predictor for Fear, Sad Brow, and Sad Mouth masking smiles ($p < .05$). It was found that a greater amount of time in the mouth region predicted greater muscle activity in the *frontalis, pars lateralis*, with these three expressions. While not displaying a significant predictor, a significant positive correlation with the same trend was observed with the Angry Brow, Disgust, and Happy expression.

Table 1. Stepwise multiple linear regressions with a significant predictor. For a predictor to be included in the regression model, the p-value needed to be less than .05.

	B	Beta	*t*	*p*
'Truly Happy' for Fear: $F(1,38) = 4.62$, $p < .05$, $R^2 = .11$, $SE_{estimate} = 0.21$				
Positive ECS	-0.03	-0.33	-2.15	.04
Negative ECS	-	-	1.29	.21
'Truly Happy' for Angry Mouth: $F(1,38) = 5.40$, $p < .05$, $R^2 = .12$, $SE_{estimate} = 0.16$				
Zygomaticus Major	-0.04	-0.35	-2.32	.03
Corrugator Supercilii	-	-	-0.05	.86
Frontalis Pars Lateralis	-	-	0.87	.39
'Truly Happy' for Angry Brow: $F(1,38) = 8.90$, $p < .05$, $R^2 = .19$, $SE_{estimate} = 0.16$				
Total Dwell Time	-	-	1.22	.23
Prop. of Time in Eyes	0.41	0.44	2.98	< .01
Prop. of Time in Mouth	-	-	0.04	.97
'Truly Happy' for Fear: $F(1,38) = 5.40$, $p < .05$, $R^2 = .12$, $SE_{estimate} = 0.16$				
Total Dwell Time	$-8.12*10^5$	-0.39	-2.61	.01
Prop. of Time in Eyes	-	-	0.05	.96
Prop. of Time in Mouth	-	-	-0.42	.68
'Truly Happy' for Happy: $F(1,38) = 6.81$, $p < .05$, $R^2 = .15$, $SE_{estimate} = 0.21$				
Total Dwell Time	$-5.20*10^5$	-0.49	-3.45	< .01
Prop. of Time in Eyes	-	-	-0.45	.65
Prop. of Time in Mouth	-	-	0.33	.75
Frontalis Pars Lateralis for Fear: $F(1,38) = 4.15$, $p = .05$, $R^2 = .10$, $SE_{estimate} = 0.91$				
Prop. of Time in Eyes	-	-	0.84	.41
Prop. of Time in Mouth	2.12	0.31	2.04	.05
Frontalis Pars Lateralis for Sad Brow: $F(1,38) = 4.39$, $p < .05$, $R^2 = .10$, $SE_{estimate} = 0.90$				
Prop. of Time in Eyes	-	-	<0.00	>.99
Prop. of Time in Mouth	2.24	0.32	2.10	
Frontalis Pars Lateralis for Sad Mouth: $F(1,38) = 6.27$, $p < .05$, $R^2 = .14$, $SE_{estimate} = 0.78$				
Prop. of Time in Eyes	-	-	0.73	.47
Prop. of Time in Mouth	2.35	0.38	2.50	.02

Table 2. Correlations between all the variables used in the regression analyses. Significant predictors are presented in bold.

		Emotion						
Dependent Variable	Predictor	Angry Brow	Angry Mouth	Disgust	Fear	Happy	Sad Brow	Sad Mouth
Truly Happy								
	Another Emotion	-.13	<.01	-.17	.03	-	-.23	-.13
	What Emotion	-.05	-.16	.16	.18	-	.19	-.08
	Positive ECS	-.24	-.25	-.28	**-.33***	.22	-.23	-.27*
	Negative ECS	.25	-.01	-.04	.01	.31*	-.20	-.16
	Zygomaticus Major	-.21	**-.35***	-.20	-.25	-.08	-.22	-.26
	Corrugator Supercilii	.17	-.04	-.19	-.11	.09	-.04	.09
	Frontalis Pars Lateralis	-.16	.10	.03	.07	.08	.01	-.04
	Total Dwell Time	.27*	-.15	-.19	**-.39***	**-.49***	.15	-.19
	Brow Prop. of Time	**.44***	-.04	.04	-.03	-.16	-.19	.09
	Mouth Prop. of Time	-.30*	.10	-.01	-.02	.11	.03	-.20
Another Emotion								
	Positive ECS	.06	.20	.08	.08	-	.13	.23
	Negative ECS	-.12	-.06	-.18	.05	-	-.04	.03
What Emotion								
	Positive ECS	.10	-.12	-.18	-.10	-	-.16	.06
	Negative ECS	.28*	.04	.05	-.12	-	.17	.17
Zygomaticus Major								
	Positive ECS	.17	.14	.13	.14	.13	.08	.11
	Positive ECS	-.05	-.11	-.06	-.06	-.07	-.09	-.12
	Brow Prop. of Time	-.15	-.14	-.12	-.09	-.14	-.08	-.09
	Mouth Prop. of Time	-.05	-.15	-.09	-.19	-.13	-.13	-.05
Corrugator Supercilii								
	Positive ECS	-.08	-.10	-.12	-.03	-.14	-.16	-.12
	Positive ECS	.14	.11	.11	.10	.02	.04	.04
	Brow Prop. of Time	.21	.01	.11	-.04	.09	.05	.05
	Mouth Prop. of Time	.02	-.04	-.04	.08	-.02	.10	.13
Frontalis Pars Lateralis								
	Positive ECS	.16	.11	.12	.14	.11	.10	.11
	Positive ECS	.24	.18	.21	.15	.17	.15	.16
	Brow Prop. of Time	-.07	-.07	-.21	-.14	-.10	-.21	-.16
	Mouth Prop. of Time	.26*	.19	.30*	**.31***	.29*	**.32***	**.38***

Note: * $p < .05$

4 Discussion

In a recent study by Perron and colleagues (2016), the recognition of masking smiles were examined in a smile authenticity judgment task. These expressions represent smiles used to mask the expression of negative emotions (Angry Brows, Angry Mouth, Disgust, Fear, Sad Brows, and Sad Mouth). During the judgment task, eye-movements and explicit knowledge were measured to determine if any of these factors were related to judgment accuracies. This study concluded that participants displayed differences in accuracies as a function of emotional expression, with Fear masking smiles being judged more accurately and Angry Brow masking smiles being judged less accurately. However, it was suggested that eye-movements and explicit knowledge could not fully explain these judgment differences.

The purpose of the current study was to explore how eye-movements, facial mimicry and emotional contagion interact with smile judgments, to determine if any of these factors can predict the varying performances displayed by Perron et al. (2016). The masking smiles used for the purpose of this study were the same as those used by Perron and colleagues (2016), with the following traces of negative emotions: Angry Brows, Angry Mouth, Disgust, Fear, Sad Brows, and Sad Mouth. According Manera and colleagues (2013), it was hypothesized that individuals would be more accurate with the masking smiles if they scored higher on susceptibility to negative emotional contagion with the ECS. As previously discussed, these individuals may be more sensitive to the negative expressions displayed in the masking smiles. Furthermore, facial mimicry was explored, where it was hypothesized that greater scores on the judgment task would be observed if there were greater mimicking behaviours of the negative emotions. Relationships between eye-movements and facial mimicry were also explored and will be discussed later, as well as relationships between the ECS and facial mimicry. Alternatively, no such relationship was found between the ECS and EMG activity (i.e. facial mimicry), supporting the results of Hess and Blairy (2001) in suggesting that facial mimicry may not effect to emotional contagion.

For the enjoyment expressions (Happy), the current study observed that dwell time was a significant predictor during the smile authenticity judgement task. More specifically, it was observed that participants did better on the task when they spent less time looking at the image. In addition, a significant correlation was observed between emotional contagion and 'Truly Happy' accuracies. Participants more susceptible to positive emotional contagion were found to do better on this task. These results are actually in contrast to the Manera et al. (2013) study, which explored Duchenne (truly happy) and non-Duchenne (not truly happy) smiles. In their study, they reported that participants scoring higher on the positive ECS were more likely to display decreased accuracies during the recognition task and label the non-enjoyment Duchenne smiles as happy, while participants scoring higher on the negative ECS performed better on the judgment task. While the current study's enjoyment smiles would have similar configurations as the Manera et al. (2013) Duchenne marker smiles, the current study's non-enjoyment masking smiles contained traces of negative emotions unlike their non-enjoyment non-Duchenne smiles. Therefore, the disparities observed between the current study and the Manera et al. (2003) study are likely due to these negative emotions. This suggests that participants sensitive to negative emotional contagion likely performed better with the enjoyment smiles because they were able to detect the absence of a negative expression.

As for the non-enjoyment masking smile recognitions, results appeared to differ as a function of emotional expression. This finding appears to be in line with the study conducted by Perron and colleagues (2016). Therefore, the six masking smiles (Angry Brow, Angry Mouth, Disgust, Sad Brow, and Sad Mouth) will be discussed separately. To begin, when participants were displayed Disgust masking smiles, it was observed that participants were quite good at labeling the emotion in the expression, with a rate above chance. However, unlike many of the other emotional expressions, none of the measures (explicit knowledge, emotional contagion, facial mimicry, or eye-movements) were found to predict or correlate with accuracy scores. Although, the current study only used three muscle locations and did not consider activity in the *levator labii*, which is often associated with disgust expressions (Lundqvist & Dimberg, 1995). As a result, future studies may need to investigate the role of facial mimicry of the *levator labii* in masking smiles.

In the current study, Angry Brow masking smiles resulted in the lowest accuracies during the smile authenticity judgment task, meaning that participants were more likely to indicate that these smiles were ‘truly happy’ than the other masking smiles. It was also observed that participants were not very accurate at labeling the other emotion in the expression, and the anger label was used at a rate that did not differ from chance. This suggests that participants were likely not able to accurately label the negative emotion in these facial expressions. These results are directly relatable to the Perron et al. (2016) study, where they also found that Angry Brow expressions resulted in the worst accuracies during the smile authenticity judgment task.

The current study added to the Perron et al. (2016) findings by displaying that the proportion of time in the eyes/brows was a significant predictor for smile authenticity judgment accuracies with the Angry Brow expression. It was found that participants were more accurate at indicating that it was ‘not truly happy’ when they spent more time in eyes/brows region. This was to be expected because a greater proportion of time in this region would give participants more time to perceive the trace of negative emotion. Significant correlations were also found where greater accuracies were related to more time on the image and less time in the mouth region. These results together appear to suggest that the low accuracies displayed during the smile authenticity judgement task are likely due to a lack of attention to the eyes/brows. Alternatively, it was hypothesized that the data would have represented perceptual difficulties if more time on a distinctive cue would have predicted poor judgment accuracies, but the current study presents attentional difficulties because less time predicted poor scores. In other words, participants are displaying an attentional difficulty with the Angry Brow masking smiles. Furthermore, a significant correlation was found between emotional contagion and explicit knowledge of the presence of another emotion in the face, where increased susceptibility to negative emotions were linked to increased accuracies. This suggests participants that are sensitive to negative emotions may be better suited to detecting the presence of another emotion in the Angry Brow masking smile, yet this did not seem to relate to smile authenticity judgment accuracies or emotion labeling accuracies.

The Angry Mouth masking smiles displayed a very different pattern of results, when compared to the Angry Brow smiles. With these expressions, participants displayed low accuracies during the smile authenticity judgment task, relative to Happy and Sad Brow expressions, but still displayed greater accuracies than the Angry Brow expressions. However, these expressions were observed to result in greatest accuracies when participants were asked to label the emotion, with a rate above chance. This suggests that, even though participants had some difficulty determining if these smiles were truly happy, they displayed explicit knowledge of the label. These results are similar to a study conducted by Gosselin, Beaupré, and Boissonneault (2002), which examined recognition of Happy and Angry Mouth masking smiles. Their findings suggested that adult participants could accurately label the emotion displayed in the masking smile. In addition, these results are similar to those of Perron et al (2016), yet the current study also found a significant predictor for smile authenticity judgment accuracies. In the exploration of facial mimicry, it was found that less *zygomaticus major* EMG activity predicted greater Angry Mouth accuracies. This was to be expected because greater activity in this muscle was hypothesized to display mimicry of the smile in happiness (Dimberg, 1982; Dimberg et al., 2000; Lundqvist & Dimberg, 1995; Oberman et al., 2007; Rychlowska et al., 2014). Therefore, decreased activity in this muscle would mean less mimicry of the smile action in these masking smile expressions.

Similar to the Perron et al. (2016) study, participants were found to do the best on the smile authenticity judgment task with the Fear masking smiles. This means that they were more likely to correctly indicate that these smiles were “not truly happy”. In addition, it was also found that participants were more likely indicate that there was another emotion in the expression, yet they were less likely to accurately label the emotional expression. While the previous study (Perron et al., 2016) found these same results, they were not able to indicate why. The current study, however, found two significant predictors for accuracies during the smile authenticity judgment task. It was found that participants that spent less time dwelling on the image had greater accuracies. This was an interesting finding because participants were already found to spend less time on these Fear masking smiles than all the other emotional expressions. This suggests that participants often did better when they made their decisions very quickly. This finding is not very surprising though because studies of fear expressions have often indicated that their processing begins much quicker than many other expressions, in the detection of threatening information (Luo, Feng, He, Wang, and Luo, 2010; Zhang, Luo, & Luo, 2013). This suggests that participants are more accurate recognizing the Fear masking smiles as “not truly happy” when they respond quickly, rather than spending more time on the expression.

Furthermore, when compared to the other expressions, except Sad Brow, it was also found that there was a greater difference between the proportion of time in the eyes/brows and the proportion of time in the mouth, with greater time in the eyes/brows than the mouth. This was also to be expected, seeing as the cue for fear was found in the eyes/brow region. Although, neither of these proportion measures were found to be able to predict or correlate with authenticity judgment accuracies.

In addition, another predictor was found to be significant for the Fear masking smiles. It was found that participants were more accurate during the smile authenticity judgment task when they were less susceptible to positive emotional contagion. This is similar to the Manera et al. (2013) study, suggesting that participants were more likely to label the Fear masking smiles as "truly happy" when they were more susceptible to positive emotions. What is also interesting with these emotional expressions is that participants labeled them fear at a rate equal to chance, but they used the sadness and surprise labels at a rate greater than chance. Further, a greater proportion of time in the mouth region was found to be a predictor for greater EMG activity in the *frontalis, pars lateralis*, a muscle that is often associated with fear and surprise. While it is unclear why participant would display increased activity in this muscle while looking at the mouth, participants were potentially mimicking a muscle that is displayed in the emotional expression. Although, as indicated earlier, eye-movement and EMG activity did not provide a significant predictor for accuracies. This finding between eye-movements and EMG activity will be discussed in greater detail later.

It was observed that participants often labeled the Sad Brow expressions as surprise, and they did not label these expressions sadness at a rate above chance. This suggests that these masking smiles are being confused with surprise expressions. It is unclear why this might occur, although sad and surprise expressions can share the *frontalis, pars medialis* (AU1; inner brow raiser) muscle action. In addition, it was found that a greater proportion of time in the mouth predicted greater EMG activity in the *frontalis, pars lateralis*. This muscle in particular is often associated with fear and surprise expressions. Therefore, it appears that participants were displaying increased EMG activity for a muscle that was not related to the expression displayed. This appears to potentially represent false alarm mimicry. More specifically, it appears they first potentially mimic an expression that is not apparent in the face (fear or surprise), then they later label the Sad Brow expression with an emotion that is often associated with the facial mimicry they earlier displayed (surprise). The current study did not measure EMG activity during the explicit knowledge phase of the study and cannot directly link mimicry to explicit knowledge, but these findings are worth noting and exploring in a future study. These results will later be discussed in greater detail.

Participants were found to spend more time on the image with the Sad Mouth expressions, with greater dwell times than the other expressions. Yet accuracies did not display greater or lower scores. In addition, participants were not very good at labeling the emotion in these expressions, with rates equal to chance. However, a significant correlation was observed between emotional contagion and smile authenticity judgment accuracies. More specifically, greater accuracies were observed when participants had a lower susceptibility to positive emotional contagion. This suggests that individuals with a sensitivity to positive emotional contagion were more likely to label these masking smiles as “truly happy”. These results are consistent with the Manera et al. (2013) results that studied Duchenne and non-Duchenne smiles. However, this finding was not displayed with any of the other masking smiles. Furthermore, the proportion of time in the mouth region was found to be a predictor for the muscle activity in the *frontalis, pars lateralis*. Unlike when this finding was found with Fear and Sad Brow masking smiles, the current study cannot easily explain why such activity might have been observed with the Sad Mouth expressions.

The current study found the proportion of time in the mouth to be a significant predictor for the *frontatlis, pars lateralis* EMG activity, with a greater amount of time leading to greater activity. A similar positive correlation was also found to be significant with Angry Brow and Happy expressions. These results were contrary to original hypotheses that a greater amount of time in a region would result in greater mimicry in that region. More specifically, it was hypothesized that greater activity would be observed for the *frontalis, pars lateralis* if participants spent more time the eyes/brows or less time in the mouth. This hypothesis was also only thought to be true for the Fear masking smiles, because it was the only expression with the *frontalis, pars lateralis* activity (i.e. AU 2; outer brow raiser) being displayed in the image. With almost all the expressions, except Disgust, displaying this trend for more EMG activity with increased time looking at the mouth, it is possible that this finding is the result of an ocular artifact. With the sensors locations of the *frontalis, pars lateralis* being similar to that of electrooculography (see Harmon-Jones & Peterson, 2009), it is possible that these findings are the result of participants looking downwards at the mouth. Due to the limitations of the current study in evaluating whether this is the result of an ocular artifact, these findings should be considered with great hesitation. As indicated, it was hypothesized that true mimicry would have been displayed by increased activity in the *frontalis*, *pars lateralis* with an increased amount of time in the eyes/brows, not the mouth. Therefore, a future study is needed to confirm that the current findings are not the result of eye-movement artifacts. This could be achieved by measuring eye-movements from below the eye as well. Furthermore, in the current study, no other relationships were found between eye-movements and EMG activity, and EMG activity was not found to differ as a function of emotional expression. These latter results suggest that participant may not be mimicking the negative emotional expressions. In addition, with all expression stimuli containing the display of *zygomaticus major* activation, it is difficult to determine if participants mimicked the positive expression.

The current study included limitations involving the EMG muscle activity measured. The current study did find differences in EMG activity across the emotional expressions. It is possible that this may have occurred due to the use of the EyeLink II, which utilizes a headband to secure the system on the individual's head. It was hypothesized increased EMG activity would be observed in muscles that are activated in the emotional image (i.e. facial mimicry). We may not have observed the expected results because headband from the EyeLink II may have been restricting muscle movements in the upper portion of the participant's face. To explore this further, a study would need to be conducted solely measuring EMG activity, without eye-tracking measures. EMG activity was also not measured from many of the potential muscles, to reduce the likelihood of a participant anticipating the true purpose of the study. For instance, the *levator labii*, the *depressor anguli oris*, and the *frontalis, pars medialis* were not measured. It is hypothesized that *levator labii* activity would be related to Disgust masking smiles, and *depressor anguli oris* activity would be related to Angry Mouth expressions. While the current study indicated that decreased *zygomaticus major* activity predicted Angry Mouth judgment accuracies, it is possible that increased *depressor anguli oris* activity would predict greater accuracies. Further, the current study did not measure EMG activity in the *frontalis, pars medialis*, which may be related to the Fear and Sad Brow masking smiles. In addition, EMG activity was not measured during the explicit knowledge questions. Therefore, it is possible that EMG activity may be able to predict which label is assigned to an expression.

5 Conclusion

In conclusion, the current study replicated the findings of Perron et al. (2016), with varying authenticity judgments as a function of masking smile expression. Fear masking smiles resulted in the greatest judgment accuracies, while Angry Brow masking smiles resulted in the worst. Furthermore, participants were found to be better able to label the emotion in the expression with the Angry Mouth expressions. Results in the current study suggest that participants may rely on different techniques for these masking smile recognitions. In effect, an increased amount of time in the eyes/brows resulted greater accuracies with the Angry Brow masking smiles, decreased facial mimicry of the smile (i.e. *zygomaticus major* EMG activity) resulted in greater accuracies with the Angry Mouth masking smiles, and decreased sensitivity to positive emotional contagion resulted in increased accuracies with the Fear masking smiles. Correlations also suggested that there may be a link between emotional contagion and authenticity accuracies with Happy and Sad Mouth expressions, with increased negative susceptibility and decreased positive susceptibility predicting greater accuracies, respectively. Together, this suggests in the recognition of enjoyment and masking smiles, the technique used may be as a function of the emotional expression.

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Appendix A

ECS

For the following statements, please use these numbers to indicate how often this occurs to you:

Never	Rarely	Often	Always
1	2	3	4

1. If someone I’m talking with begins to cry, I get teary-eyed. ___
2. Being with a happy person picks me up when I’m feeling down. ___
3. When someone smiles warmly at me, I smile back and feel warm inside. ___
4. I get filled with sorrow when people talk about the death of their loved ones. ___
5. I clench my jaws and my shoulders get tight when I see the angry faces on the news. ___
6. When I look into the eyes of the one I love, my mind is filled with thoughts of romance. ___
7. It irritates me to be around angry people. ___
8. Watching the fearful faces of victims on the news makes me try to imagine how they might be feeling. ___
9. I melt when the one I love holds me close. ___
10. I tense when overhearing an angry quarrel. ___
11. Being around happy people fills my mind with happy thoughts. ___
12. I sense my body responding when the one I love touches me. ___
13. I notice myself getting tense when I’m around people who are stressed out. ___
14. I cry at sad movies. ___
15. Listening to the shrill screams of a terrified child in a dentist’s waiting room makes me feel nervous. ___

Appendix B

Table 3. Post hoc comparisons for the 'Truly Happy' question responses. Mean differences in expected responses are analyzed between the emotional expressions.

Emotion A	Emotion B	Mean A (SD)	Mean B (SD)	p-value
Angry Brow	Angry Mouth	.49 (.17)	.66 (.17)	<.01
Angry Brow	Disgust	.49 (.17)	.70 (.24)	<.01
Angry Brow	Fear	.49 (.17)	.88 (.22)	<.01
Angry Brow	Happy	.49 (.17)	.77 (.17)	<.01
Angry Brow	Sad Brow	.49 (.17)	.73 (.21)	<.01
Angry Brow	Sad Mouth	.49 (.17)	.71 (.21)	<.01
Angry Mouth	Disgust	.66 (.17)	.70 (.24)	.23
Angry Mouth	Fear	.66 (.17)	.88 (.22)	<.01
Angry Mouth	Happy	.66 (.17)	.77 (.17)	<.01
Angry Mouth	Sad Brow	.66 (.17)	.73 (.21)	.05
Angry Mouth	Sad Mouth	.66 (.17)	.71 (.21)	.19
Disgust	Fear	.70 (.24)	.88 (.22)	<.01
Disgust	Happy	.70 (.24)	.77 (.17)	.15
Disgust	Sad Brow	.70 (.24)	.73 (.21)	.49
Disgust	Sad Mouth	.70 (.24)	.71 (.21)	.89
Fear	Happy	.88 (.22)	.77 (.17)	<.01
Fear	Sad Brow	.88 (.22)	.73 (.21)	<.01
Fear	Sad Mouth	.88 (.22)	.71 (.21)	<.01
Happy	Sad Brow	.77 (.17)	.73 (.21)	.28
Happy	Sad Mouth	.77 (.17)	.71 (.21)	.17
Sad Brow	Sad Mouth	.73 (.21)	.71 (.21)	.50

Table 4. Post hoc comparisons for the 'Another Emotion' question responses. Mean differences in accuracies are analyzed are analyzed between the emotional expressions.

Emotion A	Emotion B	Mean A (SD)	Mean B (SD)	p-value
Angry Brow	Angry Mouth	.78 (.28)	.80 (.26)	.69
Angry Brow	Disgust	.78 (.28)	.78 (.29)	.97
Angry Brow	Fear	.78 (.28)	.91 (.17)	<.01
Angry Brow	Sad Brow	.78 (.28)	.84 (.22)	.10
Angry Brow	Sad Mouth	.78 (.28)	.78 (.28)	.87
Angry Mouth	Disgust	.80 (.26)	.78 (.29)	.68
Angry Mouth	Fear	.80 (.26)	.91 (.17)	<.01
Angry Mouth	Sad Brow	.80 (.26)	.84 (.22)	.24
Angry Mouth	Sad Mouth	.80 (.26)	.78 (.28)	.50
Disgust	Fear	.78 (.29)	.91 (.17)	<.01
Disgust	Sad Brow	.78 (.29)	.84 (.22)	.09
Disgust	Sad Mouth	.78 (.29)	.78 (.28)	.88
Fear	Sad Brow	.91 (.17)	.84 (.22)	.03
Fear	Sad Mouth	.91 (.17)	.78 (.28)	<.01
Sad Brow	Sad Mouth	.84 (.22)	.78 (.28)	.10

Table 5. Post hoc comparisons for the 'What Emotion' question responses. Mean differences in expected responses are analyzed between emotional expressions.

Emotion A	Emotion B	Mean A (SD)	Mean B (SD)	p-value
Angry Brow	Angry Mouth	.10 (.21)	.34 (.33)	<.01
Angry Brow	Disgust	.10 (.21)	.26 (.29)	<.01
Angry Brow	Fear	.10 (.21)	.09 (.13)	.78
Angry Brow	Sad Brow	.10 (.21)	.16 (.23)	.18
Angry Brow	Sad Mouth	.10 (.21)	.13 (.18)	.50
Angry Mouth	Disgust	.34 (.33)	.26 (.29)	.25
Angry Mouth	Fear	.34 (.33)	.09 (.13)	<.01
Angry Mouth	Sad Brow	.34 (.33)	.16 (.23)	.01
Angry Mouth	Sad Mouth	.34 (.33)	.13 (.18)	<.01
Disgust	Fear	.26 (.29)	.09 (.13)	<.01
Disgust	Sad Brow	.26 (.29)	.16 (.23)	.11
Disgust	Sad Mouth	.26 (.29)	.13 (.18)	.05
Fear	Sad Brow	.09 (.13)	.16 (.23)	.11
Fear	Sad Mouth	.09 (.13)	.13 (.18)	.26
Sad Brow	Sad Mouth	.16 (.23)	.13 (.18)	.51

Table 6. Post hoc comparisons for the total time spent on an image (total dwell time). Mean differences in total dwell time are analyzed between emotional expressions.

Emotion A	Emotion B	Mean A (SD)	Mean B (SD)	p-value
Angry Brow	Angry Mouth	3045.35 (1275.53)	3160.54 (1132.22)	.37
Angry Brow	Disgust	3045.35 (1275.53)	3363.88 (1546.22)	.14
Angry Brow	Fear	3045.35 (1275.53)	2899.26 (1078.97)	.39
Angry Brow	Happy	3045.35 (1275.53)	3264.92 (1612.91)	.21
Angry Brow	Sad Brow	3045.35 (1275.53)	3337.16 (1357.12)	.02
Angry Brow	Sad Mouth	3045.35 (1275.53)	3529.44 (1570.46)	.03
Angry Mouth	Disgust	3160.54 (1132.22)	3363.88 (1546.22)	.21
Angry Mouth	Fear	3160.54 (1132.22)	2899.26 (1078.97)	.08
Angry Mouth	Happy	3160.54 (1132.22)	3264.92 (1612.91)	.57
Angry Mouth	Sad Brow	3160.54 (1132.22)	3337.16 (1357.12)	.20
Angry Mouth	Sad Mouth	3160.54 (1132.22)	3529.44 (1570.46)	.05
Disgust	Fear	3363.88 (1546.22)	2899.26 (1078.97)	<.01
Disgust	Happy	3363.88 (1546.22)	3264.92 (1612.91)	.68
Disgust	Sad Brow	3363.88 (1546.22)	3337.16 (1357.12)	.88
Disgust	Sad Mouth	3363.88 (1546.22)	3529.44 (1570.46)	.28
Fear	Happy	2899.26 (1078.97)	3264.92 (1612.91)	.11
Fear	Sad Brow	2899.26 (1078.97)	3337.16 (1357.12)	.01
Fear	Sad Mouth	2899.26 (1078.97)	3529.44 (1570.46)	<.01
Happy	Sad Brow	3264.92 (1612.91)	3337.16 (1357.12)	.75
Happy	Sad Mouth	3264.92 (1612.91)	3529.44 (1570.46)	.34
Sad Brow	Sad Mouth	3337.16 (1357.12)	3529.44 (1570.46)	.33

Table 7. Post hoc comparisons for the proportion of time spent gazing at an area. Mean differences are analyzed between emotion expressions, as a function of zone.

Zone	Emotion A	Emotion B	Mean A (SD)	Mean B (SD)	p-value
Brow	Angry Brow	Angry Mouth	.53 (.19)	.52 (.20)	.50
	Angry Brow	Disgust	.53 (.19)	.54 (.18)	.85
	Angry Brow	Fear	.53 (.19)	.56 (.20)	.11
	Angry Brow	Happy	.53 (.19)	.53 (.17)	.93
	Angry Brow	Sad Brow	.53 (.19)	.54 (.19)	.56
	Angry Brow	Sad Mouth	.53 (.19)	.53 (.20)	.79
	Angry Mouth	Disgust	.52 (.20)	.54 (.18)	.25
	Angry Mouth	Fear	.52 (.20)	.56 (.20)	.02
	Angry Mouth	Happy	.52 (.20)	.53 (.17)	.19
	Angry Mouth	Sad Brow	.52 (.20)	.54 (.19)	.20
	Angry Mouth	Sad Mouth	.52 (.20)	.53 (.20)	.54
	Disgust	Fear	.54 (.18)	.56 (.20)	.08
	Disgust	Happy	.54 (.18)	.53 (.17)	.87
	Disgust	Sad Brow	.54 (.18)	.54 (.19)	.68
	Disgust	Sad Mouth	.54 (.18)	.53 (.20)	.64
	Fear	Happy	.56 (.20)	.53 (.17)	.08
	Fear	Sad Brow	.56 (.20)	.54 (.19)	.26
	Fear	Sad Mouth	.56 (.20)	.53 (.20)	.08
	Happy	Sad Brow	.53 (.17)	.54 (.19)	.53
	Happy	Sad Mouth	.53 (.17)	.53 (.20)	.66
	Sad Brow	Sad Mouth	.54 (.19)	.53 (.20)	.48
Mouth	Angry Brow	Angry Mouth	.23 (.14)	.22 (.13)	.30
	Angry Brow	Disgust	.23 (.14)	.23 (.14)	.78
	Angry Brow	Fear	.23 (.14)	.19 (.14)	<.01
	Angry Brow	Happy	.23 (.14)	.23 (.11)	.55
	Angry Brow	Sad Brow	.23 (.14)	.20 (.13)	.03
	Angry Brow	Sad Mouth	.23 (.14)	.23 (.13)	.47
	Angry Mouth	Disgust	.22 (.13)	.23 (.14)	.28
	Angry Mouth	Fear	.22 (.13)	.19 (.14)	.03
	Angry Mouth	Happy	.22 (.13)	.23 (.11)	.38
	Angry Mouth	Sad Brow	.22 (.13)	.20 (.13)	.18
	Angry Mouth	Sad Mouth	.22 (.13)	.23 (.13)	.69
	Disgust	Fear	.23 (.14)	.19 (.14)	<.01
	Disgust	Happy	.23 (.14)	.23 (.11)	.66
	Disgust	Sad Brow	.23 (.14)	.20 (.13)	.03
	Disgust	Sad Mouth	.23 (.14)	.23 (.13)	.52
	Fear	Happy	.19 (.14)	.23 (.11)	<.01
	Fear	Sad Brow	.19 (.14)	.20 (.13)	.35
	Fear	Sad Mouth	.19 (.14)	.23 (.13)	<.01
	Happy	Sad Brow	.23 (.11)	.20 (.13)	.02
	Happy	Sad Mouth	.23 (.11)	.23 (.13)	.74
	Sad Brow	Sad Mouth	.20 (.13)	.23 (.13)	.11

Table 8. Post hoc comparisons for the proportion of time spent gazing at an area. Mean differences are analyzed between zones, as a function of emotional expression.

Emotion	Zone A	Zone B	Mean A (SD)	Mean B (SD)	p-value
Angry Brow	Brow	Mouth	.53 (.19)	.24 (.14)	<.01
Angry Mouth	Brow	Mouth	.52 (.20)	.22 (.13)	<.01
Disgust	Brow	Mouth	.54 (.18)	.23 (.14)	<.01
Fear	Brow	Mouth	.56 (.20)	.19 (.14)	<.01
Happy	Brow	Mouth	.53 (.17)	.23 (.11)	<.01
Sad Brow	Brow	Mouth	.54 (.19)	.20 (.13)	<.01
Sad Mouth	Brow	Mouth	.53 (.20)	.23 (.13)	<.01