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Is facial mimicry for affiliation?
Exploring facial mimicry in intergroup relations under perceived threat

Carla Sofia Ribeiro Murteira

Doctorate in Social Psychology

Supervisor:
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Goldsmiths, University of London

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Abstract

This thesis examines whether facial mimicry has an affiliative function beyond the epistemic function of facilitating emotion recognition. In one study assessing facial mimicry by *FaceReader* (N = 48) we found that facial mimicry is characterized by congruent (mirroring) and incongruent but complemental responses to emotional facial expressions, which are consistent with a relation-regulatory function. However, in a meta-analysis (k = 21; N = 1686), stronger mimicry of ingroup than outgroup members, a widely claimed indicator of an affiliative function, was only found for anger (with strong heterogeneity) but not for happiness, fear, disgust, or sadness. In our own laboratory research, three studies assessed facial mimicry by f-EMG, and how it is moderated by perceived threat. Perceived realistic intergroup threat was measured (N = 61) and experimentally induced (N = 78) to assess how facial mimicry varies in intergroup relations. Results showed that intergroup threat increased mimicry of ingroup but not of outgroup anger. However, when perceived ingroup threat was experimentally induced by ostracism (N = 80), results showed not threat effects on mimicry of ingroup anger, leaving the result of the previous two studies vulnerable to an alternative explanation of anger-mimicry regulation by the avoidance of conflict escalation rather than by an affiliative function. Overall, the reported results challenge classical claims of an affiliative function of mimicry. We conclude that mimicry might be in the service of affiliation because it facilitates emotion recognition, and that it is most probably sensitive to relation-regulatory concerns, however, the group-membership effects on mimicry provide no direct evidence for an affiliative function of mimicry.

Keywords: facial mimicry, affiliation, emotional decoding, perceived threat

PsycINFO Codes:
2500 Physiological Psychology & Neuroscience
2560 Psychophysiology
3000 Social Psychology
3020 Group & Interpersonal Processes

Resumo

Esta tese explora se o mimetismo facial tem uma função afiliativa para além da função epistémica de descodificação emocional. Ao avaliar o mimetismo facial com *FaceReader* (N = 48), verificou-se que este é caracterizado por respostas musculares congruentes (espelhamento) e incongruentes, as quais são complementares à descodificação emocional e possível facilitação da regulação da relação. Contrariamente ao descrito como indicador de uma função afiliativa, numa meta-análise (k = 21; N = 1686) verificou-se que o mimetismo é mais forte com os membros do endogrupo comparado com o exogrupo no mimetismo da raiva (com forte heterogeneidade), mas não da felicidade, medo, nojo ou tristeza. Três estudos laboratoriais com f-EMG avaliaram se o mimetismo facial é moderado pela percepção da ameaça. A percepção de ameaça realista intergrupal foi medida (N = 61) e induzida experimentalmente (N = 78) para avaliar o mimetismo em relações intergrupais. A ameaça intergrupal aumentou o mimetismo da raiva do endogrupo, mas não do exogrupo. No entanto, quando a percepção de ameaça endogrupal foi experimentalmente induzida por ostracismo (N = 80), a ameaça não afecta o mimetismo da raiva do endogrupo, deixando os resultados anteriores vulneráveis a uma explicação alternativa da regulação do mimetismo da raiva motivada pelo evitamento de conflito, em vez de uma necessidade afiliativa. Concluindo, os resultados desafiam as afirmações clássicas de uma função afiliativa do mimetismo. O mimetismo pode estar ao serviço da afiliação porque facilita o reconhecimento das emoções e regulação da relação. No entanto, os estudos do mimetismo em relações intergrupais não fornecem evidência directa para uma função afiliativa do mimetismo.

Palavras-chave: mimetismo facial, afiliação, reconhecimento emocional, percepção de ameaça

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2500 Physiological Psychology & Neuroscience
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3000 Social Psychology
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Chapter 1

General introduction

CHAPTER 1

CHAPTER 1

"No man is an island."(John Donne, p. 108-109, 1624).

Humans live in groups to enhance their survival, they need to interact with each other to communicate, share ideas and build goods for themselves and their community. Both verbal behaviour and non-verbal behavioural such as body postures or facial expressions is necessary to make the communication flow and reach these goals, also, synchronization with others is key to all sorts of communication as it improves fitness and survival chances (Scott-Phillips, 2008). Shared behaviors by synchronization with others appears to be a communication facilitator. By sharing similar behaviors with group members, social cohesion is improved and threats to survival are reduced (Dostálková & Špinka, 2010; Duranton & Gaunet, 2016; Kim, 2005). One important form of synchronization is of mirroring behaviours such as mimicry. Mimicry has most likely evolved to improve and support social interactions; it is associated with better communication flow, supporting understanding and affiliation between individuals (Chartrand & Lakin, 2013). Mimicry can be behavioral and facial. Behavioral mimicry of body postures and mannerisms has been vastly studied; however, we cannot assume that behavioral mimicry and facial mimicry bring the same types of advantages for relationships. The term facial mimicry describes the automatic and unconscious mimicking of facial expressions during interactions. Contrary to behavioral mimicry, it implies a deeper involvement with the meaning of other's emotional states. The perceiver has the chance to learn about the sender's motivations, intentions and expectations through the mimicry of facial expressions (Hess & Fischer, 2014). This thesis aims to better understand facial mimicry and to clarify its functions of affiliation and emotional decoding. Three leading questions are clarified along this thesis: 1) what is facial mimicry: is it a reflexive mechanism, responsive mechanism, or both?; 2) is facial mimicry related to an epistemic function?; and finally 3) is facial mimicry related to affiliation?

The eight following chapters clarify and expose the different stages of thinking during the Doctoral process. In Chapter 2, mimicry research and its theories are reviewed. Chapter 3 elaborates the concepts of mimicry, imitation and automatic imitation in order to distinguish the applied methodologies and to clarify the differences between the concepts. Chapter 4

funnels the scope of the thesis to facial mimicry, to assess the functions of facial mimicry in particular, methodological developments and improvements within the study of facial mimicry, and further directions for future research on facial mimicry. Chapter 5 assesses facial mimicry, how it is characterized, and how it is related to affiliation. This is the first attempt to characterize facial mimicry, and to understand how facial mimicry is related to affiliation. We aimed to test whether facial mimicry is simply a reflexive mechanism – the activation of congruent muscles by mirroring the activated muscles of observed emotion in the mimicked, for instance muscles related with anger when anger is displayed. Alternatively, we aimed to test if facial mimicry is a responsive mechanism – the activation of complemental muscles in response to observed muscular activation in the mimicked targets, for instance the activation of muscles related with fear when anger is displayed by the target. Finally, we aimed to test if facial mimicry can be a combination of reflection and of responsive mechanisms. Chapter 6 assesses facial mimicry in intergroup relations. Intergroup relations are used as proxy to assess facial mimicry's affiliation function. A meta-analytical study aimed to check the reliability and effect size of the group membership effect on facial mimicry - larger mimicry towards ingroup than outgroup members as indicator of increased affiliation needs towards the ingroup vs. outgroup members. Chapter 7 and Chapter 8 aim to test how the perception of threat moderates facial mimicry in intergroup relations. Chapter 7 focuses on perceived intergroup threat and Chapter 8 on perceived ingroup threat. Chapter 9 presents all the concluding remarks and provides an answer to the questions guiding this research, mentioned above.

Chapter 2 presents the concept of mimicry. In this chapter, mimicry is defined as the unconscious and automatic mirroring of behaviours, postures, prosody, and facial expressions. The origin of mimicry as an evolved mechanism is briefly discussed. Various theories have been proposed to understand the mechanism of mimicry and how social context can impact it. Three main branches of theories are revised: epistemic theories, social context theories, and the interpretation theory. Epistemic theories (e.g., simulation models, Gallese, 2009; *Perception-behaviour link*, Chartrand & Bargh, 1999) assume that mimicry is a simulation of other people's mind to facilitate understanding and guide interactions. Social context theories (e.g., *Social Top Down Response Theory*, Wang & Hamilton, 2012; *Implicit Socialization Account Theory*, Kavanagh & Winkielman, 2016) assume that context variables play an important role in the extent of mimicry, and mimicry varies according to the social context presented. Finally, the interpretation theory (*Mimicry in Social Context Theory*, Hess & Fischer, 2013) considers that the function of mimicry is affiliation, rather than epistemic. As that theoretical proposal

suggests that epistemic needs can be surmounted through other perception channels, mimicry of non-affiliative emotions is considered undesirable and the theory suggests that it is undermined. We conclude the chapter by discussing the three theoretical branches.

Chapter 3 aims to clarify the concept of mimicry and differentiate it from closely related, yet distinct, mirroring processes such as imitation and automatic imitation. While mimicry is unconscious, automatic and unintended, imitation is conscious, not automatic, and intentional. These terms are often not differentiated and used synonymously in reports of mirroring studies (e.g., Leighton et al., 2010). For instance, studies have used the term mimicry (or 'explicit mimicry') when participants are asked to consciously imitate targets (e.g., Inzlicht, Gutsell, & Legault, 2012), while others have used the term imitation (or 'automatic imitation') when reporting measures of unconscious mimicking (e.g., Mondillon, Niedenthal, Gil, & Droit-Volet, 2007). While terminology may somehow be a question of convention and allow some flexibility, using mimicry and imitation synonymously can result in loss of theoretical clarity due to the mixture of findings. Several researches have used all sorts of methodologies to capture mimicry phenomena; however, a closer look at the research shows that, despite their closeness, these distinct processes are related in different ways to social cognition and therefore not all results speak for mimicry. First, these mirroring behaviours are connected to the activation of different brain areas. Second, the methodologies applied in imitation and automatic imitation do not speak for mimicry, as they instruct participants to perform an action such as the imitation of a facial expression or to perform an instructed movement based on a displayed cue. Third, the nature of collected data suggests that the methods used to capture mimicry (e.g., facial muscles' movements) and automatic imitation (e.g., reaction times) do not measure the same process (Hess & Fischer, 2017) as they are not correlated (Genschow, et al., 2017). Mixing "*apples with oranges*" (Cracco, et al., 2018, p. 80) creates difficulties in the advancement of the understanding of mirroring behaviours. Given the methodological differences and neuroscientific evidence, we propose to consider mimicry, imitation and automatic imitation studies as conceptually different. Mirroring behaviours, independently of their nature, help individuals to live in communities and are of paramount importance for socialization and for understanding others. However, distinguishing different subtypes of mirroring seems necessary to further understand the social functions of mimicry and imitation among individuals.

Chapter 4 reviews the research on facial mimicry with the aim of clarifying the social functions of mimicry. Facial mimicry is proposed to be useful for affiliation or for emotion

decoding, depending on the theoretical approach. A set of studies is discussed to assess those claims. Results are not completely conclusive. While epistemic function such as emotional decoding seems to be a function of mimicking behaviours, the evidence on the affiliation function is not entirely clear. Methodological shortcomings are discussed, suggestions for further research methodologies, and directions are provided to better understand if facial mimicry aims for emotional decoding or affiliation with others. Chapter 4 also proposes advancements in the understanding of facial mimicry that clarify its affiliation role by questioning what characterizes facial mimicry: (1) a reflexive mechanism by the matching of our own with others' muscle movements – mirroring of the activated muscles in the mimicked, or (2) responsive mechanism – social response towards the inferred meaning of displayed emotion through the activation of complemental muscles in response to observed muscular activation in the mimicked targets, or (3) a mixture of reflexion and responsive muscle activations. The next chapter aims to bring light to this question.

Chapter 5 assesses how facial mimicry is characterized and how it is related to affiliation in an empirical study. Facial mimicry has been described as the mirroring of other people's emotional facial expressions. However, some controversy has been raised in the literature about the operationalization of facial mimicry and its functions. While some authors suggest mimicry as the congruent facial muscles' activation (e.g., Seibt, Mühlberger, Likowski, & Weyers, 2015), others have suggested that facial mimicry is the mirroring of what is understood by the mimicker (e.g., the emotion that is expressed in the face of the mimicked; Hess & Fischer, 2013). While the first view sees mimicry as a purely reflexive mechanism (bottom-up), the second sees it as a responsive mechanism (top-down). Interestingly, a close look at the literature shows both congruent (reflexive) and incongruent (responsive) muscles' activation to what is observed in the other's face, which rather suggests that facial mimicry is not just the mirroring of congruent muscles' contraction, but also involves contraction of other muscles that can be related to other emotions than the one expressed by the mimicked face. In this study we presented a set of emotions (happiness, anger, fear, sadness, neutral) and assess facial mimicry using a comprehensive approach (facial action coding system by FaceReader) instead of muscle-specific analysis (e.g., facial electromyography). We also tested how facial mimicry is related to empathy and need to belong as a proxy for affiliation functionality. Results revealed reflexive - congruent facial muscles' activation - and responsive - complemental muscles' activation - that can be interpreted as a social response to the emotion presented. Thus, facial mimicry seems to include both a congruent facial muscles' response (reflexive mechanism) and

social complemental response (responsive mechanism) related to the social interaction. Unexpectedly, facial mimicry was neither related to empathy nor to need to belong, except for the facial mimicry of anger. This first evidence suggests that facial mimicry may not be related to affiliation as assumed by previous theoretical proposals.

Chapter 6 analyses mimicry in intergroup relations using systematic and meta-analytical methodology to verify how facial mimicry is related to affiliation. In chapter 4, intergroup relations are suggested as a proxy to study how facial mimicry is related to affiliation. Stronger facial mimicry of ingroup than of outgroup members should be expected, as individuals have an increased need to affiliate with ingroup compared to outgroup members (Kavanagh & Winkielman, 2016). From the meta-analysis of published and unpublished studies, we conclude that there is indeed a group membership effect on facial mimicry, with stronger mimicry towards ingroups than outgroups, however, when a deeper analysis is conducted the results are not that clear. Facial mimicry shows a reliable group membership effect only for the mimicry of anger. The mimicry of happiness, sadness, disgust and fear does not seem to be affected by group membership. Moreover, heterogeneity among facial mimicry in intergroup relation studies was confirmed, thus, a series of moderators of the effect, including country of data collection and method of mimicry assessment were tested. The evidence of publication bias in the literature calls for new studies and a better understanding of the phenomena moderating facial mimicry in intergroup relations. However, in this study no clear evidence of facial mimicry speaking for affiliation was found.

Based on the puzzling results extracted from the meta-analysis, further studies were carried out to assess how facial mimicry changes in intergroup relations, and reported in two chapters. The literature suggests that mimicry of anger is affected by the intergroup relation; however, the large heterogeneity in the results calls for the study of moderators. Anger is competitive and sets an aggressive tone in the relationship; several authors have suggested that mimicry of anger should not occur due to its conflict-escalation risk (e.g., Bourgeois & Hess, 2008). The epistemic function of facial mimicry explains why mimicry of anger occurs, although we do not exclude the possibility of variation in mimicry of anger, and any other competitive emotions, due to its potential to provoke aggression. However and interestingly, only the mimicry of anger varies between ingroup and outgroup members in intergroup relations. This initial evidence suggest that facial mimicry of anger may serve other functions than just the emotional decoding. Intragroup and intergroup threat are suggested as moderators of mimicry of anger in intergroup relations. It is known that under stress individuals have a

stronger need for affiliation (e.g., Smeets, Dziobek, & Wolf, 2009; Taylor, et al., 2000; White, et al., 2012). Considering that in many cases individuals mimic to enhance affiliation, then we should expect to find stronger mimicry under stress, especially towards ingroup members compared to outgroup members (e.g., Baumeister & Leary, 1995; Kavanagh & Winkielman, 2016). Chapter 7 focuses on the perception of intergroup threat from outgroups and chapter 8 on the perception of intragroup threat from ingroups, to assess how mimicry of anger changes in intergroup contexts when individuals face a stressful environment.

Chapter 7 tests the role of perceived intergroup threat in mimicry of anger and happiness in intergroup relations. The role of perceived realistic intergroup threat is tested as a moderator of mimicry of anger and happiness in an intergroup context in a set of two studies. Considering that facial mimicry can be an affiliative mechanism and perceived intergroup threat is stressful, then we should expect to find stronger mimicry of anger and happiness towards ingroup compared to outgroup members. In study 1, individuals showed stronger mimicry of anger towards outgroup members than ingroup members; no differences for mimicry of happiness, sadness and fear were found. However, perceived intergroup threat reduced the difference between ingroup and outgroup mimicry. Individuals that perceived intergroup threat show an increased mimicry of anger response towards ingroup members, but not towards outgroups. In study 2, we ran a conceptual replication of Study 1 by experimentally manipulating the perceived intergroup threat and partially replicated this finding. Individuals showed stronger mimicry of anger towards ingroup members in the perceived intergroup threat condition than in the control condition. No differences were found between ingroup and outgroup mimicry of anger and happiness in the threat and control condition. Results suggest that mimicry of anger in intergroup relations may vary as a function of perceived intergroup threat. However, no differences were found for mimicry of happiness. The absence of differences for mimicry of happiness, together with the absence of moderation by perceived intergroup threat, bring some lack clarity to the understanding of the affiliative function of facial mimicry. Moreover, an alternative explanation for the results on mimicry of anger based on perceived power differences justified the development of a new study, presented in chapter 8.

Chapter 8 extends the previous chapter by testing the role of perceived intragroup threat in mimicry of anger in intergroup relations. In one study we assess how perceived ostracism from ingroup members affect the mimicry of anger in intergroup relations. Ostracism causes social pain (Chen, Williams, Fitness, & Newton, 2008), therefore, individuals need to re-

affiliate and connect with others to surmount that pain and stress (Wesselmann, et al., 2016). Considering facial mimicry as an affiliative mechanism, and ostracism a form of ingroup threat, a study was designed to assess the facial mimicry of anger in intergroup relations after participants were either ostracized or included by an ingroup member during a cyberball game. As in chapter 7, we expected that when facing a stressful event, such as being ostracized, individuals would mimic ingroup members more than outgroup members to surmount the need for affiliation (i.e., which is derived from the affiliation hypothesis). On the other hand, we considered the possibility that individuals would not mimic ingroup members after being ostracized by them due to feelings of powerlessness produced by the ostracism. Thus, the perception of power differences between the ostracized and the ostracizer could jeopardise mimicry of anger towards ingroup members – this is the reduced power hypothesis. The results of this study do not sustain the affiliation hypothesis. First, individuals showed an increase in mimicry of anger when included than when ostracized. And second, no were found in the extent of mimicry of anger between ingroup and outgroup members. While these results are puzzling, they suggest that not only mimicry of anger, but also perhaps of any other emotion, are unrelated to affiliation in itself.

We conclude the thesis with Chapter 9, in which we revisit the three leading questions and provide an answer to them based on the set of studies reported in this thesis. First, we questioned if facial mimicry is purely a reflexive mechanism, a responsive mechanism, or both. We conclude that individuals show a congruent facial muscles' match with the ones they observe – a reflexive mechanism – as well as the activation of other muscles that are not displayed in the observed emotions – a responsive mechanism. Thus, it seems that facial mimicry can be reflexive due to its mirroring character, and responsive due to the activation of complemental facial muscles that can serve as response towards the mimicked emotion. The second question asked if the function of facial mimicry is for emotional decoding. In our view, the reflexive mechanism of facial mimicry is indeed related to the emotional decoding, but we also suggest that the complemental mechanism of facial activation is responsible for the balance during social interactions. Thus, when individuals mimic anger, they may at the same time send signs of appeasement to avoid a conflict, which could help in affiliation. The third question aimed to assess if facial mimicry is related to affiliation. The analysis of mimicry in intergroup relations brings to bear intriguing evidence that speaks against the role of facial mimicry in affiliation. First, the group membership effect on mimicry is only valid for mimicry of anger; other emotions such as happiness, sadness, fear and disgust are equally mimicked between

ingroup and outgroup members. Second, the stressful environments that would justify an increase in facial mimicry do not always increase the mimicry in favour of ingroup members vs. outgroup members. Therefore, no clear evidence of the role of affiliation for facial mimicry can be claimed. In sum, this thesis questions classic claims about facial mimicry at the same time as it demands further needs for clarification and suggests new research avenues on the roles of facial mimicry. Bearing in mind that individuals mimic and are mimicked from the cradle to the grave, and belong to communities within which they interact more intensely, it is undeniable that facial mimicry should at least have some function in service of affiliation due to its epistemic function, even though we cannot say that this is its only function.

Chapter 2

Mimicry: a theoretical review

CHAPTER 2

Abstract

Mimicry is the automatic and unconscious mirroring of other people's behaviors, such as body postures, gestures, vocal speeches and facial expressions. Mimicry occurs spontaneously during social interactions and appears to have a profound importance to understand and affiliate with others. Mimicry seems to be an evolved mechanism to bring people together. Several theories have been proposed to clarify the functions of mimicry and how mimicry occurs in social settings. We discuss the current state of the art about mimicry and its theories.

Keywords: unconscious mimicry, affiliation, understanding, simulation, social context

CHAPTER 2

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Mimicry: a theoretical review

Social relations are made of social interactions that can be easy and harmonious, but also difficult and unpleasant. Nevertheless, all of them imply that people relate to someone else at least to some extent. A powerful way, probably the most powerful and basic one, to relate to others is by mirroring them. Individuals mirror others from the cradle to the grave, as mirroring processes help individuals to synchronize with each other in actions and in social communication (Kim, 2005). Mirroring facilitates the understanding of shared information; therefore, individuals that mirror others are better informed to decide how to behave based on others' feelings. One of those mirroring processes is mimicry.

Mimicry is the unconscious and automatic mirroring of other people's behaviors such as gestures, postures, mannerisms, speech tones and facial emotional expressions (Chartrand & Lakin, 2013; Duffy & Chartrand, 2015; van Baaren, Janssen, Chartrand, & Dijksterhuis, 2009) in social interactions. Mimicry is also known as the *"Chameleon Effect*" and considered to serve as a*"social glue"* that brings people together (e.g., Chartrand & Bargh, 1999; Seibt, et al., 2015) due to the positive consequences that it brings for social relations, such as understanding and affiliation among individuals (Chartrand & Lakin, 2013; Duffy & Chartrand, 2015; Lakin, Jefferis, Cheng, & Chartrand, 2003; Seibt, et al., 2015). In this review we briefly discuss the origins of mimicry and how it is fundamental to improve an individual's social relations, following the theories of mimicry and its social outcomes.

Origin of Mimicry

Synchronization among human beings has been essential to improve survival odds. Human beings have adapted to their environmental circumstances by behaving uniformly within groups. Similar and synchronized behaviors improved their social cohesion and helped them avoid threats to their survival (Duranton & Gaunet, 2016). Individuals willing to interact and to collaborate with each other ended up with improved odds to survive and reproduce. Some researchers have proposed the universal human need to belong to a group (e.g., Baumeister & Leary, 1995; Leary, Kelly, Cottrell, & Schreindorfer, 2003). This need for belonging and affiliation with others, and specially belonging to groups, lead people to pursue acceptance among peers (e.g., Williams, 2007). Mimicry is probably one of the behaviors that are functional for affiliation with others and belonging to a group.

As mimicry improves the odds for better relations inside the community and facilitates the communication with others (Lakin, et al., 2003), some scholars have proposed that mimicry has most likely evolved to enable individuals to maintain harmonious and cooperative relationships within their communities (Chartrand & Bargh, 1999; Lakin, Chartrand, & Arkin, 2008). Applying the principles of the Theory of Natural Selection (Darwin, 1859), individuals that are more efficient in mimicking others have better chances to build positive rapport, form social networks and increase their chances for survival and reproduction within their community (Lakin, et al., 2003). Indeed, from birth children show a tendency to mimic behaviors (e.g., stick out their tongues, smile) (Meltzoff & Moore, 1977) and facial expressions (e.g., happiness, anger, sadness) of adults (Termine & Izard, 1988), which suggests an innate and automatic character of mimicry as an evolved mechanism that is present from birth to make communication possible.

Neurologically, several researchers have proposed that mimicry is probably based on the Mirror Neuron System (MNS) (Catmur, Walsh, & Heyes, 2009; Gallese & Goldman, 1998). Mirror neurons are a special type of neurons located in the premotor cortex that fire during the observation of other individuals' motor actions. Mirror neurons' activation acts as an automatic brain mirroring mechanism in response to others' actions. Those neurons' activation allow individuals to mimic other people's neural activity (di Pellegrino, et al., 1992, Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Iacoboni, 2009; Rizzolatti & Craighero, 2004). The MNS provides a direct link between perception and action while mirror neurons fire in response to other's observed motor actions (Brass & Heyes, 2005). Mirror neurons embody perception and action simultaneously, and fire for executed and observed actions, which means that, when people observe other people's actions, they provide a neural mechanism to recognize it (di Pellegrino, et al., 1992, Gallese, et al., 1996, Rizzolatti & Craighero, 2004). Recognizing others' actions and emotions through mimicry facilitates, among others, Theory of Mind (ToM) - the ability to infer other people's mental and emotional states (Premack & Woodruff, 1978; Brüne & Brüne-Cohrs, 2006). Therefore, communication and interactions between people are facilitated due to behavioural and neural mimicry process (Condon & Sander, 1974; Gallese & Goldman, 1998; Premack & Woodruff, 1978). Indeed, several scholars agree that mimicry improves communication, understanding (Duffy & Chartrand, 2015), empathy and cooperation between people (Barsalou, 2008; Chartrand & Lakin, 2013; Iacoboni, 2009; Lakin & Chartrand, 2003). Based on this, we can conclude that mimicry seems to serve an epistemic and affiliative function during social interactions, as understanding and interactions get smoother due to mimicry.

Mimicry as primitive path to empathy and social cognition

Mimicry helps individuals to think about other people's thoughts and to put themselves in other people's shoes (e.g., Chartrand & Lakin, 2013). Mimicry is considered a "primitive motor code" that facilitates learning about others during the initial stages of development as well as throughout life (Hess, Philippot, & Blairy, 1999). Thus, it is not surprising that mimicry is considered the first path to reach empathy since birth (Hoffman, 1984). Several studies suggest that empathic children tend to mimic facial expressions more (e.g., Eisenberg, 1989; Eisenberg & Fabes, 1990; Chrisholm & Strayer, 1995). Mimicking facial expressions contributes to a better understanding of other's states and emotional experiences, which suggests that mimicry in itself facilitates social cognition (Barsalou, 2008; Hess, Blairy, & Philippot, 1999). While empathy increases mimicry towards others (e.g., Lakin, et al., 2008; Mondillon, et al., 2007), mimicking others also increases empathy towards the mimicked (Chartrand & Lakin, 2013). Thus, mimicry seems to fulfil a feedback cycle related to the understanding of other people's states, as empathy increases mimicry and mimicry increases empathy for others, suggesting an improvement in social cognition and relationships among individuals.

Mimicry for social identity

Mimicry is not just a mechanism that brings people together, but it is also a communication mechanism that seems to be fundamental among peers for socialization, social identity and social coordination. Mimicry of non-verbal behaviours is considered to be an extremely important strategy to interact with others during early development stages. This mimicry helps the infant to interact and to learn how to behave properly among peers and according to the social context before the stage of language acquisition (Eckerman, Davis, & Didow, 1989; Bates, 1975). Several studies have shown that babies mimic behaviors (Meltzoff & Moore, 1977) and complex facial expressions, such as happiness, anger and sadness (Termine & Izard, 1988) from adults. While this reveals an attempt for social cognition and coordination in infants, it may also imply a form of learning about themselves and the people around them. Interestingly, 6 week-old infants show the capacity to mimic various facial expressions and reproduce those 24 hours later when seeing the person again. This suggest, that mimicry is not only a learning mechanism, but also, according to Meltzoff & Moore (1992, 1994), an important tool to identify and communicate with others. The infant imitates the behavior from the previous encounter to re-identify, recognize and communicate with the same person hours later.

Considering the affiliative and communicative function of mimicry, mimicry facilitates the feeling of belonging to a group, which through time helps individuals to build their social identity (Meltzoff & Moore, 1992, 1994). Thus, it seems that by mimicking others, individuals learn how to behave in a group and learn the social identity of the group they are part of.

Mimicry in different social settings

Mimicry has a profound impact on relationships with others by improving the understanding and the rapport between people (Chartrand & Lakin, 2013). Increased liking for the mimicker and the mimicked after mimicry (Chartrand & Lakin, 2013; Lakin, et al., 2003) speaks in favor of an improvement of affiliation with others. Therefore, it is not surprising that mimicry has usually been considered desirable across social interactions (Lakin, et al., 2003). Yet, a recent review suggests that "the link from mimicry to liking and other positive outcomes may be fragile" (Hale & Hamilton, 2016, p. 106). The observed differences in the positive outcomes may be justified by the social context. Not all social contexts lead to similar degrees of mimicry; while some social contexts seem to improve mimicry, others show the opposite effect. For instance, a pre-existing rapport and positive valence context (Hess & Fischer, 2014; Bourgeois & Hess, 2008), the goal to affiliate (e.g., Lakin, et al., 2008) and perceived similarity to the target (e.g., Guéguen & Martin, 2009) increase mimicry behavior. However, some studies suggest that social and relational benefits of mimicry may be limited by group boundaries (Likowski, Schubert, Fleischmann, Landgraf, & Volk, 2008) and that too much or not enough mimicry leads to uncomfortable feelings between people (Leander, Chartrand, & Bargh, 2012), which leads to a decrease of mimicry behaviors. Those puzzling results have inspired different theories to explain mimicry. Thus, some theories have proposed that mimicry is not just a mechanism that improves understanding and affiliation, but that mimicry may also establish social barriers between people, as individuals do not have a best interest in affiliating in all social contexts.

Theories of Mimicry

Several theories were advanced to explain why people mimic each other and how it facilitates social interactions. Mimicking others is a form of synchronization that facilitates understanding and affiliation, thus it is not surprising that rapport and epistemic functions are attributed to mimicry by several scholars (for reviews see Chartrand & Lakin, 2013; Hess, et

al., 1999). It is important to note that the mimicry functions of understanding and affiliation are not mutually exclusive and probably occur simultaneously (Hess, et al., 1999). However, while the different theoretical approaches in the literature all contribute to the understanding of mirroring behaviours, they vary in their focus either on one or the other of these two functions. Some of the proposed theories emphasize the innate nature of mirroring behaviour, concentrate on the relation between stimulus and response, and focus on mimicry's epistemic function of emotional simulation and decoding. Others place an emphasis on the social context and how it modulates the response towards a stimulus. These theories focus rather on the function of affiliation with others. Important to note is that the definition of mimicry is contingent on the theoretical approach, and that this depends on the focus on the function of mimicry. While acknowledging the unique contribution of each of the theories that have been proposed, for the sake of systematization we distinguish three theoretical branches: epistemic theories, context theories and interpretation theory (Table 1). Theoretical approaches emphasizing the innate, automatic character of mimicry approach the phenomenon from a bottom-up perspective, whilst the context and interpretation theories approach mimicry rather from a top-down perspective. Whereas epistemic theories suggest that mimicry occurs mainly to understand other people's mental states, other theories suggest that mimicry occurs mainly to affiliate with others. All theories accept that there is a link between mimicry and affiliation. However, while epistemic theories suggest that affiliation and liking is a consequence of mimicry, other theories suggest that mimicry is actually guided by affiliation goals. Finally, the difference between context theories and interpretation theories is that, although both suggest an affiliation aim of mimicry, the interpretation theories propose that individuals do not simply mimic what they observe, but rather what they understand, in order to maintain harmonious relationships and promote affiliation.

Epistemic Theories of mimicry

While epistemic theories of mimicry do not deny that mimicry may serve a social adaptation function and, therefore, may be considered as a "*social glue*" that brings people together (Lakin, et al., 2003), this set of theories focuses on the underlying mechanisms that have a primarily epistemic function. These theories consider that mimicry is the automatic and unconscious mirroring of what is observed, such as behaviors and facial expressions. According to Chartrand and Bargh (1999), mimicry is based on a *perception-behavior link*. This means that the likelihood that individuals show some behavior is increased simply by the observation of the same motor behavior in others. While this repetition leads to an improvement in the

relationship between individuals due to the affiliation consequences, the underlying *perception-behavior link* is assumed to function independently of the affiliative consequences. Thus, mimicry should not only "occur among strangers, but it should occur even without an active goal to get along with and be liked by the interaction partner." (Chartrand & Bargh, 1999, p. 896). Hess and Fischer (2013) refer to this approach as the classical view on mimicry or as the *Matched Motor Hypothesis*, in order to emphasize that what is mimicked according to this approach is the observed motor behavior.

While the epistemic function in the *perception-behavior link* hypothesis is rather implicit, as according to this hypothesis mimicking only regulates behaviour, without necessarily leading to a conscious representation of the state of mind of the mimicked person, *Embodied Simulation Theory* advances that mimicry aims to understand other people's mental states and intentions (Gallese, 2009). Mimicry informs about other people's mental states by mentally simulating the observed behaviors. In the domain of facial mimicry, the *facial feedback hypothesis* has inspired embodied simulation theories. The facial feedback hypothesis suggests that the perception and understanding of emotions is related to facial muscles' feedback. The facial muscular activation sends signs to the brain to form a neural simulation. This embodied neural simulation seems to be responsible for the emotional experience in interactions with others expressing the respective emotion, which then allows for correct emotional decoding (for a meta-analysis please see Coles, Tarsen, & Lench, 2017, 2019). Indeed, individuals naturally mimic emotional expressions such as sadness and disgust (Hess & Blairy, 2001), and happiness and anger even when they are presented in a subliminal way (e.g., Achaibou, Pourtois, Schwartz, & Viulleumier, 2007; Dimberg, Thurnberg, & Elmehed, 2000; Dimberg, Thunberg, & Grunedal, 2002). Embodied Simulation Theory goes further, suggesting that mimicry works as a form of simulation between two different minds which speaks in favor of an improved *Theory of Mind* (ToM) (Galesse, 2009; Niedenthal, Mermillod, Maringer, & Hess, 2010). Therefore, individuals may have better insights about the other person's desires and intentions during interaction (Wang & Hamilton, 2012). As Niedenthal and colleagues (2010) put it:

> When we use the term "embodied simulation," we mean that a facial expression has triggered a simulation of a state in the motor, somatosensory, affective, and reward systems that represents the meaning of the expression to the perceiver. In an embodied simulation account, the perception of a facial expression is accompanied by the bodily and neural states associated with the expression and its correspondent emotion. This

> simulation is then used as the representation of meaning on which an interpretation or judgment is based. (p. 418)

The resulting bodily states facilitate the recreation of others' cognitive and affective states (Niedenthal, 2007). Mimicry facilitates the embodiment of others' emotional states and experiences, which may work in service of emotional contagion (Hatfield, Bensman, Thornton, & Rapson, 2014), which in turn helps in the emotional decoding and empathy for others (Niedenthal, 2007). Indeed, individuals report emotion experiences (Soussignan, 2002; Strack, Martin, & Stepper, 1988) and emotion decoding difficulties when their facial movements are restricted (Niedenthal, 2007; Niedenthal, et al., 2010; Oberman, Winkielman, & Ramachandran, 2007; Stel & van Knipperberg, 2008; for Botox treatment patients: Neal & Chartrand, 2011; Lewis, 2019). Thus, it seems that mimicry not only facilitates the understanding of others, but also the putting ourselves in other people's shoes. All those theories call for an epistemic role for mimicry, especially, for facial mimicry, which has a tremendous impact not only in the communication flow, but also in the relationships between individuals.

Context theories of mimicry

This set of theories was developed with an emphasis on the moderation of mimicry by social context. Thus, not all individuals would be mimicked or equally mimicked in all contexts. The reason is that mimicry has an affiliative function, which is not only essential for mimicry as communicative behavior, but also affects the epistemic function of mimicry itself in each socially relevant context. Three main theories have been proposed. The *Social Top Down Response Theory* (STORM) (Lakin & Chartrand, 2003; Lakin, et al., 2003; Wang & Hamilton, 2012) suggests that mimicry is a social strategy to improve people's position and status in the social context, and especially inside their group. Here, mimicry is strategic because individuals mimic whom they want to affiliate with to enhance their social position and to gain social and personal benefits (Chartrand & Bargh, 1999). The assumption is that high mimickers are so successful because their mimicry is enhanced or diminished, based on potential personal and affiliation gains (Wang & Hamilton, 2012).

Along this line, but assuming a different motivational background, *Implicit Socialization Account Theory* (Kavanagh & Winkielman, 2016) also posits that not all individuals are mimicked to the same degree. Contrary to previous theory, the social gains are not in focus, but instead in the nature of the relationship and in the usefulness of mimicry for adaptive implicit learning. According to this approach, mimicry serves the implicit learning of

appropriate social behaviour and social ways of being in a certain culture. This theory suggests that not all individuals provide the same useful knowledge for socialization. For instance, ingroup members should be mimicked more than outgroup members, as they are the more relevant role models to learn ingroup norms. Mimicking ingroup members is advantageous as individuals implicitly learn how to behave and what is appropriate to express among ingroupers by mimicking their behaviors. Learning from ingroup members is far more advantageous than learning from outgroups, because what is learned from outgroups may not fit the ingroup relations (Kavanagh & Winkielman, 2016). Mimicry is context-moderated by learning usefulness, thus, mimicry is a social-distance regulator and not a "social glue" that brings all people together. According to this approach, mimicry should be decreased or eliminated when it does not have any learning advantages for the social functioning among ingroup members.

The *Associated Reactions to Action in Context Model* (Stel, Dijk, & van Baaren, 2016) suggests that mimicry is facilitated or undermined according to previous rewarding and punishing experiences. Contrary to the two previous theories, here the focus is on the personal experiences and not on the individuals and their social identity. Also, this model does not focus on affiliation gains, but rather on the avoidance of possible negative effects of mimicry such as affiliation losses due to mimicry of inappropriate behaviours. While mirror neurons are activated, the execution of the motor mimicry is dependent on the past reward experiences associated with the observed action and context. Therefore, neural mimicry may not result in a behavioural mimicry under certain circumstances. If the behavioural mimicry brings benefits - mimicry is facilitated; if mimicry is damaging or implies the risk of punishment - mimicry is attenuated. Thus, mimicry is modulated by personal experiences and previous reinforcements. Individuals learn about the consequences of mimicry in different contexts, which conditions future mimicry.

Interpretation theory of mimicry

The *Mimicry in Social Context Theory* (Hess & Fischer, 2013) posits that mimicry depends on how individuals understand the social situation. Contrary to most other theories on mimicry, here mimicry does not have an epistemic function as understanding others can be based on other perceptual channels (Hess & Fischer, 2013). Mimicry does not function as "social glue", however, it still aims for affiliation among individuals. Mimicry varies according to individuals' interpretation of the social context. Therefore, mimicry is contingent of the nature of the relationship between mimicker and mimicked, the importance and interpretation of the social message conveyed by the mimicked in the specific context, and the potential

impact of mimicry on affiliation. For instance, in the case of facial mimicry, this theory suggests that not all emotions would be mimicked. Competitive emotions such as anger, disgust and pride should not be mimicked due to the aggressive character implied in them and possibility of aggression between individuals that could undermine affiliation (e.g., Bourgeois & Hess, 2008). Instead, individuals could understand those competitive emotions through other sensitive channels and not mimic those emotions so as to not jeopardize affiliation.

The major claim of this theory is that when individuals mimic others, they mimic what they understand is expressed by the mimicked, instead of just mirroring their behaviours or facial muscles' movements to simulate their mental states (e.g., they do not mimic a frown, but rather the anger that is expressed by this frown). Moreover, Hess and Fischer (2013, 2014) consider that at least one of two different things occur when facing an emotional expression: 1) mimicry as mirroring match of what is observed, or 2) consistent emotional reaction or facial display. Thus, mimicry is just one possible response to the other. Mimicry promotes affiliation between individuals, thus its definition should focus on its function rather than on its mechanical form, which means that mimicry "is the imitation of another's emotional display in order to understand and share the other's emotional perspective" (Hess & Fischer, 2016, page 223) and "should be restricted to situations in which the mimicker has an affiliative intent and the mimicked behaviour is also affiliative" (Hess & Fischer, 2016, page 224). When facing an emotional facial expression, individuals may show a mirroring match response (e.g., smiling as a response to a smile or showing a frown in response to an angry face) or a complementary response (e.g., smiling in response to an angry face). However, even the mirroring of what is observed may not be mimicry if it does not promote affiliation (Hess & Fischer, 2016). That means that individuals would mimic an emotional face when they understand the emotional context, however, only if it is not damaging for the relationship between the mimicker and the mimicked. For instance, a mirroring match facial expression may occur when anger is shown; however, it is not considered mimicry because it is a form of showing dominance and does not promote affiliation (Hess & Fischer, 2016). Also, a complemental face to an angry expression could be a smiling face to decrease the tension and save the affiliation with the other, however, as in the previous case this would not be considered mimicry but rather a reactive expression (Hess & Fischer, 2014). Thus, the theory proposes that what has been studied as facial mimicry so far can best be explained as being motivated by the desire to give the proper response to the others emotional expression in each social situation, including but not restricted to those responses that foster affiliation. Thus, mimicry would only occur if it implies possible positive consequences for the relationship, such as affiliation and perspective-taking.

Discussion and Conclusion

Not all theories agree in their definition of what mimicry is. For epistemic and contextual theories, mimicry is basically a reflection of what is seen in the other's face, which allows individuals to understand others and build rapports with them. In contrast, interpretation theory suggests that mimicry is rather a mirroring of what is understood, thus, it is not a pure reflexion anymore, but rather a socially motivated mirroring to a socially meaningful facial expression that promotes affiliation.

Context and interpretation theories emphasize that mimicry is dependent on the social context (e.g., Chartrand & Lakin, 2013; Hamilton & Wang, 2012; Hess & Fischer, 2013; Kavanagh & Winkielman, 2016; Seibt, et al., 2015), which reveals a more strategic function of mimicry than initially assumed in the epistemic theories. Accordingly, large part of their empirical support is based on paradigms testing this context dependency. This strategic character of mimicry does not imply that mimicry is not automatic and unconscious, however, it surely implies different levels of intentionality, as mimicry would only occur if it brings social benefits for the mimicker or promotes affiliation between individuals, otherwise mimicry would be refrained.

Several studies seem to corroborate the epistemic function and the affiliative function of mimicry. For instance, empirical studies have shown that all emotions are mimicked. Some emotions have an affiliative nature such as happiness, fear and sadness, while others, such as anger and disgust, have a competitive nature (Hess, Hühnel, van der Schalk, & Fischer, 2016). Despite the nature of the emotions, research shows that both types of emotions are mimicked (for sadness and disgust e.g., Hess & Blairy, 2001; for happiness and anger e.g., Achaibou, et al., 2007; Dimberg, et al., 2000; Dimberg, et al., 2002) suggesting some evidence for the epistemic role of mimicry. However, not all theories consider that the mirroring match of a competitive facial expression is mimicry. While epistemic and contextual theories would define the mirroring of competitive facial expression as mimicry, the interpretation theory would consider it as a reactive facial expression and not mimicry, due to the hazardous affiliative consequences of the situation between individuals.

Several studies have shown that not all individuals are mimicked in the same extent, but rather that this varies according to possible affiliation aims and relationship outcomes. The quality and amount of mimicry seems to depend on the type of relationship between people: its valence, the closeness between the relational partners and whether the interaction crosses group boundaries or not. Empirical evidence shows that people preferably mimic ingroup members

(e.g., Bourgeois & Hess, 2008; van der Schalk, et al., 2011; Yabar, Jonhston, Miles, & Piece 2006), friends (e.g., Bourgeois & Hess, 2008), and powerful people (Cheng & Chartrand, 2003), when perceiving themselves or the group in a risky situation, such as after being excluded (Lakin, et al., 2008) or seeing exclusion towards someone of their own group group (Castelli, Pavan, Stefanelli, & Tassoni, 2011). Also, mimicry seems to impact relational outcomes, which can be translated in social or personal gains. People feel closer (van Baaren, Holland, Kawakami, & van Knippenberg, 2004), are more pro-social and willing to help (van Baaren, et al., 2004; van Baaren, Holland, Steenaert, & van Knippenberg, 2003), give more money (van Baaren, et al., 2003), and are persuaded by high mimickers (Maddux, Mullen, & Galinsky, 2008). Mimicry seems to increase when the affiliation between individuals already exists, when they aim to build affiliation between them, or even when it brings personal benefits. While all this evidence speaks in favour of context theories, it is less clear about how it speaks for interpretation theory. Contrary to other theories, the interpretation theory is mainly supported by studies on facial mimicry, thus it is unclear how behavioural mimicry studies would speak for this theory. Although affiliation is dependent on social context, it is unclear whether mimicry is only a reflexive process or if it implies a responsive process where individuals mimic what they understood when it is affiliative. Thus, future research would benefit from a clarification on how mimicry is characterized: reflexion (mirroring match), reactive expression, or both.

Epistemic and contextual theories consider that mimicry facilitates the epistemic function, namely emotional and behavioral decoding, during the social interaction. One could consider that the epistemic function helps in the affiliative process that results from mimicry. On the other hand, the interpretation theory considers that mimicry is not at the service of an epistemic function, but rather of affiliation among individuals. While the first two theories – the epistemic and the contextual – are complemental, the latter is opposed to both. Epistemic and contextual theories see mimicry as a mirroring match, while interpretation theory considers that this mirroring match is mimicry only when it serves affiliation. This major difference in the definition of mimicry brings controversy to the field and opens up new research avenues to better understand the affiliative nature of mimicry.

Table 1:

Theories of mimicry.

<table>
<tr><th>Epistemic Theories</th><th colspan="3">Context Theories</th><th>Interpretation Theory</th></tr>
<tr><td colspan="2">Focus on the epistemic function of mimicry</td><td colspan="3">Focus on the social context’s moderation of mimicry</td><td>Focus on mimicry as an affiliative response</td></tr>
<tr><td>Perception-behavior link (Chartrand & Bargh, 1999), later called Matched Motor Hypothesis (Hess & Fischer, 2013)</td><td>Embodiment Simulation Theory (Gallese, 2009)</td><td>Social Top-Down Response Theory (STORM) (Wang & Hamilton, 2012)</td><td>Implicit Socialization Account Theory (Kavanagh & Winkielman, 2016)</td><td>Associated Reactions to Action in Context Model (Stel, et al., 2016)</td><td>The Mimicry in Social Context Theory (Hess & Fischer, 2014)</td></tr>
<tr><td colspan="2">Goal: simulation, affiliation as a consequence of simulation</td><td colspan="3">Goal: affiliation and simulation</td><td>Goal: affiliation</td></tr>
</table>

CHAPTER 2

Chapter 3

Mimicry, Imitation and Automatic Imitation: A short review of the concepts and methodologies

CHAPTER 3

Abstract

Mimicry and imitation are mirroring behaviors that may occur during social interactions. While mimicry is unconscious and automatic, imitation is conscious and controlled. These mirroring behaviors are connected to the activation of similar brain areas, yet with some singularities that call for a differentiation in analysis the processes. We discuss mimicry, imitation and automatic imitation arguing for a need to consider them as distinct processes. Our assessment indicates that neuroscientific evidence and methodological differences emphasize the need for theoretical distinction.

Keywords: unconscious mimicry, automatic imitation, imitation, mirroring behaviors, methodology

CHAPTER 3

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Mimicry, Imitation and Automatic Imitation: A short review of the concepts and methodologies

Communities are built on social relationships. Individuals live, learn and grow up together by relating with others and sharing goods. Thus, the ability to understand others is paramount for human sociability (Oatley, 2016). The mirroring behaviors via the observation and copying of observed behavior boosts human relations (Oatley, 2016). Mimicry and imitation are forms of behavioral mirroring (Chartrand & Lakin, 2013; Hale & Hamilton, 2016) that functions as 'a social glue' due to its positive effects across social interactions (Lakin, et al., 2003). Mirroring improves communication and emotion recognition (Chartrand & Bargh, 1999; Duffy & Chartrand, 2015; Guéguen, Jacob, & Martin, 2009; Stel & van Knippenberg, 2008), as well as empathy and cooperation (Barsalou, 2008; van Baaren, et al., 2004; Chartrand & Lakin, 2013; Iacoboni, 2009; Lakin & Chartrand, 2003), and increases liking and affiliation between people (Chartrand & Bargh, 1999; Kavanagh & Winkielman, 2016). Different types of mirroring behaviors have been considered in research. Despite their similarities, fundamental differences related to its automaticity vs. controlled nature may help to clarify its social functions in communication processes and affiliation with others.

Mimicry is an unconscious and automatic behavior, whereas imitation is a conscious and intentional behavior (Hale, 2016). However, the terms are often not differentiated and are used synonymously in reports of mirroring studies (e.g., Leighton, Bird, Orsini, & Heyes, 2010). For instance, some studies have used the term mimicry or 'explicit mimicry' when participants are asked to consciously imitate targets (e.g., Inzlicht, et al., 2012), while others have used the term imitation or 'automatic imitation' when reporting measures of unconscious mimicry (e.g., Mondillon, et al., 2007). While this terminology may to some degree be a question of convention and allow some flexibility, using the terms mimicry, imitation and automatic imitation synonymously can result in loss of theoretical clarity due to the mixture of findings. Accordingly, we propose that mimicry, imitation and automatic imitation should be treated as different concepts and differentiated in the mirroring literature to better understand the behavioral and affiliative impact of mirroring in social relations. To back up the argument, we briefly review the neuroscientific evidence and the most common research methodologies to suggest mimicry, imitation and automatic imitation as different processes.

Mimicry vs. Imitation vs. Automatic Imitation

Different levels of automaticity are present in mimicry, imitation and automatic imitation. Considering the controversy between automatic and controlled actions, it seems that a process is not always purely automatic or controlled, but rather something in between. Having Bargh (1994) as reference, we analyzed mimicry, imitation and automatic imitation based on the four pillars of automaticity: automaticity, intentionality, awareness, and controllability.

Mimicry is the unconscious and automatic mirroring of other people's behaviors such as gestures (behavioral mimicry) and facial emotional expressions (facial mimicry) (Chartrand & Lakin, 2013; Duffy & Chartrand, 2015) during social interactions. A short time elapses between the observed action and mimicry (Cacioppo, et al., 2014; Duffy & Chartrand, 2015; Hale & Hamilton, 2016; Hess & Fischer, 2014); individuals do not decide to mirror others, they do it unintentionally, and therefore, mimicry is not planned (Hale & Hamilton, 2016). Moreover, mimicry is uncontrolled as the individuals do not know the impact of mimicry on their own and other people's behavior, and are not able to stop mimicry unless they are instructed to. This phenomenon has also been called the *'Chameleon Effect'* in the social psychological literature (e.g., Chartrand & Bargh, 1999) and pertains to mirroring actions such as yawing after someone yawns, or smiling after someone smiles.

Imitation is the conscious mirroring of another person's behavior during social interactions. Imitation is planned (Hale & Hamilton, 2016), intentional and controlled because individuals are aware of their mirror decision and take steps to execute or stop that mirroring. However, only half of the process is controlled, because individuals are not necessarily aware of the imitation consequences on their own and others' behavior. Nevertheless, the partial control that is exercised over imitation suggests that imitation, contrary to mimicry, is not an automatic process. It captures behaviors such as repeating a behavioral sequence to fill a glass of water (e.g., Inzlicht, et al., 2012), or mirroring facial expressions when instructed to do it (e.g., Schneider, Hempel, & Lynch, 2013).

Automatic imitation is not a pure mirroring behavior. It is an experimental approach developed to assess mirroring behaviors (Hale & Hamilton, 2016). Individuals perform an instructed action based on a stimulus-response compatibility paradigm, which means that individuals have their behavior either facilitated or constrained according to the topographical features of the task. The ease in translating an observed stimulus into an action is dependent on the resemblance between the observed stimulus and the task to be executed (Brass, Bekkering, Wohlschläger, & Prinz, 2000); therefore, a similar topography facilitates, while a different topography hinders the execution of the task (Heyes, 2011). The classical task in the automatic

imitation paradigm implies lifting of a finger in response to a visual cue that may be topography-congruent or incongruent. For instance, individuals are instructed to lift the index or the middle finger when presented a visual cue, such as a number (pre-specified cue). A mirror hand that shows the lifting movements is also presented at the same time. The visual cue could either sign the movement to lift the index or the middle finger, and the cued movement can be congruent or incongruent with the mirror hand. The congruent trial would be when the individuals see the number that cues the same finger to be lifted as the one lifted in the mirror hand, the incongruent trial would be when the number cues the finger that is not mirrored by the mirror hand (Brass, et al., 2000; Cracco, De Coster, Andres, & Brass, 2015). The congruent topography between the observed cue, mirroring hand and the executed lifting movement facilitates action and leads to faster responses compared to the incongruent topography (Brass, et al., 2000). Automatic imitation is a proxy to assess imitation behaviors because when the observed finger movement is congruent the task gains an imitative dimension. On the other hand, when the observed finger movement is incongruent the incorrect movement is activated and has to be suppressed leading to slower actions - interference. The observed movement influences the initiation of action even if the movement is pre-defined (Brass, et al., 2000), and individuals report the urge to imitate before the cue (Cracco, et al., 2018). Contrary to mimicry and imitation, to overcome the interference, which is the tendency to imitate the mirroring hand, during the task, individuals need to pay attention and exercise cognitive control just as in the classic Stroop task (Ridley, 1935) and Simon task (Simon & Wolf, 1963). Automatic imitation is conscious and partially controlled, as individuals have the choice to start and stop the mirroring. They are not aware, however, of the consequences. Despite the awareness during the execution of the task, and control to start and stop the mirroring task, automatic imitation is not an intentional mirroring. Automatic imitation is the process that interferes during the incongruent topography: even though individuals initiate the action and are aware of the interference during the task, it is very difficult to control and overcome the automatic imitation, and this mirroring is thus not intentional. This paradigm was created as an attempt to study mirroring behaviors by creating an interference in the imitation process. Some authors have used it as a proxy to study mimicry and imitation (Hale & Hamilton, 2016).

Different levels of automaticity are present in the latter two concepts. While mimicry is automatic, imitation and automatic imitation are not, and imitation is a learnt behavior while mimicry is not; thus, imitation implies the awareness and comprehension of other people's actions and sequences (Braadbaart, de Grauw, Perret, Waiter, & Williams, 2014; Yoon & Tennie, 2010). Contrary to mimicry, imitation is conscious - individuals are aware of the

behavioral execution and plan of action – and intentional – individuals start and stop the action. However, it is still a partially non-controlled process because individuals do not know how imitation impacts their own and other people's behavior and beliefs. Therefore, imitation is better classified as a controlled behavior than is mimicry. Automatic imitation, however, contrary to imitation, is a paradigm developed to study mirroring behaviors which aimed to create cognitive interference during the task. Thus, automatic imitation is conscious and partially controlled as individuals have the choice to start and stop the task; however, it is also partially automatic and non-intentional as individuals are not able to stop the interference during the task, even though they are aware of it, which impacts their performance and distresses them during the task. In sum, considering the four pillars of automaticity (Bargh, 1994), one could say that the main and clear difference between those processes in on the level of intentionality and awareness. Mimicry is not intentional and individuals are not aware of it, imitation is conscious and intentional, and automatic imitation is partially conscious but automatic and non-intentional. Thus, we may conclude that mimicry is more of an automatic process than the imitation and automatic imitation. These differences may lead to different social cognition outcomes.

The neuroscience of mirroring behaviors

Behavioral mirroring is an evolved function that facilitates human adaptation to social environments. Mirroring is based on the Mirror Neuron System (MNS) (Catmur, et al., 2008; Heyes, 2011), which is an automatic neural system that mirrors other people's neural activity when behavioral actions, such as grasping objects from a table, are observed (di Pellegrino, et al., 1992; Iacoboni, 2009; Gallese, et al., 1996; Rizzolatti & Craighero, 2004). Thus, the MNS is assumed to be a neural mechanism to recognize other people actions (di Pellegrino, et al., 1992; Gallese, et al., 1996; Rizzolatti & Craighero, 2004) and perform actions (Brass & Heyes, 2005). The MNS is assumed to simulate the neural activity usually involved in observed actions and emotions, and it is active while individuals view or imitate facial expressions (Leslie, Johnson-Frey, & Grafton, 2004; Schilbach, 2016) and behaviors (Iacoboni, et al, 1999; Leslie, et al., 2004). The MNS is active in mimicry, imitation and automatic imitation, however, they are probably related to singularities in brain activation, as mimicry is more of an automatic process compared to imitation and automatic imitation.

Some research has been carried out to learn about the differences in brain activation for mimicry, imitation and automatic imitation tasks. Studies have shown a common ground in

brain activation for mimicry and imitation of facial expressions, and for automatic imitation of hand movements and to some extent to facial expressions. Premotor areas, right superior temporal gyrus, bilateral superior frontal gyrus, posterior temporalo – occipital and cerebellar areas are activated (Carr, et al., 2003; Iacoboni, et al., 1999; Leslie, et al., 2004; Rauchbauer, et al., 2015). In the case of facial expressions, imitation is related to the activation of a bilateral mirroring system, i.e. a goal-planning and a motor-execution system, while mimicry is related to the activation of a mirror system in the ventral premotor cortex in the right hemisphere (Iacoboni, 2005; Leslie, et al., 2004). Broca's area, left hemisphere, is related to conscious goal-directed movements (Leslie, et al., 2004). Therefore, it is not surprising that Broca's area is related to imitation and automatic imitation, but not to mimicry of facial expressions as mimicry is not planned, not intentional, but automatic. Also, imitation and automatic imitation of facial expressions are related to increased activity in the right inferior gyrus (Lee, Liu, & Hoosain, 2006), superior frontal gyrus and superior parietal lobule (Rauchbauer, et al., 2015). In contrast, facial mimicry is related to the activation of the basal temporal lobe (Wild, et al., 2003), and the mentalizing network (MENT) (Schilbach, 2016). Posterior cingulate cortex and precuneus activations, which are part of the mentalizing network (MENT), are related to social cognition (Schilbach, 2016). Thus, while imitation and automatic imitation are associated to an increased activity in Broca's area, mimicry is related to MENT network, which suggests mimicry is social cognition oriented, while imitation and automatic imitation are not. The activation of MENT during mimicry of facial expressions seems to indicate that mimicry has a social cognition function while imitation and automatic imitation do not. Indeed, mimicry is related to empathy while imitation is not, and mimicry is impaired by autism while imitation is not (Cracco, et al., 2018). Also, mimicry is moderated by social context (Hess & Fischer, 2016), and no clear evidence of context moderation is provided for automatic imitation (Cracco, et al., 2018).

Brain activation seems to differ between imitation and mimicry of facial expressions, however, it remains unclear whether the same applies for behaviors. The absence of brain evidence for mimicry of behaviors due to the impossibility of adapting confederate-based studies to brain-imaging studies limit the conclusion to imitation and mimicry of facial expressions. The role of Brocas's area in imitation and automatic imitation remains unclear. Broca's area has been related to the imitation of facial expressions and to the automatic imitation of hand gestures such as finger lifting (Iacoboni, 2005; Leslie, et al., 2004), but not to the imitation of hand opening and grasping movements (Molenberghs, Cunnington, & Mattingley, 2009), but, a study to compare the brain activation for the imitation of hand gestures and automatic imitation of hand gestures is still missing.

Methodologies applied to measure mimicry

Mimicry has been assessed by the direct observation of mirroring behaviors and facial expressions by measuring the intensity and frequency of movements.

Facial Electromyography

Facial electromyography (f-EMG) is the measurement of the changes in electrical activity during the contraction of facial muscles (Tassinary, Cacioppo, & Vanman, 2007). Small electrodes are attached to participants' skin to assess the electrical activity, following the guidelines for human electromyography (Fridlung & Cacioppo, 1986). To assess facial mimicry, electrodes are applied to specific muscles: *corrugator supercilii* for anger, fear and sadness; *zygomaticus maj*or or *orbicularis oculi* for happiness; *levator labii superioris* for disgust (e.g., Bourgeois & Hess, 2008; Cacioppo, Petty, Losch, & Kim, 1986; Hess, et al., 2017; van Boxtel, 2010; van der Schalk, et al., 2011).

This methodology is sensitive enough to detect facial micro-movements invisible to the naked eye, providing an accurate measurement of the facial muscles' activation. Although this methodology is highly sensitive to disturbance due to electric noise and participants' skin conditions (Huang, Chen, & Chung, 2004), when applied by a trained researcher the data obtained is of a good level of quality. F-EMG has been criticized due to the ambiguous meaning of these muscles' activity. The measured facial movements may be due to other emotions or feelings than the ones researchers intend to measure. For instance, the *corrugator supercilii* may be activated due to fear, anger, sadness, annoyance or even attention (Seibt, et al., 2015). Although there exists the possibility of assessing the same emotion with multiple muscles, that solution is not always recommended because the wired electrodes may be uncomfortable and block the natural movements for participants, or even create more electric noise. One solution for that problem can be to improve the electrodes set up, such as the use of wireless electrodes, to allow multiple electrodes per emotion, so as to obtain a more comprehensive analysis of muscles' movement and mimicry. Internal consistency issues in the measurements, depending on the methodology applied to analyse the data, have been pointed out too (Hess, et al., 2017).

Facial Action Coding System (FACS)

FACS is a rating system for facial muscles' movement. During an experiment, participants' facial expressions are recorded by cameras. FACS organizes the human face in muscle units called Action Units (AU) by region in the face, thus, each recorded facial expression can be manually coded (Ekman, Friesen, & Hager, 2002). FACS are used to rate facial movements such as emotional expressions and then facial mimicry. Before the assessment of mimicry, a set of AUs related to the emotions under study are previously defined. The researcher decides to conduct a comprehensive analysis – all AUs are coded; or a selective analysis – pre-determined AUs are coded (Cohn, Ambadar, & Ekman, 2007). The analysis may assess the presence/absence of activity in the AU and the intensity of that activity (Cohn, et al., 2007). This methodology is time-costly and demands three certified FACS coders to assess the AUs (Cohn, et al., 2007), moreover, micro-facial movements that are not visible but could be captured by f-EMG can be lost during coding.

Recently, FaceReader software (Noldus Information Technology, 2017) has been used in some mimicry research (e.g., Sachisthal, Sauter, & Fischer, 2016). FaceReader rates participant's facial expressions based on the FACS. Participants' facial expressions are recorded and then coded in the software. FaceReader has been shown to provide similar results to those of f-EMG (D'Arcey, 2013) and valid results when assessing the basic emotions (Lewinski, den Uyl, & Butler, 2014). Thus, it seems that FaceReader can accurately detect the facial muscles' movements related to each emotion. This method is economic; however, it is also highly sensitive to environmental variables. Video recording conditions are strict: light, contrast and facial orientation should be controlled. Moreover, FaceReader may not be able to detect micro-facial movements such as those involved in mimicry.

Facial Expression Coding System (FACES)

FACES was recently applied in the field of facial mimicry research (Cheung, Slotter, & Gardner, 2015). FACES assesses the emotional valence considering three parameters: intensity, frequency, and duration of emotional display over time. Contrary to FACS, it does not consider any form of facial muscles' movement in isolation (discrete approach), but rather considers a dimensional approach, evaluating the whole face for each emotion (Kring & Sloan, 2007). Considering that facial mimicry is a congruent matching of facial muscles' movements (Seibt, et al., 2015), valence methods may not be good measures of facial mimicry. While other methods, such as f-EMG and FACS, evaluate muscle movements to assess facial mimicry, FACES only assesses the general valence of the face. For instance, when evaluating a facial stimulus expressing anger, individuals will show a negative valence facial expression, however,

that facial expression may be facial mimicry of anger or a response in form of fear or even sadness. Thus, FACES may only assess how participants' feel about the expressed face, which in itself cannot speak for facial mimicry, as facial mimicry is not a dual-valence response, but a mirroring of what is seen.

Confederate studies

In this kind of studies mimicry is assessed during a real life interaction with a confederate. The interaction is recorded and then coded based on a behavioural coding system. All behaviours considered as mimicry are previously listed by the researchers to create a behavioral coding system that is applied to analyse the data. The method consists in counting them (e.g., Lakin, et al., 2008). It is an easy way to assess mimicry of gestures such as rubbing one's face or tapping a foot. There is no need for certified credentials or specialized training to do the coding. However, it is necessary to have at least three coders blind to the hypothesis.

Pupilometry

Pupilometry assesses the pupils' dimension using the eye-tracking technique (e.g., Kret, Fisher, & De Dreu, 2015). This method evaluates if the pupils' dimensions are mimicked. It is a sensitive method to detect small pupillary contractions and expansions. However, it is highly sensitive to environmental variables such as the room's light that may influence pupillary contraction.

Time Bisection Task

The Time bisection task is an indirect measure of mimicry. Participants assess how long a picture of an emotional facial expression is presented on the screen. Negative emotional facial expressions such as anger and fear are judged to last longer than the neutral ones, thus, longer time estimates are associated with higher mimicry levels for negative emotions (Mondillon, et al., 2007). It is a quick and easy method to assess mimicry online and offline. Despite its simplicity, this method is not often used due to the uncertainty about the validity of the method to assess mimicry. No studies have been conducted to verify how other mimicry measures such as FACS or f-EMG are related to the Time Bisection Task.

Methodologies applied to measure imitation effects

Imitation has been assessed by testing its effects on psychological variables and emotion decoding. Contrary to mimicry, these methodologies ask participants to imitate the observed action. Later on, the imitation effect is assessed on diverse psychological variables. Participants may be asked to imitate behavioral gestures or behavioral sequences of a model or target, such as rub their face or take a sip of water from a glass, or yet to imitate facial expressions such as smiling or frowning. Usually, a between-subject design is applied to assess the effect of imitation, thus, in the experimental condition the participant is instructed to imitate, while in the control condition, the participant only observes the behavior (e.g., Inzlicht, et al., 2012). In the case of facial expressions, the methodology applied is similar, however, a third condition is added to block mimicry. Here participants are asked to restrict their facial movements while watching the videos or images (e.g., Schneider, et al., 2013) or to hold a pencil between their lips or a pin in their eye-brows to restrict the smiling and frowning movements (e.g., Niedenthal, 2007). Thus, a comparison between imitation, facial blocking and facial mimicry (control) on a dependent variable of interest is the key product for these methods. It does not assess imitation or mimicry in itself, only its consequences.

Some problems may arise using this methodology. First, it is not clear if all participants imitate facial expressions or movements during the experiment, even when they are instructed to, and it is difficult to guarantee the quality of the experimental manipulation (Hale & Hamilton, 2016). Second, the intensity of imitation will vary according to participants and to their level of understanding of the instructions (Hale & Hamilton, 2016). Finally, in the case of facial mimicry, completely refraining from mimicry is extremely difficult, thus, full facial blocking is not guaranteed.

Methodologies applied to measure automatic imitation

Automatic imitation has been measured by assessing response times (RT), response accuracy (RA) and kinematics (KM, description of the movements) to evaluate the imitation level using stimulus response-compatibility paradigms (Heyes, 2011).

Imitation Inhibition Task (IIT)

Three modalities of the IIT were developed: forced-choice RT paradigm, simple response RT paradigm and simple response kinematics paradigm (Cracco, et al., 2018).

In the forced-choice RT paradigm of the IIT (Brass, et al., 2000; Cracco, et al., 2015) participants have to choose between the execution of two different movements depending on a

pre-specified cue while observing a movement on the screen that is congruent or incongruent with the executed movement. For instance, they see on the screen a hand that mirrors their own hand and are instructed to lift the index or middle finger depending on the number that is presented on the screen (pre-specified cue). While the numbers are presented, the mirror hand also shows the lifting movement, and that hand's finger movement can be congruent or incongruent with the participant's executed move. Several adaptations were made to this task, such as substituting the finger movements by a Joystick Task: participants see an actor moving the joystick towards or away from themselves (Müller, et al., 2013); a Hand Opening Task: participants see an actor opening or closing his or her hand (Shaw, et al., 2013); or a Grasping Task: participants see the actor grasping an object from the top or the bottom (van Schie, Waterschoot, & Bekkering, 2008). Another version of the IIT is the Social Affective Mimicry Task (SAMT), which adds social affective variables to the task. While participants perform the IIT task, they are presented with pictures of facial expressions such as happiness or anger (Rauchbauer, et al., 2015). In another adaptation, participants can see a hand typing on a keyboard (Gleibs, Wilson, Reddy, & Catmur, 2016) that can belong either to an ingroup or to an outgroup member. The addition of social affective variables aims to test if automatic imitation is affected by the social context, such as emotions expressed by others and group membership.

In the simple response RT paradigm, IIT is developed without requiring participants to choose their response depending on the pre-specified cue. Instead, participants can prepare the response before the trial (Cracco, et al., 2018). For instance, participants are instructed to lift or tap their finger as soon as the mirror hand lifts or taps the finger (Brass, Bekkering, & Prinz, 2001; Brass, et al., 2000) which means that participants can anticipate and be prepared to give a response right away without having to consider any congruent or incongruent cue before giving the response.

In both the forced choice RT paradigm and the simple response RT paradigm, response times and error rates are collected for congruent and incongruent trials. The automatic imitation effect is the mean difference between congruent and incongruent trials: larger differences indicate larger automatic imitation (Cracco, et al., 2018).

The simple response kinematics paradigm IIT is also without pre-specified cue. However, instead of measuring reaction time and accuracy rates the results focus on kinematics. For instance, participants are instructed to wave their arms horizontally or vertically while an experimenter waves in the same direction (congruent trials) or in the other direction (incongruent trials) (Kilner, Paulignan, & Blakemore, 2003). Incongruent trials are related to

larger variability in the movements than congruent trials (Cracco, et al., 2018) and this difference in variability is used as an indicator of automatic imitation.

Discussion

Imitation and automatic imitation have been used as proxies to study mimicry (Hale & Hamilton, 2016). However, brain research evidence and profound methodological differences suggest a need for theoretical clarification, as using them as a proxy (Hale & Hamilton, 2016) may undermine the clarity of our understanding of mirroring behavior's social functions. Mimicry studies directly collect information about a behavior's frequency (e.g., behavioral mimicry) or intensity (e.g., facial mimicry); imitation studies are used to verify the effect of imitation on other relevant variables; and automatic imitation studies assess reaction times to measure interference and facilitation processes during the mirroring process. Contrary to mimicry and imitation methods, the Imitation Inhibition Task (IIT) seems to provide information about attention and cognitive control to overcome the interference during the imitation task based on the opposition between interference and facilitation just like the classic Stroop task (Ridley, 1935) and the Simon task (Simon & Wolf, 1963). Response times and response accuracy are measured to assess the automatic imitation index (Genschow, et al., 2017). The nature of the collected data is distinct to that of mimicry, thus it is not clear if automatic imitation data are informative about mimicry (Hess & Fischer, 2017).

Another difference between mimicry, imitation and automatic imitation lies in the experimental setting. When participants are instructed to mirror behaviors their levels of awareness of the task changes; thus, it is implied that they have more explicit control and stronger involvement of executive functions than in typical mimicry tasks where attentional control and awareness of the mimicking behavior are absent (Chartrand & Bargh, 1999; Genschow, et al., 2017; van Leeuwen, van Baaren, Martin, Dijksterhuis, & Bekkering, 2009). The different levels of automaticity across paradigms would bring difficulties to understand the epistemic and affiliation function of mimicry. Considering that decoding is an automatic process, and that mimicry paradigms assess the automatic processes that facilitate decoding and affiliation, imitation paradigms would force those functions, and automatic imitation would assess the interference processes that may affect them. Considering the epistemic function of facial mimicry, while imitation paradigms may tell us about the consequences of forcing facial imitation or facial blocking of the facial expression, automatic imitation paradigms do not

provide evidence about the effectiveness of emotional decoding or affiliation. None of the imitation or automatic imitation paradigms can clarify the relation between mimicry, decoding and affiliation during social interactions and how it impacts the social interaction. Different conclusions about the decoding and affiliation function of mimicry could be drawn and expected from different research paradigms.

Not all studies' conclusions point in the same direction. We consider that inconsistencies across studies are probably related to the nature of their respective methods, and in our humble opinion this may speak for different cognitive processes, as the previous neuronal evidence suggests. For instance, in the domain of mimicry of behaviors and facial expressions in intergroup relations, different methods have been used. Research applying mimicry-related methods has shown that individuals mimic ingroup members' facial expression more than those of outgroup members (e.g., van der Schalk, et al., 2011). In contrast, research using the automatic imitation paradigm has shown inconsistent results across studies, such as larger mirroring of outgroup than ingroup members independently of the facial expression displayed (happiness vs. anger, e.g., Rauchbauer, et al., 2015), larger mirroring of happy facial expressions towards ingroups vs. outgroups (Rauchbauer, et al., 2016, Study 1), and no group membership effect for happiness (Rauchbauer, et al., 2016, Study 2 and Study 3). Thus, it seems that automatic imitation and mimicry may not be influenced in the same way by group membership. Also, when intergroup attitudes are considered, results differ across the different paradigms too. For instance, behavioural mimicry is moderated by implicit and explicit prejudice towards outgroups. Explicit prejudice is related to a decrease in mimicry, however, contrary to what most theories would predict, implicit prejudice increases mimicry towards outgroups (Yabar, et al., 2006). On the other hand, when a behavioral automatic imitation methodology is applied, implicit prejudice (Rauchbauer, et al., 2015, 2016) and explicit prejudice (Rauchbauer, et al., 2015, 2016) do not have a moderating effect on automatic imitation. Finally, when individuals are instructed to imitate other people's behavioural sequences, such as filling a glass of water, they show less prejudice towards outgroups afterwards compared to people that imitate ingroup members (Inzlitch, et al., 2012). However, no evidence exists about how attitudes evolved in the time between before and after the imitation. Once again, it does seem that mimicry, imitation and automatic imitation may serve different social cognitive purposes as they are not equally affected by attitudes towards outgroups.

Research on empathy would also benefit from this theoretical distinction. Mimicry is sometimes used as a measure of empathy. Mimicry studies have shown that mimicry increases

empathy towards others and that empathic people mimic others more (e.g., Lakin, et al., 2008). However, automatic imitation is not related to empathy (Cracco, et al., 2018). As far as we know, no imitation studies have been conducted to test the relation between empathy and imitation. Yet, the fact that mimicry is related to empathy and automatic imitation is not, already speaks for different social cognition functions.

Research about the epistemic function of mirroring behaviors has shown congruent results when mimicry and imitation of facial expression methodologies have been applied. Imitation and mimicry of facial expressions seem to contribute to a better emotional decoding (e.g., van der Shalck, et al., 2011; Oberman, Winkielman, & Ramachandran, 2007, 2009). While imitation and mimicry seem to improve emotional decoding, there is no evidence yet for automatic imitation paradigms as far as we know, although we would expect that automatic imitation would not facilitate the understanding of other people's emotions or behaviors.

No studies have been conducted to assess how mimicry, imitation and automatic imitation are correlated. To the best of our knowledge, only a single study has assessed how mimicry and automatic imitation are related, and results have shown that mimicry and automatic imitation are not correlated (Genschow, et al., 2017). Finally, no studies have explored how mimicry, imitation and automatic imitation affect social variables such as prejudice or affiliation and how these variables are correlated. However, the studies described in this chapter suggest that the relation between each mirroring behavior and the respective social variable of interest may not follow the same pattern. Despite the lack of research in many areas, we argue, like other authors, that mimicry, imitation and automatic imitation are different and dissociable processes despite the fact that they are related due to MNS activation (e.g., Leslie, et al., 2004; Genschow, et al., 2017). The existing evidence allows us already to conclude that mimicry, imitation and automatic imitation are related in different ways to different social processes.

Conclusion

Mimicry, imitation and automatic imitation are mirroring behaviors, but they are different behaviors. Whereas mimicry is unconscious and automatic, imitation and automatic imitation is fairly conscious. Given the methodological differences and neuroscientific evidence, we propose to consider mimicry, imitation and automatic imitation studies as conceptually different. Mirroring behaviors, independent of their nature, help individuals to live in communities and are of paramount importance for understanding others and to socialization. Yet, distinguishing different subtypes of mirroring seems necessary to further understand the

social functions of mimicry and imitation and how automatic imitation can facilitate the understanding of mimicry and imitation.

CHAPTER 3

Chapter 4

Facial mimicry in social relations

CHAPTER 4

Abstract

Emotional decoding and affiliation functions are reviewed as drivers of facial mimicry. Individuals mimic facial expressions to understand and to affiliate with the expresser. However, a close look at the literature shows limited evidence for these claims as studies exhibit methodological shortcomings. Suggestions for further methodological and research directions are provided.

Keywords: unconscious mimicry, affiliation, emotion decoding

CHAPTER 4

CHAPTER 4

Facial mimicry in social relations

"(H)uman sociality is based on emotions and … involves sharing pieces of mind" (Oatley, 2016, p. 7). This sharing is supposedly facilitated by a mirroring process named facial mimicry (Oatley, 2016). Facial mimicry is the automatic and unconscious mirroring of emotional facial expressions between at least two individuals, almost at the same time (e.g., Duffy & Chartrand, 2015; Seibt, et al., 2015).

Several theories explain why people mimic each other and how it facilitates social interactions. Some of the theoretical proposals focus on mimicry's epistemic function, and others emphasise how contextual meaning modulates the mimicry of facial expressions for the sake of affiliation. This review focuses on research on facial mimicry[1] and its role in social interactions. More precisely, it elaborates on how much evidence exists for the assumption that facial mimicry aims at understanding the emotions of and/or affiliating with others as proposed by the existing literature.

The understanding and even definition of mimicry depends on the theoretical approach adopted. Some theories start off from the idea that mirroring of emotional expressions provides the mimicker with information about the mimicked, such as emotional states, motivations, feelings and behavioral intentions (Hess & Fischer, 2017; Oatley, 2016). Theories with such an epistemic approach define mimicry as a congruent match of facial muscular activations during an interaction (e.g., Seibt, et al., 2015, e.g., *Perception-behavior link*, Chartrand & Bargh, 1999; *Simulation Theory,* Gallese, 2009). One implication of such an approach is that the mimicker should be agnostic to the type of emotion and social implications of the mimicked muscular activity, given that the emotional recognition is only inferred from the mimicking process.

Other theories start off from the observation that mimicry increases liking, strengthens social bonds and smoothens communication (e.g., *Social Top Down Response Theory*, Wang & Hamilton, 2012; *Implicit Socialization Account Theory,* Kavanagh & Winkielman, 2016) and therefore can be better understood as having a primary social function, such as affiliation. Probably the most extreme of these theoretical approaches defines mimicry as a mirroring of the understood emotional expression, rather than of observed muscular activations (*Context View of Mimicry Theory*, Hess & Fischer, 2013). This denies mimicry's epistemic function, as it implies that the mimicker knows already what emotion is expressed based on other channels

[1] Studies where participants were instructed to imitate facial expressions are not considered.

rather than mimicry. It also implies that mimicry is more likely if the emotional expression facilitates affiliation compared to other complementary facial expressions (e.g., smiling towards an angry target). Therefore, for the sake of affiliation and peaceful relationships emotions of an affiliative nature, such as happiness, fear and sadness should be mimicked more than competitive ones, such as anger, pride and disgust (Hess, et al., 2016), as the latter can escalate conflict and aggression between individuals (e.g., Fischer, Becker, Veenstra, 2012; Hess & Fischer, 2014).

Mimicry to understand

Competitive and affiliative emotions are mimicked (for sadness and disgust e.g., Hess & Blairy, 2001; for happiness and anger; e.g., Achaibou, et al., 2007; for fear: e.g., van der Schalk, et al., 2011), speaking for an epistemic function of facial mimicry. Moreover, individuals show difficulties in emotional experience and slower decoding when their facial movements are restricted or reduced experimentally (e.g., Oberman, et al., 2007; Niedenthal, 2007) or by cosmetic Botox-treatments (e.g., Lewis, 2018). This speaks in favour of the need for facial muscles' feedback for emotion decoding and experience, consistent with the facial feedback hypothesis (see Coles, et al., 2017, 2019)[2].

Evidence speaking against such universal epistemic function comes from research showing that mimicry does not seem fundamental for emotional decoding among Moebius syndrome patients with facial paralysis (Bogart & Matsumoto, 2009), or that suppression of facial movements does not affect all emotions equally, as results of blocking studies seem to vary across emotions (for a review see Hess & Fischer, 2013). However, such results do not rule out any epistemic function of facial mimicry, but rather suggest that emotional decoding relies on additional channels (Hess & Fischer, 2013). Interestingly, some studies have shown incongruent facial muscles' activation towards other people's emotions, bringing light to possible epistemic and affiliative goals with contradictory implications (for a review see Hess & Fischer, 2013). For instance, research with romantic partners found that when anger was displayed by their partner, participants scoring high in communal strength showed an increased activation of *Zigomatic major* (muscle related to smile), but not of *Corrugator Supercilii* (muscle related to frown; e.g., Häfner & Ijzerman, 2011, Study1). However, even when participants were explicitly instructed to accommodate to the partner's angry face (e.g., smile),

[2] This meta-analysis is not mimicry specific. A meta-analysis with mimicry studies is recommended to assess facial mimicry's epistemic function.

some *Corrugator* activation did occur (Study3). Another study has shown that the mimicry of anger is accompanied by the activation of muscles related to fear and happiness as well (van der Schalk, et al., 2011, Study2). Thus, facial mimicry may not be a mere reflexive reaction to muscle movements, nor just a promoter of affiliation through the display of an appropriate facial response. It is possible that both processes occur at the same time, which would explain the incongruences and congruencies in muscle activation during facial mimicry.

Mimic to Affiliate

Mimicry in general brings positive consequences for relationships. The "social glue" hypothesis suggests that mimicry fosters affiliation and liking among individuals to initiate and maintain positive relationships (Chartrand & Lakin, 2013; Lakin, et al., 2003). However, doubts have been pointed out because liking as result from mimicry is not guaranteed and results are rather mixed (for a review see Hale & Hamilton, 2016). Also, too much or too little mimicry is related to uncomfortable feelings between people (Leander, et al., 2012), suggesting that mimicry does not have to be related to liking and affiliation under all circumstances. Thus, theoretically it would make more sense to look into a more flexible social function, such as showing the appropriate emotional expression, rather than a rigid need for affiliation. Moreover, most of these studies assess behavioral mimicry. Facial mimicry is more complex than behavioral mimicry as emotions carry meaning (Hess & Fischer, 2017). Thus, a careful assessment of facial mimicry as a mechanism of affiliation is missing. More research to assess how facial mimicry affects liking of both the mimicked and the mimicker is necessary. The few existing studies on facial mimicry found that mimicry affects liking the mimicked and it mediates a positive effect of ingroup membership on liking towards the mimicked, but only for negative emotions such as anger and fear (e.g., van der Schalk, et al., 2011) but not for happiness. However, results should be interpreted with caution, as anger is considered competitive while fear is not. Another study suggests that previous positive attitudes enhance facial mimicry. Individuals mimic more happiness and sadness from individuals they like than from individuals towards which they have negative or neutral attitudes (e.g., Likowski, et al., 2008). More studies verifying how the mimicry of competitive vs. affiliative emotions and liking are related are needed.

Research considering attachment style, cooperative vs. competitive, hierarchical, intergroup relations, and ostracism may help shed light on how facial mimicry is related to

affiliation, as all of them are intimately related to the desire of affiliation yet for different purposes.

Attachment style. If facial mimicry aimed to increase affiliation, one would expect to find stronger facial mimicry in securely attached individuals than in avoidant ones, but also stronger mimicry among anxious than secure individuals. Indeed, as a response to sad facial expressions, avoidant individuals show less somatosensory brain activity related to facial mimicry than non-avoidant people (Suslow, et al., 2009), and anxiously attached people more than securely attached people (Donges, Kugel, Stuhrmann, Grotegerd, & Redlich, 2012). Only one study assessed facial mimicry directly and did not find any differences for mimicry of happiness and anger between avoidant and non-avoidant individuals. Yet, this study compared only 12 avoidant with 49 non-avoidant individuals. Thus, attachment style should be considered for future research as one way to capture the relation between facial mimicry and affiliation needs.

Competition vs. cooperation. From a contextual perspective, competition and cooperation in relationships should influence facial mimicry. In cooperative relationships affiliation is desired. In competitive relationships it is not, and individuals are less prone to affiliate, thus, mimicry should be decreased (Hess & Fischer, 2013). Indeed, happiness, sadness (Seibt, et al., 2013; Weyers, et al., 2009) and anger are mimicked (Likwoski, Mühlberger, Seibt, Pauli, & Weyers, 2011) in cooperation relationships, but, not in competition relationships (Lanzetta & Englis, 1989; Weyers, Mühlberger, Kund, Hess, & Pauli, 2009). Thus, it seems that when affiliation is desired as it is in cooperative relationships, mimicry increases. Yet, it does so independently of the competitive or affiliative nature of the emotions.

Asymmetric relations. Both the epistemic and the affiliation approach would predict that in relationships marked by hierarchical differences powerless people should show more facial mimicry than the powerful, as the powerless have more to gain from understanding and affiliating with the powerful than the other way around. However, results show a different pattern. Research by Carr, Winkielman, and Oveis (2014) found that powerless individuals mimicked happiness across powerless and powerful expressers, while anger was only mimicked if shown by powerless targets. On the other hand, powerful individuals showed mimicry of happiness when shown by powerless, but not when shown by powerful targets. These results are difficult to explain by both the epistemic and the affiliation approach and call for a more comprehensive analysis of social-contextual factors.

Group membership. Individuals learn group norms and behaviors with ingroups, therefore individuals have an increased need to affiliate with ingroup compared to outgroup

members. Thus, stronger facial mimicry of ingroup than of outgroup members should be expected. A recent meta-analysis has shown stronger facial mimicry towards ingroups than outgroups, however, the effect is only reliable for anger (Murteira & Waldzus, 2020b). Affiliative emotions such as sadness and happiness do not seem to be affected by group membership of the mimicked person. The effect of group membership on mimicry of anger allied by the absence of such an effect for happiness and sadness is intriguing. It seems to be more compatible with a need for understanding than for affiliation. Yet, even the epistemic approach can only explain this result post-hoc. It would not predict it.

Other research has combined group membership with ostracism. If facial mimicry is an affiliative mechanism, we would expect that facial mimicry increase towards ingroup vs. outgroup members after ostracism. However, no differences were found for mimicry of happiness, anger, sadness and disgust between groups after complete ostracism (i.e., being ostracized by both ingroup and outgroup members). Outgroup members were even more mimicked than ingroup members on negative emotions when group membership was combined with ostracism (i.e., being ostracized only by ingroup but not by outgroup members; Hühnel, Kuszynski, Asendorpf, & Hess, 2018). Overall, it seems that group membership as such does not moderate facial mimicry. Nevertheless, the small number of available studies, the variety of methods to assess mimicry, plus the small effect size subject to large heterogeneity found in the above-mentioned meta-analysis call for more studies to assess the group membership effect on facial mimicry, in combination with ostracism or other relevant conditional factors.

Methodological issues

All of these studies have assessed facial mimicry as a reflexive response due to the nature of the methods used to access facial mimicry. Thus, despite the different definitions of facial mimicry by different approaches, they all rely on the observation of muscle activation or movements. The two most common measures of facial mimicry use Facial electromyography (f-EMG) or the Facial Action Coding System (FACS). Electromyography measures the changes in the electric activity in facial muscles' contraction using electrodes (Tassinary, et al., 2007). FACS is a classification system that organizes the human face in muscle units called Action Units (AU), which coding is based on the observation of facial muscles' movements (Ekman, et al., 2002). However, facial muscles' activation may be due to different reasons. For instance, the activation observed in the *Corrugator Supercilii* (muscle related to frown) may be related to fear, anger, sadness, annoyance or even attention (Seibt, et al., 2015). Thus, muscle

movements may be due to other processes rather than facial mimicry. Moreover, the inference of facial mimicry from muscle activation is context-based. For instance, the same muscles have been used to assess anger and sadness in the same studies, and the meaning of the muscle's activation depends on the presented stimulus. Overcoming these methodological shortcomings is paramount to clarify any questions about the functionality of facial mimicry.

A more comprehensive approach assessing more muscles or AUs per emotion would help to clarify what facial mimicry is, as well as its function, as it would allow for better differentiation between emotions. Recent advances in f-EMG allow the use of wireless electrodes, enabling the placement of extra electrodes in participants' faces, without the loss of comfort. For FACS, extending the number of assessed AUs would be useful. Facial analysis software such as FaceReader assesses the AUs automatically (Noldus Information Technology, 2017; e.g., Sachisthal, et al., 2016). Other promising methods to assess facial mimicry are kinematics systems, such as Vicon Cara (Vicon, 2019). Facial movements are assessed using a highly accurate 3D facial motion capture system that provides a model of the muscles' movement. Thus, precise information about subtle muscle movements for the whole face is obtained.

Conclusion and future directions

The review suggests some, but rather weak evidence supporting the proposal that facial mimicry is related to the recognition and understanding of other people's emotions. However, facial mimicry seems to be one out of several channels used for emotion recognition. At the same time, social context factors moderate facial mimicry, yet in a more complex way than the parsimonious assumption of a general affiliation function would suggest. Sophisticated theoretical proposals have been advanced, and promising paradigms have been developed to clarify how facial mimicry is influenced by relevant context factors such as competition and cooperation, liking, group membership, attachment style or ostracism. Yet, what is needed is (a) an improvement in the measure of facial mimicry and (b) a more realistic conceptualization of the potential social functionality of facial mimicry as one kind of complemental response to other people's emotional expressions. Only then the still open question can be addressed, whether facial mimicry is (1) a reflexive process matching own with others' muscle movements (congruent match), or (2) a socially motivated response towards their inferred meaning (complemental match), or (3) a mixture of congruent and complemental muscle activations,

which are identical in most situations, but that can get in each other's way under some circumstances.

Chapter 5

What is facial mimicry: an attempt to understand facial mimicry and its relation to affiliation and emotional decoding

CHAPTER 5

Abstract

Facial mimicry has been described as the mirroring of other people's emotional facial expressions. However, some controversy emerged in the literature about the operationalization of facial mimicry and its functions. While some authors consider mimicry as the activation of the same facial muscles as the observed ones - congruent facial muscles; others have suggested that facial mimicry is the mirroring of the emotion that is understood by the mimicker. While the first view sees mimicry as a reflexive mechanism (bottom-up), the second sees it as a response mechanism (top-down). Moreover, mimicry has been considered an affiliative mechanism, a claim that lacks clear evidence. In the current study we present a set of emotions (happiness, anger, fear, sadness, neutral) and assess facial mimicry using a comprehensive approach based on facial recognition software data instead of muscle-specific analysis, and explore how facial mimicry is related to empathy and need to belong as proxies for affiliation. Results revealed both the activation of congruent facial muscles and of complemental muscles; the latter can be interpreted as a social response. Thus, facial mimicry seems to be both a congruent facial muscles' response (reflexive) and a socially complemental response related to the social interaction. Unexpectedly, facial mimicry was neither related to empathy nor to need to belong, except mimicry of anger.

Keywords: unconscious facial mimicry, congruent mirroring of muscles' activation, complemental activation, FaceReader.

CHAPTER 5

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What is facial mimicry: an attempt to understand facial mimicry and its relation to affiliation and emotional decoding

Social interactions are marked by sharing among people. People share ideas, feelings, emotions and states of mind. This sharing is supposedly facilitated by a mirroring process named facial mimicry (Oatley, 2016). Facial mimicry is the automatic and unconscious mirroring of emotional facial expressions between at least two individuals, almost at the same time (e.g., Duffy & Chartrand, 2015; Seibt, et al., 2015). Although some evidence suggests that facial mimicry may help in the emotional decoding of other individuals' states (Murteira & Waldzus, 2020a), it is less clear what exactly facial mimicry is and how it is related to affiliation. While some authors consider mimicry as the activation of the same facial muscles as the observed ones - congruent facial muscles' activation (e.g., Seibt, et al., 2015), others have suggested that facial mimicry is the mirroring of what is understood by the mimicker when it promotes affiliation (Hess & Fischer, 2013). The latter proposal implies that one can expect that mimicry involves the activation of additional muscles' activation rather than just of congruent facial muscles. For instance, when individuals mimic happiness, they do not simply mimic the muscular activations related to the smiling, but the understood emotional state of happiness. In this paper, facial mimicry is assessed with the help of face recognition software – FaceReader 4.1 (Noldus Information Technology, 2017). FaceReader allows a comprehensive approach instead of a local muscle approach as used in several studies (e.g., facial electromyography). We aim first to assess facial mimicry using this novel and comprehensive approach, and secondly to assess how facial mimicry is related to emotional decoding and affiliation. Empathy and need to belong will be used as a proxy for affiliation.

Functions of mimicry

According to evolutionary biologists, grouped animals increase their survival odds by synchronizing. Thus, individuals are adapted to improve their social cohesion and thus help them avoid threats to their survival (Dostálková & Špinka, 2010; Duranton & Gaunet, 2016). Human beings in particular, as a species that has evolved to live in groups, show the need to belong to a group since birth (e.g., Baumeister & Leary, 1995). This need for belonging and affiliation with others leads people to pursue acceptance by peers (e.g., Williams, 2007). Facial mimicry, like other forms of mimicry, seems to be an affiliative mechanism that has most likely

evolved to help individuals in maintaining harmonious and cooperative relationships within their communities (Chartrand & Bargh, 1999; Lakin, et al., 2008) by improving the communication among individuals (Lakin, et al., 2003). If mimicry has an affiliative function, then it would not be surprising that individuals use it more strongly with whom they aim to affiliate with, and stronger mimicry would be shown when the belonging to a group is jeopardized. Indeed, people show a tendency to mimic ingroup members more than outgroup members (e.g., van der Schalk, et al., 2011; Yabar, et al., 2006; Bourgeois & Hess, 2008) and friends (e.g., Bourgeois & Hess, 2008). Also mimicry is suggested to increase after an ostracism process due its re-affiliative power (e.g., Williams, 2007). Therefore, individuals increase mimicry when perceiving themselves in a risky group situation, such as after being excluded (Lakin, et al., 2008) or after witnessing exclusion towards an ingroup member (Castelli, et al., 2011). Thus, we may expect that stronger facial mimicry is related to a stronger need to belong to a group. Testing this relation would be valuable to better understand the relation between facial mimicry and affiliation.

Understanding emotions is crucial to human social functioning, as it is imperative for effective communication and behavior during social interactions. Some doubts have been raised about the necessity of facial mimicry for accurate emotional decoding (Hess & Fischer, 2013). However, indirect evidence for the important role of mimicry in emotional decoding comes from studies on empathy. The capacity to understand and experience others' emotions seems to be related to empathy. Mimicry is suggested to play a role in empathy and it is the first path to empathy from birth (Hess, et al., 1999; Hoffman, 1984). Several studies conducted with infants suggest that empathic children tend to mimic facial expressions more (Chrisholm & Strayer, 1995; Eisenberg, 1989; Eisenberg & Fabes, 1990). Emotional empathy (to feel what the other feels) and cognitive empathy (to understand what other feels) are supported by facial mimicry (Stel, 2016). Nevertheless, despite the fact that several studies were conducted to test the relationship between emotional experience and emotional facial mimicry, the evidence is still limited and not clear, and part of the conclusions that have been drawn from this research were made based on theoretical inference rather than the empirical evidence itself (Hess, et al., 1999). In particular, these studies did not verify the correlational associations between emotional empathy, cognitive empathy, and emotional decoding. Thus, testing these associations would be worthwhile to better understand the relations between facial mimicry, emotional decoding, emotional empathy, and cognitive empathy.

Several theories were developed to explain mimicry. Some of the proposed theories consider mimicry to be an innate response to stimuli, thereby focusing on a facial mimicry's

epistemic function as an emotional simulation to help in the decoding and experience of emotion. Other theories emphasize the social context and how it modulates the response to a stimulus, thereby focusing on mimicry's function of affiliation with others (for a review please see Chapter 1). As examples of these approaches we will briefly review two theoretical branches: epistemic theories and interpretation theory.

Facial mimicry: two concurrent views

The function and even the definition of facial mimicry depends on the theoretical approach used. Some theories assume an epistemic function for facial mimicry, while others do not. Epistemic approach theories suggest that mirroring emotional expressions provides the mimicker with information about the mimicked, such as emotional states, motivations, feelings and behavioral intentions (Hess & Fischer, 2017; Oatley, 2016). Here facial mimicry is defined as a congruent mirroring of facial muscular activations during an interaction (e.g., Seibt, et al., 2015, e.g., *Perception-behavior link*, Chartrand & Bargh, 1999; *Embodied Simulation* Theory, Gallese, 2009). According to this approach, when the congruent facial muscles' match occurs, emotion recognition is facilitated.

Interpretation theory suggest that facial mimicry is the mirroring of the understood emotional expression and not of the observed muscular activations as such (*Context View of Mimicry Theory*, Hess & Fischer, 2013). Individuals mimic affiliative emotional states instead of muscular activations. This approach dismisses the epistemic function of facial mimicry, and emphasizes facial mimicry as an affiliative process instead. According to this view, the mimicker knows what emotion is expressed based on other channels rather than on facial mimicry. Emotions of an affiliative nature, such as happiness, fear, and sadness should be mimicked more than competitive ones, such as anger, pride, and disgust (Hess, et al., 2016), as the latter emotions can escalate conflict and aggression between individuals (e.g., Bourgeois and Hess, 2008; Fischer, et al., 2012; Hess & Fischer, 2013; Hess & Fischer, 2014) and jeopardize their affiliation. Thus, when individuals understand competitive emotions, facial mimicry should not occur because it does not promote affiliation. Instead, a complemental facial expression that facilitates affiliation is more likely (e.g., smiling towards an angry target); If, on the other hand, the congruent mirroring of facial muscular activations occurs in those cases, the authors do not consider it as a form of mimicry because it does not promote affiliation. Neither of these are consider forms of mimicry, but rather reactive expressions; only the mirroring of affiliative emotions is considered mimicry (Hess & Fischer, 2016).

The empirical evidence for these claims is rather mixed. Several studies have shown that competitive and affiliative emotions are mimicked (for sadness and disgust e.g., Hess & Blairy, 2001; for happiness and anger; e.g., Achaibou, et al., 2007; for fear: e.g., van der Schalk, et al., 2011). Individuals do show difficulties in emotional experience and slower decoding when their facial movements are restricted or reduced experimentally (e.g., Oberman, et al., 2007; Niedenthal, 2007) or by cosmetic Botox-treatments (e.g., Lewis, 2018). That speaks for the necessity of facial muscles' feedback for emotion decoding and experience, consistent with the facial feedback hypothesis (see Coles, et al., 2017, 2019)[3]. This evidence speaks for an epistemic function of facial mimicry and therefore for a congruent mirroring of facial muscles' activation to characterize mimicry. However, facial mimicry seems to be unrelated to an epistemic function among Moebius syndrome patients with facial paralysis (Bogart & Matsumoto, 2009). Also, the suppression of facial movements in blocking studies do not seem to affect all emotions equally (for a review see Hess & Fischer, 2013). While the latter results suggest that facial mimicry may be dispensable for emotional decoding, it does not clearly speak for the interpretation theory too. Despite the evidence that individuals can learn and decode other people's facial expression without facial mimicry, this evidence is not specific for competitive emotions. Also, it is unclear whether this speaks for a facial mimicry of what is understood, for the activation of congruent mirroring muscles, or for a complemental response towards the expresser.

Some of this lack of clarity about facial mimicry's functions can be attributed to methodological limitations (Murteira & Waldzus, 2020c). So far, two methods are used to assess facial mimicry: Facial electromyography (f-EMG) and Facial Action Coding System (FACS). Electromyography assesses the electric activity in facial muscles' contraction using electrodes (Tassinary, et al., 2007). FACS is a classification system that categorizes the face in muscle units named Action Units (AU). FACS' coding is based on the observation of facial muscles' movements (Ekman, et al., 2002). Both methods are based on the assessment of muscles' movements related to the emotion in study. Thus, muscles other than the ones related to the emotion under study are typically dismissed.

These concurrent views of mimicry bring challenges to the current research on facial mimicry. The different understandings on what facial mimicry is brings the need to study how facial mimicry is characterized. While emotional decoding and affiliation are considered the

[3] This meta-analysis is not mimicry specific. A meta-analysis with mimicry studies is recommended to assess facial mimicry's epistemic function.

main social functions of facial mimicry, there are reasons to doubt these ideas despite their plausibility. While some, though not yet comprehensive, evidence points to emotional decoding by facial mimicry, the situation is even less clear for mimicry's affiliative function (Murteira & Waldzus, 2020a); thus some clarification is still needed. We propose that facial mimicry may use the emotional decoding function in the service of affiliation. We could expect to find the congruent mirroring muscles' activation to facilitate the emotional decoding, while mirroring of what is understood could help the individuals to give the proper social response to facilitate affiliation. Thus, congruent muscles' activation related to the emotion, plus the activation of other muscles related to other emotions to facilitate affiliation, may characterize facial mimicry.

A comprehensive approach assessing more muscles or AUs per emotion would help to clarify what facial mimicry is and how to operationalize it in future studies. In the current study, we therefore first assess the facial mimicry of a set of emotions using facial analysis software such as FaceReader. FaceReader assesses the AUs automatically (Noldus Information Technology, 2017; e.g., Sachisthal, et al., 2016), which allows the assessment of mimicry without any pre-selection that manual coding demands due to the coding difficulties. We recognise that disentangling the reflex - congruent mirroring of muscles' activity, from the mirroring response of what is understood, or even from a complemental facial response can be difficult. However, assessing mimicry using this comprehensive methodology may bring light to the understanding of mimicry. Second, we will assess the relation of facial mimicry with the need to belong. If facial mimicry is an affiliative mechanism, it should be expected that need to belong is positively related with facial mimicry. Third, we aim to study the relation between facial mimicry and empathy. If facial mimicry is an empathic process that helps in understanding others, then it would be expected that stronger empathy is related to stronger facial mimicry, which would speak for the importance of facial mimicry in emotional decoding and experience. Also, if facial mimicry facilitates emotional decoding, then we could expect to find a positive relationship between facial mimicry and the emotional decoding.

Overview of the study

This study aimed to assess mimicry of facial expressions in a Portuguese sample. We aim to verify if mimicry is characterized only by the congruent muscles' activation related to the emotion displayed or if mimicry is more than this. Taking into account that facial mimicry has been considered an affiliative and decoding mechanism, we generated our hypotheses based on the possibility that both of these functions may exist in parallel. Mirroring the muscles' activation would help in decoding, while mirroring what is understood in others' emotions would help individuals to give proper social responses and facilitate affiliation. Therefore, we expect that mimicry is characterized by the congruent muscles' activation related to the emotion – decoding - plus the activation of other muscles that can be related to other emotions as a form of complemental response towards the observed emotion – affiliation. Thus, mimicry would be both reflexive (i.e., congruent mirroring of muscles' activation) and responsive (i.e., complemental non-matching muscles' activation related to other emotions). In the case of non-affiliative emotions such as anger, we would expect to find congruent muscles' activation to facilitate the emotional decoding. We would also expect to find the complemental facial expressions to facilitate affiliation such as fear, sadness and happiness. Considering the competitive nature of anger compared to affiliative emotions, we consider that anger would trigger stronger complemental facial expressions such as fear, sadness and happiness to keep safe the relationship between the mimicker and the mimicked and preserve affiliation. Moreover, we aim to test the relationship between facial mimicry, need to belong to a group and empathy. We expect to find a positive relationship between facial mimicry and need to belong to a group, and a positive relationship between facial mimicry and empathy. Finally, we aim to test the relationship between facial mimicry and emotional decoding. We expect to find a positive relationship between facial mimicry and emotional decoding.

Method

Design and sample size calculation

Fifty-six participants took part in the study. Participants volunteered for participation. Eight participants were excluded due to video recording problems. From the remaining sample (N = 48), 47 were White, and one was Black. Forty-five participants were Portuguese citizens.

Twenty-eight were females, 20 were males, one was other. The average age was 22.2 years (*SD* = 2.66).

The study used a 5 (emotion: happiness vs. sadness vs. fear vs. anger vs. neutral facial expression) within-subject design. Participants were recorded during the study. G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) was used to conduct a power analysis on a repeated measures design (*F*-test, repeated measures, within-subject design). Input parameters were: estimated effect size $f = 0.25$, $\alpha = .05$, power = .80, number of groups = 1, number of measurements = 3, correlation between repeated measures = .5, and nonsphericity correction = 0.5 (Faul, et al., 2007). The output parameters resulting from this analysis showed that for a critical *F* of 4.07, with the actual power of 80% the total required sample size is 44 participants.

Stimuli

Participants were shown videos with dynamic facial expressions. In dynamic facial expressions each video displays the development from neutral until the full emotional expression. ADFES database for facial expressions with Mediterranean ascends models was used (van der Schalk, Hawk, Fischer, & Doosje, 2011). Four emotions were selected: anger, fear, sadness and happiness. Two female and two male expressers performed the emotion with a head-turning movement to improve the eye gaze with the participant during the experiment. Such a technique had been found to increase mimicry responses (van der Schalk, Hawk, et al., 2011). The head-turning movement improves mimicry due to an increased perception from the participants that the emotion is towards them. In contrast to the used dynamic videos, in direct videos models look toward the camera from the beginning to the end of the sequence, which is related to a smaller mimicry (van der Schalk, Hawk, et al., 2011).

Procedure

Participants were seated in front of a computer. A brief explanation of the study was provided and informed consent was obtained from each participant. Participants were told that the study aimed to observe the influence of personality traits on perception of emotions. The experiment had three parts. The Qualtrics survey (Qualtrics, 2019) started assessing demographic variables such as age, gender, nationality, education, political orientation, and religion. Individual difference variables such as cognitive and emotional empathy (Limpo, Alves, & Castro, 2010) and need to belong (Leary, et al., 2013) and political orientation were

assessed. All measures and items in each measure were presented to participants in random order. In the second part, participants were shown a set of videos. Videos were presented using Open Sesame (Mathôt, Schreij, & Theeuwes, 2012). Each trial started with a blank screen (1000 ms), followed by a fixation cross and a bip sound (1000 ms). Each video lasted 6000 ms, but the last still frame of the stimulus video was presented for an additional 4000 ms to prevent missing mimicry responses. The four emotional expressions were displayed in random order with 3 repetitions. A bip sound was used to synchronize stimulus presentation with the camera during recordings. Participants were video-recorded during the presentation of the stimuli (video plus still frame) in order to later assess mimicry with FaceReader 4.1 (Noldus Information Technology, 2017). In the third part, some questions related to decoding accuracy for each of the shown emotions were asked. Finally, participants were debriefed and thanked. The experiment lasted 15 minutes on average.

FaceReader

To analyze the recorded facial expressions that participants showed while they were visualizing the stimuli, FaceReader 7.1 was used (Noldus Information Technology, 2017). FaceReader is an automated software package to code facial expressions. FaceReader identifies a participant's face to create a model of the active appearance (Cootes & Taylor, 2004) to code the intensity of each facial action unit (AU) such as the facial muscle contractions and relaxations on a scale ranging from 0 to 1 (Lewinski, et al., 2014). Data was analyzed applying a precision of 20Hz frame rate, which means that for each second 20 data points were generated to classify each AU. Data was Z-transformed within-subjects. Data was aggregated by mean for each emotion and each trial (Sachisthal, et al., 2016) to determine the participant's mimicry to each stimulus type in a 8000ms time window. FaceReader provides information about the general emotional facial state of participants scoring each video for eight emotional dimensions: Neutral, Happy, Sad, Angry, Surprised, Scared, Disgusted and Contemptuous. Only the relevant general emotional states: Happy, Sad, Angry and Scared, - were considered to assess mimicry.

Measurements

Empathy (α = .75 M = 4.01; SD = 0.50) was assessed by the Portuguese adaptation of the Interpersonal Reactivity Index (Limpo, et al., 2010). Participants provided their answer on a scale from 1 "*Completely disagree"* to 6 "*Completely agree*". The scale has two sub-scales:

cognitive empathy (α = .51; *M* = 4.40; *SD* = 0.47) and *emotional empathy* (α = .66; *M* = 3.57; *SD* = 0.63).

Belonging (α = .85; *M* = 3.25; *SD* = 0.77) was assessed by the Need to Belong Scale (Leary, et al., 2013). Participants provided their answer on a scale from 1 "*Completely disagree"* to 5"*Completely agree*".

Manipulation checks

Emotions decoding accuracy. Participants rated the intensity of fear, happiness, sadness, and anger after each emotion displayed on a scale from 1 "*not intense at all*" to 5 "*very intense*" (van der Schalk, et al., 2011).

Results

Manipulation checks.

Emotions decoding accuracy. Emotion categorization to each emotional display was analyzed with a Repeated Measures GLM with the 5 (emotion displayed: anger vs. sadness vs. happiness vs. fear vs. neutral facial expression) x 4 (emotion decoding accuracy: anger vs. sadness vs. happiness vs. fear) within-subject design. Assumption of Sphericity was violated; therefore, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom when necessary. A main effect of emotion displayed, F (3.39, 159.10) = 15.43, $p < .001$, $\eta^2 = 0.25$, and a main effect of emotion decoding accuracy, F (3, 141) = 27.07, $p < .001$, $\eta^2 = 0.37$, were found. A significant interaction between emotion displayed x emotion decoding accuracy, F (6.21, 291.78) = 183.80, $p < .001$, $\eta^2 = 0.80$, was found suggesting that each displayed emotion was differently decoded. For all emotions displayed a main effect of emotion was found, thus, participants rated happiness displays as happier than other displays, anger displays were rated as angrier than other displays, sadness displays were rated as sadder, and finally fear displays were rated as more fearful than other displays (for detailed statistical information please see Table 2).

Table 2:
Decoding accuracy for each emotion displayed.

Emotion Displayed	*Emotion*
Happiness	F (1.54, 72.56) = 457.53, p< .001, η^2 = 0.91
Anger	F (1.94, 91.23) = 86.74, p < .001, η^2 = 0.65
Sadness	F (2.31, 108.72) = 161.18, p< .001, η^2 = 0.77
Fear	F (1.92, 90.20) = 177.22, p < .001, η^2 = 0.79

Emotion Displayed	Happiness	Anger	Sadness	Fear	Neutral facial expression
Decodings	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Happiness	4.53 (0.69) [a, e, f]	1.07 (0.25) [a]	1.13 (0.36) [a]	1.15 (0.36) [a]	1.43 (0.64) [a]
Anger	1.24 (0.48) [b]	3.26 (1.04) [b, e, f]	1.30 (0.65) [a, b]	1.31 (0.55) [a, b]	1.59 (0.78) [a, c]
Sadness	1.21 (0.48) [b, c]	1.89 (0.82) [c]	4.17 (0.90) [c, e, f]	1.59 (0.78) [c]	2.45 (1.19) [b]
Fear	1.14 (0.40) [b, c]	1.46 (0.69) [d]	2.24 (1.09) [d]	3.85 (1.03) [d, e, f]	1.48 (0.76) [a, c]

Note: Assumption of Sphericity was violated, thus, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom.

[abcd] Pairwise comparisons between decodings for each emotion displayed with different superscripts differ significantly from each other (p < .05, two-tailed)

[e] Planned contrast between the matching decoding emotion and the emotion displayed vs. other decoding emotions for each emotion displayed. Superscripts differ significantly from each other (p < .05, two-tailed)

[f] Planned contrast between the matching decoding emotion and the emotion displayed vs. other emotional displays. Superscripts differ significantly from each other (p < .05, two-tailed)

Analysis of mimicry process

Mimicry of happiness, sadness, fear and anger were analyzed. All emotions were mimicked, however, some emotions were mimicked more intensively than the others. A Repeated Measures GLM was applied to assess the facial mimicry for the five emotions displayed, for each emotion presented five emotional states were assessed by FaceReader, thus, a 2 within-subject factor analysis was conducted: 5 (emotion displayed: anger vs. sadness vs.

happiness vs. fear vs. neutral facial expression) x 5 (emotion assessed: anger vs. sadness vs. happiness vs. fear vs. neutral facial expression) within-subject design. Assumption of Sphericity was violated; thus, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom.

The main effect of emotion displayed was marginally significant, F (3.59, 154.46) = 2.19, p = .081, η^2 = 0.05, and the main effect of emotion assessed was significant, F (2.67, 114.84) = 2.78, p = .05, η^2 = 0.06. A significant interaction between *emotion displayed x emotion assessed*, F (10.35, 444.87) = 2.99, p = .001, η^2 = 0.07, was found, which shows that facial expressions vary according to the emotion displayed. Planned contrasts were computed using MMATRIX subcommand to assess facial mimicry for each emotion displayed.

Mimicry of anger. A planned contrast was designed to assess mimicry of anger vs. other assessed emotions when anger is displayed (1, -1/4, -1/4, -1/4, -1/4)[4]. Results showed stronger mimicry of anger than of other facial expressions, F (1, 43) = 4.39, p =.04, η^2 = 0.09, M_{Anger} = .15; SD = 0.40; $M_{Happiness}$ = -.07; SD = 0.22; $M_{Sadness}$ = .10; SD = 0.37; M_{Fear} = .05; SD = 0.40; $M_{Neutral}$ = -.01; SD = 0.36.

Mimicry of happiness. A planned contrast was designed to assess mimicry of happiness vs. other assessed emotions when happiness is displayed (-1/4, -1/4, 1, -1/4, -1/4). Results showed stronger mimicry of happiness than of other facial expressions, F (1, 43) = 6.15, p = .02, η^2 = 0.13, M_{Anger} = -.08; SD = 0.30; $M_{Happiness}$ = .12; SD = 0.39; $M_{Sadness}$ = .01; SD = 0.33; M_{Fear} = -.06; SD = 0.27; $M_{Neutral}$ = -.07; SD = 0.38.

Mimicry of sadness. A planned contrast was designed to assess mimicry of sadness vs. other assessed emotions when sadness is displayed (-1/4, 1, -1/4, -1/4, -1/4). Results did not show stronger mimicry of sadness rather than other facial expressions, F (1, 43) = 0.05, p = .83, η^2 = 0.00, M_{Anger} = .00; SD = 0.40; $M_{Happiness}$ = -.05; SD = 0.21; $M_{Sadness}$ = .01; SD = 0.31; M_{Fear} = -.02; SD = 0.24; $M_{Neutral}$ = -.07; SD = 0.24.

Mimicry of fear. A planned contrast was designed to assess mimicry of fear vs. other assessed emotions when fear is displayed (-1/4, -1/4, -1/4, 1, -1/4). Results showed marginal significance evidence for stronger mimicry of fear rather than other facial expressions, F (1, 43) = 3.75, p = .06, η^2 = 0.08, M_{Anger} = .03; SD = 0.23; $M_{Happiness}$ = .11; SD = 0.37; $M_{Sadness}$ = .03; SD = 0.29; M_{Fear} = .11; SD = 0.35; $M_{Neutral}$ = -.16; SD = 0.29.

[4] The emotions are presented by the following order in the contrasts: anger, sadness, happiness, fear, neutral facial expression.

Mimicry of neutral facial expression. A planned contrast was designed to assess mimicry of neutral facial expression vs. other assessed emotions when neutral is displayed (-1/4, -1/4, -1/4, -1/4, 1). Results showed stronger mimicry of neutral facial expression than of other facial expressions, F (1, 43) = 4.27, p = .05, η^2 = 0.09, M_{Anger} = .03; SD = 0.26; $M_{Happiness}$ = -.17; SD = 0.22; $M_{Sadness}$ = .01; SD = 0.41; M_{Fear} = .02; SD = 0.32; $M_{Neutral}$ = .09; SD = 0.29.

All emotions were strongly mimicked, with the exception of sadness. Nevertheless, the most interesting result comes not from the mimicry itself, but from the complemental facial expressions that were assessed during mimicry. As results pointed out, mimicry of each emotion was accompanied by other facial muscles activations that were related to other facial expressions rather than the visualized one (please see Figures 1, 2, 3, 4, and 5 for each emotional display).

Figure 1: Emotional activation for Sadness displays.

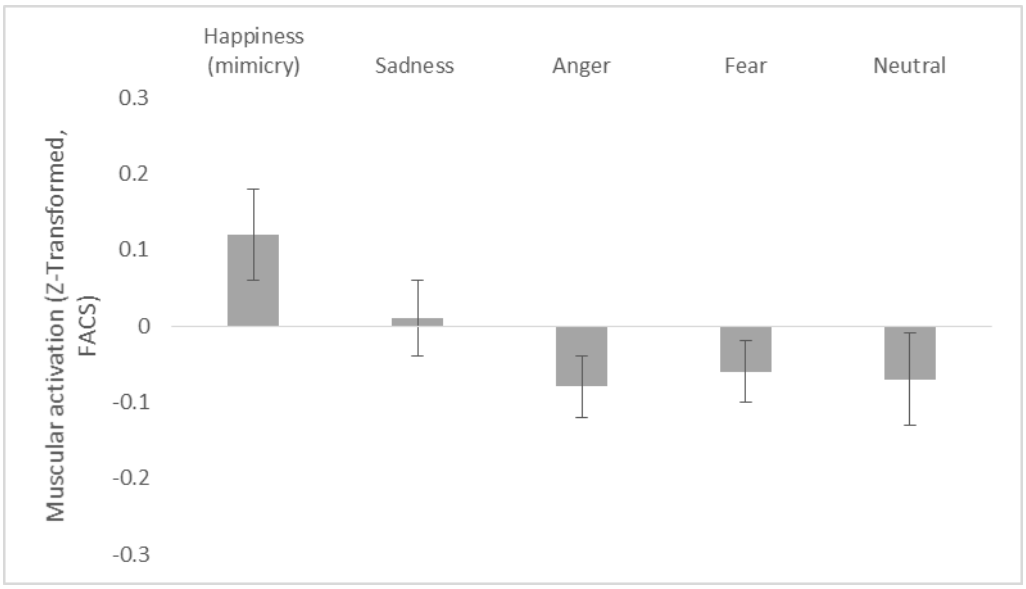

Figure 2: Emotional activation for Happiness displays.

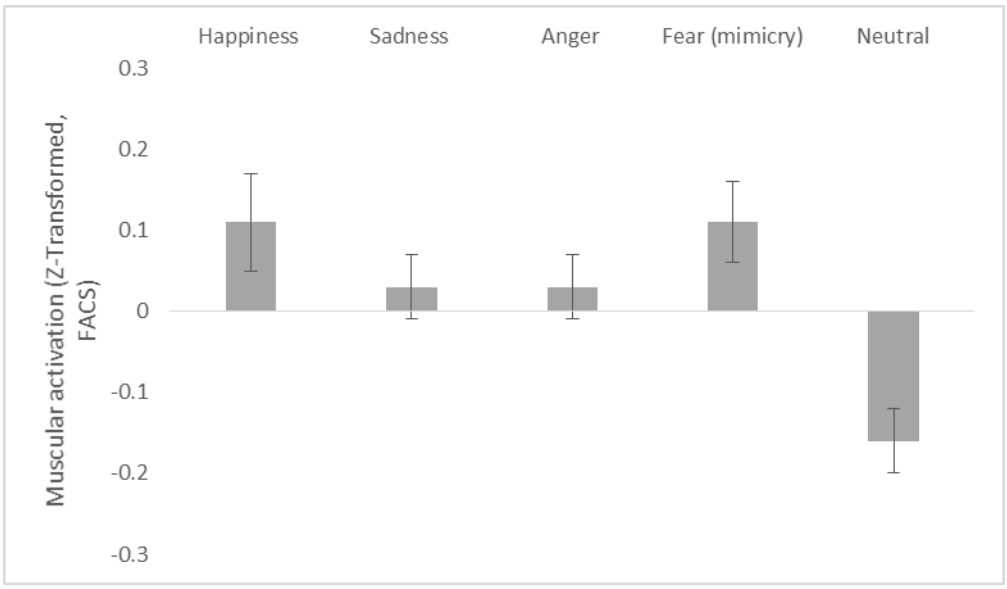

Figure 3: Emotional activation for Fear displays.

Figure 4: Emotional activation for Anger displays.

Analysis of complemental facial expressions for mimicry of anger

When individuals were displayed anger, they showed mimicry of anger accompanied by other complemental facial expressions such as fear, sadness and happiness (Figure 4). Considering the competitive nature of anger vs. other shown emotions, we consider that anger would trigger stronger complemental facial expressions such as fear, sadness and happiness to keep safe the relationship between the mimicker and the mimicked and preserve affiliation. A planned contrast was designed to assess if there is stronger happiness response when seeing an angry face compared to neutral facial expressions (0, 0, 1, 0, -1). Results showed that individuals show stronger happiness facial expression when seeing an angry vs. neutral face, F (1, 43) = 3.97, p = .05, η^2 = 0.08, for anger emotional display: $M_{Happiness}$ = -.07; SD = 0.22; for neutral emotional display: $M_{Happiness}$ = -.17; SD = 0.22. A similar planned contrast was designed to assess if there is stronger sadness response when seeing an angry face compared to a neutral facial expressions (0, 1, 0, 0, -1). Results showed that individuals do not show stronger sadness facial expression when seeing an angry vs. a neutral face, F (1, 43) = 1.66, p = .21, η^2 = 0.04; for anger emotional display: $M_{Sadness}$ = .10; SD = 0.37; for neutral emotional display: $M_{Sadness}$ = .01; SD = 0.41. Finally, a similar planned contrast was designed to assess if there is a stronger fear response when seeing an angry face compared to a neutral facial expressions (0, 0, 0, 1, -1). Results showed that individuals do not show stronger fear facial expression when

seeing an angry vs. a neutral face, F (1, 43) = 0.13, p = .73, η^2 = 0.00; for anger emotional display: M_{Fear} = -.06; SD = 0.27; for neutral emotional display: M_{Fear} = .02; SD = 0.32.

Need to belong and mimicry

To assess how need to belong affects facial mimicry we ran a Repeated Measures GLM with 2 within-subject factor analysis: 5 (emotion displayed: anger vs. sadness vs. happiness vs. fear vs. neutral facial expression) x 5 (emotion assessed: anger vs. sadness vs. happiness vs. fear vs. neutral facial expression) with need to belong as covariate. The main effect of emotion displayed, F (3.56, 149.60) = 1.29, p = .28, η^2 = 0.03, and emotion assessed, F (2.69, 113.02) = 0.203, p = .88, η^2 = 0.01, did not reach the level of significance. Contrary to expected, the interaction between *emotion displayed x emotion assessed*, F (10.25, 430.37) = 0.76, p = .67, η^2 = 0.02, and the interaction *emotion displayed x emotion assessed x need to belong*, F (10.25, 430.37) = 0.56, p = .84, η^2 = 0.01, did not reach the level of significance. Moreover, correlational analysis showed no significant relation between facial mimicry and need to belong across the displayed emotions (Table 3).

Empathy and mimicry

A similar analysis was conducted to assess how emotional empathy affects facial mimicry: a similar Repeated Measures GLM with emotional empathy as covariate was run. The main effect of emotion displayed, F (3.55, 149.21) = 1.32, p = .27, η^2 = 0.03, did not reach the level of significance. The main effect of emotion assessed, F (2.75, 115.64) = 2.15, p = .08, η^2 = 0.05, was marginally significant. As expected, the interaction between *emotion displayed x emotion assessed*, F (10.19, 427.78) = 1.91, p = .04, η^2 = 0.04, and the interaction *emotion displayed x emotion assessed x emotional empathy*, F (10.19, 427.78) = 2.00, p = .03, η^2 = 0.05, reached the level of significance. Emotional empathy seems to improve facial mimicry as correlational analysis have shown significant positive relation between facial mimicry of anger and emotional empathy, however, a marginally significant negative relationship between mimicry of sadness and happiness and emotional mimicry was found (Table 2). These puzzling results do not show a clear relation between facial mimicry and emotional empathy.

A similar analysis was conducted to assess how cognitive empathy affects facial mimicry. The main effect of emotion displayed, F (3.63, 152.45) = 0.92, p = .45, η^2 = 0.02, did

not reach the .05 level of significance. The main effect of emotion assessed, F (2.80, 117.52) = 2.79, p = .05, η^2 = 0.06, was significant. Contrary to expected, the interaction between *emotion displayed x emotion assessed*, F (10.27, 431.44) = 0.99, p = .46, η^2 = 0.02, and the interaction *emotion displayed x emotion assessed x cognitive empathy*, F (10.27, 431.44) = 1.06, p = .40, η^2 = 0.03, did not reach the level of significance. Moreover, correlational analysis showed no significant relation between facial mimicry and cognitive empathy across the displayed emotions (Table 3).

Correlational analyses were performed to study the relationship between empathy, emotional decoding and facial mimicry. Table 4 shows that no relation between empathy, need to belong and emotional decoding was found. Table 5 shows that no relation between facial mimicry and emotional decoding was found.

Table 3:
Correlations between empathy, need to belong and facial mimicry of each emotion displayed.

	Mimicry Happiness	Mimicry Anger	Mimicry Sadness	Mimicry Fear	Emotional Empathy	Cognitive Empathy	Need do Belong
Mimicry Happiness	---						
Mimicry Anger	-.03	---					
Mimicry Sadness	.01	-.02	---				
Mimicry Fear	-.14	.29^{+}	.23	---			
Emotional Empathy	-.27^{+}	.35**	-.28^{+}	.01	---		
Cognitive Empathy	-.13	.03	-.1	.08	.62***	---	
Need to Belong	-.14	.1	.01	-.21	.31*	.12	---

Note: $^{+}p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 4:
Correlations between empathy, need to belong and emotional decoding of each emotion displayed.

Decodings	Happiness	Anger	Sadness	Fear
Emotional Empathy	-.09	-.08	.14	.24
Cognitive Empathy	.10	-.10	.19	.14
Need to Belong	.11	.25^{+}	.24^{+}	.08

Note: $^{+}$ $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

The emotional decoding refers to the matching between the emotional decoding and the displayed emotion. For instance the decoding of happiness refers to the degree individuals rated the emotional display of happiness as happy.

Table 5:
Correlations between facial mimicry and the emotional decoding of each emotion displayed.

Decodings	Happiness	Anger	Sadness	Fear
Mimicry Happiness	-.05			
Mimicry Anger		.004		
Mimicry Sadness			.44	
Mimicry Fear				.54

Note: $^{+}$ $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Discussion

In this study we studied how facial mimicry of happiness, fear, sadness and anger is characterized, and how it is related to affiliation and emotional decoding. Mimicry is defined differently depending of the theoretical approach. While Epistemic theories suggest that mimicry is defined as a congruent mirroring of facial muscular activations during an interaction to promote emotional decoding (e.g., Seibt, et al., 2015, e.g., *Perception-behavior link*, Chartrand & Bargh, 1999; *Embodied Simulation Theory*, Gallese, 2009), the interpretation theory suggests that mimicry is the mirroring of what is understood and not the mirroring of facial muscular activations. According to interpretation theory, only affiliative emotions (e.g., happiness) are mirrored, while competitive emotions (e.g., anger) are not mimicked because

they do not promote affiliation (Hess & Fischer, 2014, 2016). These concurrent definitions of mimicry bring a challenge for the understanding of what is facial mimicry, but also to the understanding of facial mimicry's functions. We therefore designed a study to assess how facial mimicry is characterized. We expected to find (a) congruent muscles' activation related to the emotion displayed and (b) the activation of other muscles related to possible complemental emotions. We consider that the congruent muscle's activation would be related to the emotional decoding, while the complemental emotions would be related to affiliation. Moreover, we expected to find a stronger need to belong and empathy related to facial mimicry. Also, we expected that if facial mimicry has an epistemic function, then facial mimicry would be positively related to emotional decoding.

Our results showed that happiness, fear and anger were strongly mimicked, whereas sadness was not mimicked. The results also revealed that individuals showed other facial expressions while watching the videos. These other emotional responses may be considered complemental or responsive emotional expressions in response to the emotional display. For instance, when seeing a fearful face participants mimicked fear, but also showed happiness, sadness and anger. Mimicry of happiness occurred accompanied by sadness displays. Finally, while seeing an angry face individuals mimicked the angry face, but also showed strong activity for sadness and fear.

Results clearly showed that facial mimicry is not a mere congruent facial muscles' activation, nor just the mimicry of what was understood. Facial mimicry seems to be part of an integrative response that combines both congruent facial muscles' activation and a responsive action, because mimicry seems to be always accompanied by complemental facial expressions that most likely are triggered by what was understood and the need for affiliation. Thus, it seems that facial mimicry is at the same time an epistemic mechanism and a social response characterized by the expression of the congruent mirroring of muscular facial activation related to the emotion visualized, plus other emotions that can be complemental to the visualized emotion.

This new study brings light to both the epistemic and affiliation function of facial mimicry. Facial mimicry seems to have an emotional decoding and epistemic role due to the congruent mirroring of facial muscles' activation. Facial mimicry seems to have an affiliation purpose as individuals do show other muscles' activation related to complemental emotions that may signal social appeasing. This would be particularly relevant for competitive emotions, as those emotions do not promote affiliation by themselves. For instance, in the case of anger individuals show fear and sadness while they mimic anger. This may be a sign of social

appeasement to avoid conflict escalation (Häfner & IJzerman, 2011). Surprisingly no relation between facial mimicry and empathy and facial mimicry and need for belonging was found, with one exception. Mimicry of anger was positively related to empathy. Interesting preliminary research has shown that stronger emotional empathy is related to a better understanding of anger (Nesbitt, 2017). These results could suggest that mimicry in the case of anger serves rather as a decoding mechanism than as an affiliation mechanism. Nevertheless, this evidence is still very preliminary, and further studies are necessary. Despite the absence of relation between facial mimicry and need to belong, the facial evidence of complemental emotional expressions that could act as an affiliative mechanism suggests that facial mimicry may have an affiliative function and facilitate belonging to a group. The absence of a relation between empathy, facial mimicry, and emotional decoding was also surprising. This result suggests that empathy and facial mimicry are not mandatory for emotional decoding, as the emotion can be caught through other channels (Hess & Fischer, 2013), although we cannot exclude that facial mimicry and empathy are not necessary for emotional decoding as several studies suggest that blocking facial mimicry impairs emotional decoding and experience (e.g., Coles, et al., 2017, 2019; Oberman, et al., 2007; Lewis, 2018; Niedenthal, 2007).

Future directions

The results suggest a need for a better facial mimicry assessment. For instance in electromyography and FACS studies it would be interesting to analyze not only the congruent mirroring muscles or AUs, but also analyze the activation of possible complemental muscles or AUs to learn about complemental emotions. New studies assessing facial mimicry with FaceReader or similar software are highly recommended. To the best of our knowledge, our study was the first attempt to engage in a more comprehensive analysis and characterization of facial mimicry, thus more studies of a similar kind are desirable. Moreover, we would also recommend studies considering different cultural settings as the need to affiliate is culturally grounded and even mimicry behaviors seem to vary across cultures (Markus & Kitayama, 1991; van Baaren et al., 2003).

CHAPTER 5

Chapter 6

Facial mimicry in intergroup relations: a meta-analytic review and an attempt to understand the affiliative nature of facial mimicry

Abstract

Some authors claim individuals mimic facial expressions to understand and to affiliate with the expresser. However, a close look at the literature shows limited evidence for these claims. Considering that facial mimicry evolved for affiliation, then we should expect that not all individuals are equally mimicked. In the domain of intergroup relations, we expect to find stronger facial mimicry towards ingroup members than outgroup members. To verify this claim of facial mimicry for affiliation, a meta-analysis was conducted to test the reliability of the group membership effect on facial mimicry. Results show surprising heterogeneity. As expected, stronger facial mimicry was found towards ingroup members than outgroup members, however, the effect was only reliable for facial mimicry of anger. Emotions such as sadness, happiness and fear are equally mimicked irrespective of group membership of targets. Variables such as country of data collection and method of facial mimicry assessment were tested as moderators of the effect. The evidence of publication bias calls for new studies and better understanding of the phenomena moderating facial mimicry in intergroup relations.

Keywords: unconscious facial mimicry, group relations, intergroup facial mimicry, emotions, anger

CHAPTER 6

Facial mimicry in intergroup relations: a meta-analytic review and an attempt to understand the affiliative nature of facial mimicry

Expressing feelings and emotions is part of a daily life but understanding them is sharing a cognitive and behavioral experience with others. A subtle process that probably facilitates communication and understanding between individuals is mimicry. Mimicry is the automatic and unconscious mirroring of facial, vocal or postural expressions of other people (Chartrand & Lakin, 2013; Duffy & Chartrand, 2015; van Baaren, Janssen, et al., 2009). It occurs when at least two people unconsciously engage in the same behavior during an interaction (Cacioppo, et al., 2014). Mimicking people smoothens social relations: it improves social communication (Chartrand & Bargh, 1999; Duffy & Chartrand, 2015; Guéguen, et al., 2009), empathy, and cooperation (Barsalou, 2008; Chartrand & Lakin, 2013; Iacoboni, 2009; Lakin & Chartrand, 2003), and it increases liking and affiliation between people (Chartrand & Bargh, 1999; Kavanagh & Winkielman, 2016). Therefore, mimicry has been suggested to be a 'social glue' (Lakin, et al., 2003) due its positive outcomes for social relations. Moreover, mimicry can be affected at least to some extent by the characteristics of the relationship and the people involved in it. Mimicry has been suggested to be larger in tighter relationships and for positive emotions (Bourgeois & Hess, 2008; Fischer & Hess, 2014), when there is a goal to affiliate (e.g., Lakin, et al., 2008), and when there is perceived similarity between people (e.g., Guéguen & Martin, 2009), such as, the group membership (e.g., Kavanagh & Winkielman, 2016). These findings have inspired the elaboration of several theories to understand the functions of mimicry and how social context may predict mimicry.

The current meta-analytical review aims to clarify how facial mimicry varies in the intergroup context. Facial mimicry is the automatic and unconscious mirroring of emotional facial expressions between at least two individuals, almost simultaneously (e.g., Duffy & Chartrand, 2015; Seibt, et al., 2015). Facial mimicry is considered to work in favor of emotional decoding and affiliation; however, while there seems to be some evidence for the epistemic function, the same is not true for the affiliative function (Murteira & Waldzus, 2019a). We consider stronger facial mimicry of ingroup than of outgroup members in intergroup relations as a proxy for the often claimed affiliation function, as would be expected to find stronger affiliative behaviors among ingroup members than in intergroup context (e.g., Kavanagh & Winkielman, 2016). Therefore, by assessing facial mimicry in intergroup relations we intend to shed some light on the affiliative function of facial mimicry. The current meta-analysis

examines whether people mimic ingroup members more than outgroup members. Some studies have shown larger facial mimicry towards ingroups than outgroups (e.g., van der Schalk et al., 2011), while others have not (e.g., Sachisthal, et al., 2016). Different research methods to assess facial mimicry have been applied, and not all studied social groups are the same; some groups are marked by social differences, such as ethnicity, while others are marked by preferences, such as sport clubs. The social complexity of the group is likely to influence the group membership effect on facial mimicry, for instance interacting with people from different ethnicities and people from different sport clubs does not imply the same social history and severity of conflicts between groups, therefore, the willingness to affiliate with ingroup and outgroup members could change based on the history of the social groups in study (Blocker & McIntosh, 2017).Thus, it is important to understand whether the effect of group membership on facial mimicry is reliable, and how the different methods of assessment and the type of social groups impact the effect. To set the stage for the empirical analysis, we will briefly discuss theories of mimicry that predict the group membership effect on facial mimicry.

Theories of mimicry

Several theories were advanced to explain the function of mimicry for social relations. Three main theoretical branches can be distinguished: theories that consider mimicry a) as an epistemic mechanism, b) as an epistemic mechanism moderated by social context to promote affiliation, or c) as an affiliation mechanism. While the first one assumes that mimicry is a form of simulation of other people's mind as an epistemic mechanism, the latter two suggest that social variables play a role in mimicry, which renders mimicry not always desirable, but conditioned by social context. Despite the recognition of social context influences, the second branch assumes, like the first branch, that mimicry is a form of simulation; nevertheless, not all people are equally mimicked. The third branch assumes that mimicry is not necessary for understanding, that is, it has no epistemic function, but is rather an affiliative mechanism.

Epistemic Theories suggest that mimicry works as a form of simulation between two different minds to promote understanding between individuals. Neural support for an epistemic function is probably provided by the identification of the Mirror Neuron System (MNS), which allows a neural simulation of other persons' neural activity (Galesse, 2009; Niedenthal et al., 2010). This simulation facilitates the communication between people because it brings better insights about other peoples' desires and intentions during interactions (Wang & Hamilton, 2012). Mimicry is suggested to be a *perception behavior link* that increases the odds of a

behavior occurrence after seeing it, which leads to a better understanding and affiliation among individuals (Chartrand & Bargh, 1999; later named *Matched Motor Hypothesis by* Hess & Fischer, 2013). For the mimicking of emotions, the *Facial Feedback Hypothesis* suggests that facial movements are fundamental to perceive and experience emotions (e.g., Coles, et al., 2017, 2019). This simulation of matching muscles' movements helps in the creation of experiences that are associated with the emotions visualized in the expresser. This speaks for the idea that the facial mimicry of facial expressions is a simulation of other persons' emotional expressions with an epistemic purpose. No intergroup differences would be expected on the extent of facial mimicry. The lack of proximity and familiarity between ingroup and outgroup members could change the facial mimicry needs towards outgroup members. For the understanding of outgroup members, facial mimicry might be more important than for the understanding of ingroup members, because individuals share more experiences and contexts with ingroup members than with outgroup members. Therefore, individuals can more easily project what an ingroup member feels compared to an outgroup member, which would be translated in a decrease of the difference on facial mimicry extent between groups.

Social context theories emphasize that facial mimicry is not only in service of an epistemic function, but also in service of affiliation, which would naturally be dependent on the relations between the individuals involved in the interaction. Several theories were developed: *Social Top Down Response Theory (STORM)* (Wang & Hamilton, 2012), *Implicit Socialization Account Theory (ISAT)* (Kavanagh & Winkielman, 2016), and *Associated Reactions to Action in Context Model* (ARAC) (Stel, et al., 2016). Each theory proposes a different approach that could help understand why ingroup members would be more mimicked than outgroup members.

According to the *Social Top Down Response Theory (STORM*), mimicry is a social strategy to improve one's own position and status in the social world (Wang & Hamilton, 2012). Individuals mimic those that bring advantages for them, especially if they are in a risky situation. Thus, mimicry is not a pure decoding mechanism, but is also an affiliation mechanism, in which the decoding could be in the service of that affiliation. Other theories emphasize the learning experiences in mimicry processes. Rather than having mimicry solely driven by affiliation goals, or by status goals, mimicry is a learning process that helps in the production of the relevant responses for each social context. The *Implicit Socialization Account Theory (ISAT)* (Kavanagh & Winkielman, 2016) suggests that mimicry is a learning mechanism, where individuals mimic those from whom they learn the relevant social behaviors, namely other ingroup members. Larger facial mimicry towards ingroups vs. outgroup members

is expected as facial mimicry plays a role in socialization to learn the adequate responses and how to behave amongst ingroup members. Thus, facial mimicry of outgroup members would be limited because it does not bring advantages to interact with ingroup members. The *Associated Reactions to Action in Context Model* (ARAC) (Stel, et al., 2016) considers that mimicry is not a learning mechanism, but a process that is conditioned by previous learnt experiences. This theory suggests that mimicry is facilitated or attenuated as function of past learning experiences. Mimicry is facilitated if it brings benefits, according to what was learnt in the past, becoming an automatic response in that context. However, mimicry is attenuated or undermined if it is damaging or related to a punishment. The automaticity of mimicry is modulated by personal experiences, thus, the mimicry response will vary between individuals based on the learnt associations across different contexts and over time. Thus, ARAC theory would not predict differences on facial mimicry between groups depending on the past experience and rewarding effect of past facial mimicry in similar situations.

Altogether, the *social context theories* predict stronger facial mimicry towards ingroup members than outgroup members. A stronger need to affiliate with and to learn from ingroup members as compared to outgroup members would drive this difference in mimicry in an intergroup context.

Finally, the *Mimicry in Social Context Theory* (MSCT) (Hess & Fischer, 2013) considers that facial mimicry is an affiliation mechanism rather than an epistemic mechanism. This theory was originally formulated considering facial mimicry only. However, it can be extended to all sorts of sensitive channels, according to its authors. Instead of having facial mimicry in service of an epistemic function, individuals mimic what they understand. Thus, mirroring facial expressions is determined by a previous understanding of those expressions that is not dependent on a mental/physical simulation. According to this theory, individuals aim to mimic in order to regulate the relationships with others and not to simulate their mental states. The main motivation would be to give the proper response for each social situation and to foster affiliation. Thus, not all emotions would be mimicked equally. This approach would predict that only affiliative emotions are mimicked due to the negative consequences that the facial mimicry of non-affiliative (e.g., competitive) emotions would have for affiliation. Facial mimicry of emotions such as anger and disgust would be unlikely to avoid the escalation of violence or conflict (Bourgeois & Hess, 2008; Fischer, et al., 2012; Hess & Fischer, 2013). Some authors have suggested that facial mimicry of anger is not expected, especially among ingroup members, as this emotion signals an attack or criticism (Roseman, Wiest, & Swartz, 1994; Bourgeois & Hess, 2008; Fisher, et al., 2012; Hess & Fisher, 2014). Anger is a natural

response towards an attack or frustration that aims to surmount the source of unpleasantness or an obnoxious situation (Ekman, 2007). Anger is related to conflict resolution (Izard, 1992) and to defensive initiatives (Berkowitz, 1990) to improve safety (Bowlby, 1973). Therefore, anger signals the intention not to affiliate with the other (Bourgeois & Hess, 2008) and its facial mimicry would be undermined (Hess & Fischer, 2014). Considering the affiliative nature of facial mimicry then we could expect that only affiliative emotions, such as happiness and sadness are mimicked, compared to competitive emotions, such as anger and pride (Hess, et al., 2016). Also, we could expect to find stronger facial mimicry of ingroup members than outgroup members due to people's best interest in affiliating with ingroup members (e.g., Kavanagh & Winkielman, 2016).

Facial mimicry in intergroup relations

Given the assumptions of the theoretical approaches described above, in intergroup contexts facial mimicry may vary as a function of the group membership of the mimicked person. The reason is that individuals should have less interest to affiliate with outgroups members than with ingroup members, or less interest to learn how to behave in ingroup contexts from facial mimicry of outgroup members than from facial mimicry of ingroup members. Moreover, the positive experiences during ingroup interaction should facilitate the facial mimicry towards ingroups vs. outgroups. Indeed, several studies point to larger facial mimicry towards ingroup members than outgroup members (e.g., Bourgeois & Hess, 2008; van der Schalk, et al., 2011). However, some recent studies (most of them unpublished at the moment of this review) have shown larger facial mimicry towards outgroups than ingroups (e.g., Wessler & van der Schalk, 2016), and others have shown absence of any group membership effect for facial mimicry (e.g., Sachisthal, et al., 2016). These unexpected results contribute to doubts about the group membership effect on facial mimicry and raise the question on how intergroup context actually shapes facial mimicry, and how facial mimicry is related to affiliation.

Little is known about under what conditions such intergroup differences in facial mimicry occur. Some of the studies have proposed to study moderators and mediators of the group membership effect on facial mimicry (please see Table 6). Social context variables such as liking (van der Schalk, et al., 2011), empathy (Mondillon, et al., 2007), and the type of emotions, positive vs. negative, (van der Schalk, et al., 2011) seem to moderate the larger facial mimicry towards ingroups than towards outgroups. More liking, empathy, and negative

emotions are associated with an increase of the difference in facial mimicry between ingroup and outgroup targets.

Another critical point that may influence if such intergroup difference in facial mimicry occurs is the methodology applied to assess mimicry (please see Table 2 for an overview of methods). Facial mimicry studies have generally applied facial electromyography (f-EMG) to measure facial mimicry, however other methodologies were also applied such as Facial Action Coding System (FACS) and the Time bisection task. All methodologies have been criticized for their lack of reliability and validity (for a summary of its methods and its pros and cons, please see Table 7, for a review please see Murteira & Waldzus, 2020c). Criticisms have also been directed to f-EMG due to the meaning attributed to specific muscles' movements. For example, the use of f-EMG in the assessment of emotions such as anger may lead to erroneous conclusions, because high *Corrugator Supercilii* activity may not necessarily be due to anger, but to attentional processes, annoyance, fear or sadness (Ekman, 2003; Seibt, et al., 2015). FACS could be criticized for the meaning attributed to muscles' movements as well. FACS groups facial muscles into Action Units (AU) that are evaluated to assess the emotional state of the individual. Only one AU at a time is assessed to measure facial mimicry; however, each emotion is composed by several AUs. Their interpretation may thus be biased, as the same AU is associated with different emotional displays, and the same emotion may elicit different facial patterns (Ekman, et al., 2002). Finally, the Time bisection task is an indirect measure of facial mimicry. Participants estimate how long a picture of an emotional facial expression is presented on the screen. Negative emotional facial expressions such as anger and fear are estimated to last longer than neutral ones, thus, longer time estimates are related to higher mimicry levels for negative emotions (Mondillon, et al., 2007).This method raises validity concerns when it is used for facial mimicry assessment, because it is unclear if the larger time estimation is indeed due to a facial mimicry process. A moderator analysis to assess how the method of assessment of facial mimicry affects the group membership effect on facial mimicry is recommended.

Finally, another critical point to consider in the study of facial mimicry in intergroup relations is the type of social groups used in the studies. Studies have applied social categories with different social relevance. Two main types of groups can be identified: real-World incidental groups such as sport teams and college majors, and real-World socially consequential groups such as those based on religion, political affiliation and race (Blocker & McIntosh, 2017). It would be plausible to assume that the type of group has an influence on the group membership effect on facial mimicry. The more complex the group is, the more other factors such as attention, affiliation and emotional valence may contribute to the extent of facial

mimicry (Blocker & McIntosh, 2017). Thus, it is unclear how facial mimicry is affected across studies due to differences in the type of social groups assessed. A moderator analysis to assess how the type of social groups affects the group membership effect on facial mimicry is therefore recommended.

Table 6:
Mediator and moderators of higher mimicry towards ingroups than outgroups.

Study	Design	Mediators and Moderators	Conclusion
Mondillon, et al. (2007).	**1st Study** n= 43 female IV: 2 emotions (anger vs. neutral) x group membership (ingroup: Caucasian vs. outgroup: Chinese) within-subject design. DV: time perception, over-estimation of time indicates higher levels of mimicry **2nd Study** n= 41 female IV: 2 emotions (anger vs. neutral) x group membership (ingroup: Chinese vs. outgroup: Caucasian) within-subject design. DV: time perception, over-estimation of time indicates higher levels of mimicry.	**1st Study** Measure of Empathy. **2nd Study** Measure of Empathy.	**1st Study** Higher mimicry of ingroup members compared to outgroup members. Group membership effect on mimicry is not moderated by empathy. High-empathy participants mimic ingroup members more than low-empathy participants, but not for the case of outgroup members. **2nd Study** No replication of the results. Chinese participants mimicked the angry faces of the ingroup and the outgroup members equally. These Chinese participants were immigrants in France, as immigrants they may feel a higher desire/need to affiliate with the outgroup members.
van der Schalk, et al. (2011).	**1st Study** n= 42 females IV: 3 emotions (anger vs. happiness vs. fear) x 2 group membership (ingroup: Psychology student vs. outgroup: Economics student) within-subject design. DV: Mimicry of the facial expressions presented in the photos performed by ingroup or outgroup members (f-EMG). **2nd Study** n= 153 females IV: 2 emotions (anger vs. happiness vs. fear) x 2 group membership (ingroup: Dutch vs. outgroup: non-Caucasian) between-subject design. DV: Mimicry of the facial expressions presented in the videos performed by ingroup or outgroup members (FACS).	**1st Study** Measure of Liking before and after manipulation. Score of Liking based on friendliness and positivity-negativity of the model (1= disliking; 7= liking). **2nd Study** Emotion displayed. Social category. Liking.	**1st Study** Higher mimicry of ingroup members compared to outgroup members. Participants showed equal amounts of mimicry towards outgroups versus ingroup members in happiness displays. **2nd Study** Higher mimicry of ingroup members compared to outgroup members. There are no differences in happiness displays grounded on group membership. Group membership moderates the effect of mimicry. The effect of social category on liking is not moderated by the display of emotion. The effect of social category on mimicry is moderated by the emotion display. Obs. Outgroup members included Moroccans, Surinamese, Africans and Indonesians.

Table 7:
Methodologies to measure facial mimicry.

Method	Description	Pros and Cons
f-EMG	Electric activity measurement of selected facial muscles to assess emotions (Huang, et al., 2004), such as *Corrugator Supercilii* to assess anger, sadness and *Zigomaticus Major* to assess happiness.	Pros Sensitive method to detect small muscle facial movements. Cons The electric muscle activity may be due to other emotions or feelings than the measured one. Assessment of one muscle per emotion. Uncomfortable for participants. Highly sensitive to environmental variables: sensitive to electric noise in the room.
FACS	Rate participants' facial expressions based on Facial Action Coding System. FACS organize human faces into muscles units called Action Units (AU). Participants' facial expressions are recorded and then manually coded (Ekman, et al., 2002) to assess mimicry.	Pros It allows the combination of various AUs to assess the mimicry of emotion. Low sensitivity to environmental variables may interfere with the measurement. Cons Need for three certified FACS coders to assess mimicry per study. Participants may notice that they are being recorded.
FaceReader	Rate participants' facial expressions based on Facial Action Coding System. Participants are recorded and then coded with FaceReader software (Noldus Information Technology, 2017).	Pros It allows the combination of various AUs to assess the mimicry of emotion. Automatic codification, thus it does not need certified coders. Cons Highly sensitive to environmental variables. Recording conditions are strict: light, contrast and face orientation has to be controlled. FaceReader may not be able to detect slightly muscles movements as mimicry. Participants may notice that they are being recorded.
Time bisection task	Measurement based on the estimate of time that each emotional facial expression is presented to participants. The longer the time estimated, the higher the mimicry towards each facial expression (Mondillon, et al., 2007).	Pros Quick and easy method to assess mimicry online and offline. Cons Uncertainty about the reliability of the method to assess mimicry.

Overview of the study

The effect size (ES) and reliability of the group membership effect on facial mimicry is not clear, and a variety of methods to assess facial mimicry were applied. In the current review we aim to test how the methods applied to measure facial mimicry moderate the ES. The file-drawer effect (Franco, Malhotra, & Simonovits, 2014; Rosenthal, 1979; Scargle, 1999) in social psychology may have biased the conclusions about facial mimicry in intergroup relations in published literature. Thus, it is justifiable to apply meta-analytical techniques to published and unpublished studies to better understand the group membership effect on facial mimicry and how social context shapes it.

First, we test the reliability of the group membership effect on facial mimicry: we expect a small ES of the group membership effect on facial mimicry, with larger facial mimicry towards ingroup members than outgroup members (Hypothesis 1). Regarding facial mimicry of specific emotions, we test whether there is larger mimicry towards ingroups than outgroups in sadness displays (Hypothesis 2), in fear displays (Hypothesis 3), and happiness displays (Hypothesis 4). We expected that mimicry of anger (Hypothesis 5), and disgust (Hypothesis 6) are not changed by the group membership, if facial mimicry aims for affiliation.

Second, some moderator hypotheses were tested. Type of social groups (Hypothesis 7), method of facial mimicry's assessment (Hypothesis 8), and country of data collection (Hypothesis 9) were tested as moderators of the group membership effect on facial mimicry. Finally, due to the substantial number of unpublished studies collected, we also tested for the presence of publication bias in this meta-analysis (Hypothesis 10).

Method

Operationalization of facial mimicry

We define facial mimicry as a form of automatic and unconscious mirroring of other people's facial emotional expressions. Facial mimicry can only be measured and not be given as an instructed task to participants because of its' automatic and unconscious character. Therefore, only studies that consider facial mimicry as an automatic and unconscious process

were included in the study. All studies that instructed participants to imitate were not considered in the present study[5].

Inclusion criteria

To analyze the reliability of the group membership effect on facial mimicry several inclusion criteria were developed:

Criterion 1. As our focus is on the relationship between group membership and facial mimicry, only empirical studies in which group membership was manipulated as the independent variable and facial mimicry was assessed as the dependent variable were considered. Each study should have at least one measurement of facial mimicry towards ingroups or outgroups. We included studies that imply facial mimicry measurement towards specific social categories that could be considered as a form of group membership (e.g., ethnic groups, sport teams, political believes). Studies considering robots for outgroup members were excluded.

Criterion 2. Each study should have a clear cut result that allows to compare the extent of facial mimicry of ingroup members with facial mimicry of outgroup members, even if this comparison was not the first purpose of the study. To obtain the estimate of the effect size (ES) for each emotion, we contacted the authors of studies that only reported the main effect of group membership on facial mimicry but did not disclose the effect for each emotion in the manuscript.

Criterion 3. Only studies with non-clinical participants were considered for analysis; studies conducted with participants diagnosed with autistic spectrum disorder, schizophrenia, dementia, personality disorders, and Attention Deficit Hypersensitivity Disorder (ADHD) were

5 Mimicry and automatic imitation studies have been considered to share the same theoretical background; however, the nature of the methodologies involved to assess each form of mirroring are different. In automatic imitation studies participants are aware of the task, they are explicitly instructed to imitate a sequence of actions, such as facial expressions, while in mimicry studies they are only instructed to visualize the facial expressions.
Our review is only about studies on mimicry. Recently some authors have pointed out that mimicry and automatic imitation are probably two different concepts despite the fact that they are related (Genschow, et al., 2017; Murteira & Waldzus, 2020c). The instruction to imitate imposes extra cognitive demand, which is not present in mimicry studies, that can have an influence in social interactions (Stel, Dijk, & Olivier, 2009). Thus, this review will only consider mimicry studies that do not involve such possible cognitive demands in the process in order to avoid their possible interference with the group membership effect on mimicry. Please note that sometimes the terms mimicry and automatic imitation are used interchangeably in the literature. The current meta-analysis only covers mimicry as an automatic and unconscious mirroring, even if the author use the term mimicry, but refer to automatic imitation or use the term automatic imitation but refer to mimicry. Thus, the distinction that served as inclusion criterion is based on the applied methodology and does not rely on terminology. All studies that instructed participants to mirror behaviors were excluded.

not considered. Facial mimicry is a social process; thus, we considered that facial mimicry from clinical participants would not be representative of the norm in the general population. Due to social disorders, they show specificities in facial mimicry behavior (for a review of the impact of each condition on facial mimicry please see Duffy & Chartrand, 2015).

Criterion 4. Only studies that did not prescribe any substance (e.g., oxytocin) or placebo before the facial mimicry measurement were considered. Studies that applied oxytocin were excluded, as oxytocin artificially increases the need for bonding (Carter, Williams, Witt, & Insel, 1992) with implications for the extent of facial mimicry (Korb, Malsert, Strathearn, Vuilleumier, & Niedenthal, 2016).

Criterion 5. Only studies with human beings as participants, and as ingroup and outgroup targets were considered; studies with robots or animals were excluded from analysis.

Several unpublished studies were included in the analysis in order to account for possible publication bias. The unpublished studies considered in the analysis used similar methods to assess facial mimicry and similar stimuli to the ones used in published studies. Moreover, some of the unpublished studies were pre-registered.

Identification of the relevant studies

To find published and unpublished studies that meet these criteria a planned search procedure was used. Search for published papers was conducted by consulting relevant databases, covering all publications, such as papers, books and book chapters, from 1900 to 2017 systematized in PsycArticles, PsyInfo, Psychological and Behavioral Sciences Collection, b-on, and ISI-Web of Science, as well as UMI Dissertation Abstracts. To find the studies, a set of keywords were applied: mimicry/automatic imitation + social categorization; mimicry/automatic imitation + ingroup/in-group; mimicry/automatic imitation + outgroup/out-group; mimicry/automatic imitation + group membership; mimicry/automatic imitation + intergroup relations. We also have consulted the reference lists of the found papers, as well as reference lists of main paper reviews about mimicry, such as Hess and Fischer (2013), Chartrand and Lakin (2013) and Seibt and colleagues (2015). Additionally, we have consulted the handbook about facial mimicry from Hess and Fischer (2016) in order to find additional articles or book chapters. To find unpublished studies such as dissertations or unpublished papers, a call for unpublished studies was disseminated to members of social psychology associations, such as American Psychological Association (APA), American Psychological

Science (APS), European Association of Social Psychology (EASP), Society of Experimental Psychology (SESP), and Society for Personality and Social psychology (SPSP). The organizations that accepted our request, European Association of Social Psychology (EASP) and Society of Experimental Psychology (SESP), sent an email to all members describing the aim and criteria of this meta-analysis.

From the search on the databases 21132 results were retrieved, only 267 results were about facial mimicry in intergroup relations. Two hundred forty nine studies did not meet the inclusion criteria. Those studies did not fit our operationalization of facial mimicry, or used robots as outgroups, or administered drugs to participants, or were conducted among clinical samples, or did not reported sufficient statistical information to estimate the effect size. All duplicates were excluded. We included 14 papers (8 published, 6 unpublished) that fit the criteria to be included in the meta-analysis. From these papers, 20 studies were extracted.

Computation and analysis of the effect sizes (ES)

All papers that fit the criteria were carefully analyzed. The results considering the group membership effect on facial mimicry were extracted. Statistics such as descriptive statistics, means and standard deviations, *F*-tests, *t*-tests, and R^2 were extracted. Most of the studies do not report the effect size (ES), thus we derived them from other statistics by applying the conversion formulas provided by Lakens (2013) and the online Pratical Meta-Analysis Effect Size Calculator (Mark, Lipsey, & Wilson, 2001). The effect size for the *F*-tests was calculated applying the formula a), the formula b) was applied when data was from *t*-test, formula c) was applied when data was from a regression analysis, and formula d) was applied when data was from descriptive statistics.

a)

$$\eta_p^2 = \frac{F * df_{effect}}{F * df_{effect} + df_{error}}$$

b)

$$d_s = t\sqrt{\frac{1}{n1} + \frac{1}{n2}}$$

c)

$$r = \sqrt{R}$$

d)

$$d_s = \frac{\bar{x}_1 + \bar{x}_2}{\sqrt{\frac{(n_1 - 1)SD_1^2 + (n_2 - 1)SD_2^2}{n_1 + n_2 - 2}}}$$

Pearson's *r* was selected as the indicator of effect size because of its simplicity. All previous calculated effect sizes were converted to Person's *r*. Pearson's *r* varies between -1 and 1: for small effect size *r* >= .10 and *r* < .30; for medium effect size *r* >= .30 and *r* < .50; for large effect size *r* >= .50 (Statistics Solutions, 2017). A positive mean ES indicates that participants' mimicked ingroup members more than outgroup members, while a negative one indicates that participants mimicked outgroup members more than ingroup members. The absence of significant results was conservatively assigned to a value of *r* = 0 for the ES. The developed database has detailed comparisons for each study and for each emotion separately. We are aware that the presence of multiple tests per study violates the assumption of independence of the measures. However, it would not be possible to extract meaningful information for each type of emotion from the main effect of group membership on facial mimicry in studies.

The sampling method applied for the study of the group membership effect on facial mimicry is not probabilistic, thus the random effects model is appropriate for our analysis, rather than the fixed effects model. The random effects model postulates that part of the differences in the effect size across studies is random and due to unidentifiable sources, thus, the random effects model assumes that there is a distribution of true effects sizes and that the true effect size will be distributed around the mean. In contrast, the fixed effect model assumes that all studies have a common effect size and the reported differences among studies are due to sampling error (Hedges, 1992; Hedges & Olkin, 1985; Mark, Lipsey & Wilson, 2001; Rosenthal, 1995; Borenstein, et al., 2009; Borenstein, Hedges, Higgins, & Rothstein, 2010). As research about facial mimicry in intergroup relations has used different samples with different characteristics (e.g., age, gender, country, level of education), the mixed characteristics of samples will imply different effect sizes across studies due to the sampling methods, different populations from which these samples are drawn, characteristics of the sample and

methodology applied (Borenstein, et al., 2009). Thus, a random effects model is more appropriate to handle the heterogeneity of the studies in the analysis. Furthermore, a random effects model allows for the generalization of findings to the population, while a fixed effects model only applies the conclusions to the studies in analysis (Borenstein, et al., 2009).

Ratings of studies and samples

To develop the meta-analysis database we created a set of variables to rate the studies that fit the previous criteria. Those ratings included the date and source of publication, as well as the Journal Quartil, when applicable. All studies have applied an experimental design. Each study was rated as a within or between-subject design. We were interested in the clear-cut result of the group membership effect on facial mimicry. However, the presence of a manipulation prior to the facial mimicry assessment in some studies may have moderated the effect. Thus, we rated the studies according to the presence or absence of a prior experimental manipulation. Another indicator of research quality was the method used to measure facial mimicry (e.g., f-EMG, observational methods, stimulus time estimation, Facial Action Coding System; for more information about methods please see Table 7). Finally, participants' characteristics were collected to describe the sample: age, gender, geographical area of the study and the target groups involved in the study (ingroups and outgroups).

Statistical methods

To conduct analysis of the mean effect size (ES) with 95% confidence intervals we used the SPSS meta-analysis macro MetaES and MetaF developed by David B. Wilson (Wilson, 2006), which is based on Hedges and colleagues' method (Hedges, 1992; Hedges & Olkin, 1985; Hedges & Vevea, 1998). The mean ES was calculated weighting the sample size (MetaES macro) to guarantee that larger samples sizes contributed proportionally more to the final averaged ES. To test the hypothesis that there is a reliable effect of group membership on facial mimicry the *Z*-Test[6] was used (Borenstein, et al., 2009).

[6] The Z –Test (Borenstein, et al., 2009) assumes that the data distribution follow a normal distribution. The null hypothesis postulates that the mean ES of the group membership effect on mimicry equals zero (no differences between extent of ingroup and outgroup's mimicry). The *Z*-statistic test assumes that the statistical test of the null hypothesis is approximately normal, with a significance level of $p < .05$. Thus, when rejected on the level of $p < .05$ we assume that the alternative hypothesis is retained, which means that there are differences between ingroup and outgroup mimicry.

To test the variability of ESs across studies, homogeneity was calculated using Cochran's *Q* statistics[7]. Heterogeneity in meta-analysis means that there are significant differences across the analyzed studies, thus there is evidence of different ESs among the selected studies (DeCoster, 2004). To quantify that heterogeneity, we used the I^2 statistic (100% ((*Q* – df) / *Q*)) which represents the percentage of variability across the reported effect sizes that is due to heterogeneity and not to chance (Borenstein, et al., 2009; Huedo-Medina, Sánchez-Meca, Marín-Martínez, & Botella, 2006). To verify the nature of effect sizes' heterogeneity across studies a categorical moderator analysis (ANOVA) was applied (MetaF macro). Moderator analyses were conducted to evaluate how facial mimicry's method of assessment, type of emotions displayed, country, type of social groups, and whether the study is publish or not affects the ES for the group membership on facial mimicry. Some of these moderator analyses have less than 20 ESs, which may imply insufficient statistical power and unstable estimates with consequences for the final conclusions for each moderator (Marín-Martínez & Sánchez-Meca, 1998; Sánchez-Meca & Marín-Martínez, 1998). Despite these limitations, we decided to conduct the analysis and cautiously interpret the results since they are important moderator analyses for the purpose of this meta-analysis.

Results

The meta-analysis was applied to 20 studies with experimental design. The overall sample size from the collection of all studies was 1656 participants (age: *M* = 22.51; *SD* = 1.87), 56% females, 26% males, 18% unknown gender. The data was collected across 9 countries: Portugal, New Zealand, USA, Canada, France, Netherlands, Spain, Germany and Italy.

Assessing the group membership effect on facial mimicry

We expected stronger facial mimicry towards ingroups than outgroups (H1). From the analysis we concluded that the weighted mean effect estimated by the random effect model was

[7] *Q* statistics (Borenstein, et al., 2009) relies on a chi-square distribution with *k*-1 degrees of freedom, and is based on the distribution of the sum of the squared differences between each individual study effect and the pooled effect across studies. *Q* statistics aim to assess the homogeneity of each set of ESs. The null hypothesis postulates that there is homogeneity among the sample of studies selected for the meta-analysis, that is, that there is no variance in the difference between mimicry towards ingroups and outgroups. The rejection of the null hypothesis indicates significant heterogeneity among the selected studies, thus that there is variance in difference in mimicry between ingroups and outgroups.

significantly larger than 0 (ρ = 0.13, *SE* = 0.03, 95% CI = [0.06; 0.19]; *Z* = 3.81, *p* < .001, *k* = 63). Thus, there was a reliable effect of group membership on facial mimicry, with stronger facial mimicry towards ingroups than outgroups. However, there was also significant heterogeneity (*Q* = 301.59, *df* = 62, *p* < .001, I^2 = 79%). For instance, some studies applied an experimental manipulation other than the ingroup versus outgroup membership of the target before the facial mimicry assessment. A moderator analysis was conducted using a categorical meta-ANOVA to test the moderating effect of having vs. not having such previous experimental on the group membership effect on facial mimicry. Results showed that there is variance between those studies having vs. not having such previous manipulation on the group membership effect on facial mimicry (*Q* = 9.23, *df* = 1, *p* = .01, I^2 = 89%), which means that the group membership effect on facial mimicry was reliable only for studies that did not have such previous manipulation (ρ = 0.19, *SE* = 0.04, 95% CI = [0.12; 0.27]; *Z* = 4.93, *p* < .001, *k* = 42), while those studies with the previous manipulation do not show a reliable group membership effect on facial mimicry (*p* = 0.01, *SE* = 0.04, 95% CI = [-0.08; 0.09]; *Z* = 0.16, *p* = .87, *k* = 22). As this difference between studies with and without manipulation before mimicry might not be the only source of heterogeneity, we decided to conduct a more comprehensive moderator analysis.

Assessing how type of emotion affects the group membership effect on facial mimicry.

A moderator analysis was conducted using a meta-ANOVA to test the moderating effect of type of emotion (sadness vs. fear vs. happiness vs. anger vs. disgust) on the group membership effect on facial mimicry. Results showed that there is no variance between each type of emotion (*Q* = 0.95, *df* = 6, *p* = .99), which means that the group membership effect on facial mimicry does not vary based on the type of emotion mimicked. However, the lack of a significant moderation by type of emotion must be interpreted with caution, given the small number of studies entering the analysis. We therefore decided to analyse the ES of group membership effect separately for each type of emotion in order to test Hypothesis 2 (sadness), 3 (fear), 4 (happiness) 5 (anger) and 6 (disgust). Results showed that there was a reliable ES of the group membership effect on emotional displays of anger (ρ = 0.14, *SE* = 0.05, 95% CI = [0.03; 0.24]; *Z* = 2.48, *p* < .01, *k* = 21), but not on emotional display of happiness (ρ = 0.11, *SE* = 0.06, 95% CI = [-0.002; 0.22]; *Z* = 1.92, *p* < .05, *k* = 19), fear (ρ = 0.13, *SE* = 0.12, 95% CI = [-0.11; 0.37]; *Z* = 1.04, *p* = .29, *k* = 5), sadness, (ρ = 0.10, *SE* = 0.08, 95% CI = [-0.07; 0.26]; *Z* = 1.17, *p* = .24, *k* = 10) or disgust (ρ = 0.13, *SE* = 0.18, 95% CI = [-0.22;

0.48]; $Z = 0.72$, $p = .47$, $k = 2$). Thus, it seems that so far the evidence for a group membership effect on facial mimicry is only reliable for anger (Hypothesis 5) displays, but not any of the other emotions (Hypotheses 2, 3, 4 and 6). Yet, due to the small number of studies on facial mimicry of fear, sadness and disgust, results should be interpreted with caution. Thus, it cannot be concluded that the group membership does not exist for these other emotions. Theoretically relevant, however, is that there is not enough evidence yet to assume the existence of such a group membership effect on the facial mimicry of these emotions.

Assessing how type of social groups affects the group membership effect on facial mimicry.

A moderator analysis was conducted using a meta-ANOVA to test the moderating effect of type of social groups[8] (incidental vs. consequential) on the group membership effect on facial mimicry (Hypothesis 7). Results showed that there is no variance between each type of social group ($Q = 0.93$, $df = 1$, $p = .33$), which means that the group membership effect on facial mimicry does not vary based on the type of social group mimicked. However, when the ESs are analysed, only consequential groups are related to a group membership effect on facial mimicry ($\rho = 0.12$, $SE = 0.13$, 95% CI = [0.06; 0.19]; $Z = 3.67$, $p < .001$, $k = 60$, while incidental group are not ($\rho = 0.27$, $SE = 0.16$, 95% CI = [-0.03; 0.58]; $Z = 1.76$, $p = .08$, $k = 3$). However, the small number of studies using incidental groups do not allow for a conclusive conclusion about a possible moderation by the group type.

Assessing how facial mimicry measurement methodology affects the group membership effect on facial mimicry.

A moderator analysis was conducted using a meta-ANOVA to test the moderating effect of type of facial mimicry measurement methodology (f-EMG vs. FACS vs. implicit measure of facial mimicry with time estimation vs. FaceReader) on the group membership effect on facial mimicry (Hypothesis 8). Results showed that there is no significant variance between methodologies of measurement ($Q = 4.11$, $df = 3$, $p = .25$), which means that the group

[8] Type of social groups: 1) incidental groups "are often conceptualized as minimal groups, but that are based on actual social identities. Although incidental groups (e.g., college major, sport player) do not have clear histories of unequal opportunities in the social structure" (Blocker & McIntosh, 2017, page 403); 2) consequential groups "encompass groups with histories of clear differences in opportunities and social power (e.g., people of a different race, religion, political affiliation, or position of social power) (Blocker & McIntosh, 2017, page 406).

membership effect on facial mimicry does not vary between the different methods. However, when the ESs are analysed, results showed that the average significant effect size of the group membership effect of studies with f-EMG (ρ = 0.17, *SE* = 0.04, 95% CI = [0.09; 0.24]; *Z* = 4.51, *p* < .001, *k* = 47), but, for studies using FACS (ρ = 0.03, *SE* = 0.08, 95% CI = [-0.12; 0.18]; *Z* = 0.35, *p* = .72, *k* = 9),the implicit measure of facial mimicry with time estimation (ρ = 0.07, *SE* = 0.15, 95% CI = [-0.22; 0.35]; *Z* = 0.47, *p* = .67, *k* = 3), or FaceReader (ρ = 0.00, *SE* = 0.12, 95% CI = [-0.24; 0.24]; *Z* = 0.00, *p* = 1, *k* = 4) was not. However, each of the methods analyzed is misrepresented in the meta-analysis (*k* < 20) which may have shown low reliability in some methods that may not be true. Thus, due to the small number of studies on facial mimicry using each of the listed methods results should be interpreted with caution. Thus, it cannot be concluded that the group membership effect on facial mimicry does not exist when other methodologies are used to assess the effect.

Assessing how cultural background affects the group membership effect on facial mimicry.

A moderator analysis was conducted using a meta-ANOVA to test the moderating effect of country-of-data-collection (USA vs. Canada vs. Netherlands vs. France vs. Germany vs. Portugal vs. Italy) on the group membership effect on facial mimicry (Hypothesis 8). There is variance between the countries in the analysis (*Q* = 32.64, *df* = 6, *p* < .001, I^2 = 82%), which means that the group membership effect on facial mimicry varied across countries. Reliable effect sizes of the group membership effect on facial mimicry was found in studies conducted in Canada (ρ = .42, *SE* = 0.06, 95% CI = [0.31; 0.54]; *Z* = 7.00, *p* < .001, *k* = 10) and in the USA (ρ = .21, *SE* = 0.08, 95% CI = [0.05; 0.36]; *Z* = 2.58, *p* < .01, *k* = 6), but not for the Netherlands (ρ = .05, *SE* = 0.05, 95% CI = [-0.05; 0.15]; *Z* = 0.95, *p* = .34, *k* = 14), France (ρ = .11, *SE* = 0.15, 95% CI = [-0.20; 0.42]; *Z* = 0.71, *p* = .48, *k* = 2), Germany (ρ= .04, *SE* = 0.04, 95% CI = [-0.04; 0.12]; *Z* = 0.90, *p* = .37, *k* = 22), Portugal (ρ = .00, *SE* = 0.19, 95% CI = [-0.38; 0.38]; *Z* = 0.00, *p* = 1, *k* = 1), Italy (ρ = .07, *SE* = 0.11, 95% CI = [-0.14; 0.27]; *Z* = 0.61, *p* = .54, *k* = 8). However, due to the small number of studies on facial mimicry for some of the listed countries results should be interpreted with caution. Thus, it cannot be concluded that the group membership effect on facial mimicry does not exist in the countries where the effect was not found.

Publication bias analysis

From the overall analysis there is a small random effect size of group membership on facial mimicry. People mimic ingroup members more than outgroup members, however when the analysis was conducted by emotion no moderation effect was found. However, it is clear that some studies show higher facial mimicry towards ingroups while others show higher facial mimicry of outgroups (Table 8). In order to better understand this result, a publication bias analysis was conducted to check whether the group membership effect on facial mimicry is stronger for published than for unpublished studies (Hypothesis 10). The results showed a significant variance between published and non-published studies (Q = 9.40, df = 1, p < .01, I^2 = 89%). Reliable effect sizes of the group membership effect on facial mimicry was found in published studies (ρ = 0.21, SE = 0.04, 95% CI = [0.13; 0.29]; Z = 5.25, p < .001, k = 37), but not for the unpublished studies (ρ = 0.03, SE = 0.04, 95% CI = [-0.06; 0.11]; Z = .58, p = .56, k = 26). Thus, there seems to be a considerable publication bias involved in the group membership effect on facial mimicry.

Table 8:

Summary of the studies in the meta-analysis.

Author	Design	Mimicry measurement	*n*	Mimicry	Ingroup	Outgroup	*r*
Published studies							
Ardizzi, et al. (2014)	Within Subject	f-EMG	36		Teenagers	Adults	
Study1				Happiness			0
				Anger			.185
				Sadness			.108
			36	Fear	Adults	Teenagers	.227
				Happiness			0
				Anger			0
				Sadness			0
				Fear			0
Bourgeois & Hess (2008)	Within Subject	f-EMG	54	Anger	Political party	Other political party	.4126
Study1				Happiness			0
Bourgeois & Hess (2008)	Between Subject	f-EMG	60		Caucasian and Basketball player	African men	
Study 2				Anger			0
				Happiness			0
				Sadness			.301
Mondillon, Niedenthal, Gil, & Droit-Volet (2007)	Within Subject	Time Bisection Task	47	Anger	Whites	Chinese women	.2132

Study1							
Mondillon, Niedenthal, Gil, & Droit-Volet (2007)	Within Subject	Time Bisection Task	41	Anger	Chinese women	Whites	0
Study2							
van der Schalk, et al. (2011) Study 1	Within Subject	f-EMG	42	Anger Happiness Fear	Psychology student	Economics student	.462 0 .360
van der Schalk, et al. (2011) Study2	Between Subject	FACS	174	Anger Happiness Fear	Whites	Non-white (Moroccan, Surinamese, African, Indonesian)	.153 0 .08
Sachisthal, Sauter, & Fischer (2016)	Within Subject	FaceReader	67	Happiness Anger Sadness Fear	Deutsch	Moroccan	0 0 0 0
Hess & Bourgeois (2010) Study 1	Within Subject	f-EMG	96	Happiness Anger	Same sex	Same sex	.550 .670 .575 .495
Hess & Bourgeois (2010) Study 2	Within Subject	f-EMG	144	Happiness Anger	Opposite sex	Opposite sex	.650 .390
McHugo, Lanzetta, Sullivan, Masters, & Englis, (1985)	Within Subject	f-EMG	40	Zygomatic Corrugator	Political party	Other political party	0 -.470
McHugo, Lanzetta, & Bush (1941)	Within Subject	f-EMG	100	Zygomatic Zygomatic Corrugator Corrugator	Political party	Other political party	.388 .298 .297 .437

Unpublished studies							
Gentsch (2009) Study1	Mixed	f-EMG	61	Anger Happiness Sadness	European Female	Arabic men	.257 .251 .219
Hühnel & Hess (2016) Study1	Within Subject	f-EMG	40	Anger Happiness Sadness Disgust	Young people	Old people	.346 0 0 -
Kuzsyuski, Huhnel, Asendorpf, & Hess (2016)	Mixed	f-EMG	60	Anger Happiness Sadness Disgust	Young people	Adult people	.181 (Exclusion condition) -.471 (Partial exclusion) 0 (Exclusion condition) 0 (Partial exclusion) .329 (Exclusion condition) 0 (Partial exclusion) .532 (Exclusion condition) -.274 (Partial exclusion) -
Hühnel, Kuszynski, Hess, & Asendorpf (2016)	Between Subject	f-EMG	99	Happiness Anger	Young people	Old people	.195 0

Wessler & van der Schalk (2016) Study2	Between Subject	f-EMG	154	Anger	White	Non-White	0 (control condition) -.274 (experimental condition)
				Happiness			0 (control condition) .274 (experimental condition)
				Sadness			0 (control condition) 0 (experimental condition)
Wessler & van der Schalk (2016) Study1b	Between Subject	f-EMG	101	Anger	Whites	Non-white (Moroccan, Surinamese, African, Indonesian)	0 (control condition) 0 (experimental condition)
Wessler & van der Schalk (2016) Study 1a	Within Subject	f-EMG	100	Happiness	Whites	Non-white (Moroccan, Surinamese, African, Indonesian)	0 (control condition) -.199 (experimental condition)
Murteira (2016)	Within Subject	Time Bisection Task	79	Neutral Anger	Caucasian	Japanese	0 0

CHAPTER 8

Discussion

Mimicry is essential to understand another person's intentions and desires (Wang & Hamilton, 2012). Mimicry improves social cognition as it is related to empathy, understanding and cooperation between people (Barsalou, 2008; Chartrand & Lakin, 2013; Iacoboni, 2009; Lakin & Chartrand, 2003). However, despite all these rather universal advantages, mimicry has been suggested to be larger towards ingroup than outgroup members (e.g., Bourgeois & Hess, 2008; van der Schalk, et al., 2011) due to affiliation needs. As it remains unclear if the function of facial mimicry is affiliation (Murteira & Waldzus, 2020b), and given that the theoretical approaches that emphasize the social context (e.g., *Social Top-Down Response Theory*, Wang & Hamilton, 2012; *Implicit Socialization Account Theory*, Kavanagh & Winkielman, 2016; *Associated Reactions to Action in Context Model*, Stel, et al., 2016; *Mimicry in Social Context Theory*, Hess & Fischer, 2013) of facial mimicry predict stronger facial mimicry of ingroup than outgroup members, the group membership effect on facial mimicry could be used as a proxy to test the affiliative function of facial mimicry.

We aimed to assess the reliability of the group membership effect on facial mimicry to assess how facial mimicry is related to affiliation. The meta-analysis revealed a reliable small group membership effect for facial mimicry, providing evidence of stronger facial mimicry towards ingroup members than outgroup members. Categorical moderation analyses were conducted to disentangle the heterogeneity observed across the studies considered in the meta-analysis, but due to the small number of studies so far these moderation analyses were only partially conclusive. First, there was no significant moderation by type of emotion. Emotions such as happiness, sadness, fear, disgust and anger were considered to assess how facial mimicry varies across social groups. However, results are not completely clear when each emotion is considered in detail. The group membership effect was only reliable for anger. About the group membership effect on mimicry of disgust, sadness and fear there are no conclusive interpretations possible, because of the small number of studies so far.

Results have revealed that participants equally mimic *happiness* across the group boundaries for most of the studies, with the only exception of two studies (Gentsch, 2009; Hess & Bourgeois, 2010; see Table 8). The absence of differences is most likely due to the low social cost of mimicking positive emotions, as mimicking outgroup happiness has no negative consequences for the self or for the ingroup (Hess & Fischer, 2014). Indeed, it may have positive consequences for the self, such as outgroup respect and acceptance.

For *sadness* and *fear*, results revealed that larger facial mimicry towards ingroups vs. outgroups was reported across studies. Despite the promising evidence, the small number of studies do not show a reliable group membership effect across those emotions. The lack of effect is not conclusive as the small number of studies could explain the lack of effect. Some arguments can be drawn to expect larger mimicry of fear and sadness towards ingroup members than outgroup members. First, several authors have proposed that sadness is a high social cost emotion that would be reserved for closer individuals such as ingroup members due to the increased empathy towards them (e.g., Gordijn, Wigboldus, & Yzerbyt, 2001; Xu, Zuo, Wang, & Han, 2009; Cikara, Bruneau, & Saxe, 2011). Showing empathy towards an ingroup member would be related to a better acceptance within the group and guarantee support from group members in future interactions. Second, mimicking ingroup fear may work as a protective strategy towards a common threat, and therefore, bring social gains inherent to survival and self-protection. Though, it is important to consider that reduced facial mimicry of sadness and fear towards outgroups has also been explained by a schadenfreude mechanism towards outgroups (Boecker, Likowski, Pauli, & Weyers, 2015).

For facial mimicry of *anger*, results showed mixed evidence. While some studies showed larger facial mimicry of anger towards ingroups than outgroups, other have shown the opposite, or a lack of effect (see Table 8). Nevertheless, the meta-analytical analysis showed that individuals mimic anger more towards ingroup members than outgroup members. While context theories could expect this result, the MSCT would not predict mimicry of anger (Hess & Fischer, 2014). Facial mimicry of anger is considered by some scholars to be contra-productive as it may be related to aggression[9] (e.g., Bourgeois & Hess, 2008; Hess & Fischer, 2014). Despite the doubts raised about facial mimicry of anger and despite the fact that its advantage is not well understood in the literature (Fisher & Hess, 2014), facial mimicry of anger occurs (Niedenthal, 2007; Oberman, et al., 2007; Söderkvist, Ohlén, & Dimberg, 2017). It is also surprising that mimicry of anger is stronger towards ingroup members, as this emotion is suggested to not be mimicked to avoid social constraints (Hess & Fischer, 2014). Based on these results, we may at least consider that facial mimicry of anger is not related in itself to the escalation of aggression. Nevertheless, studies assessing how facial mimicry is related to

[9] Anger is one of the six basic emotions that have evolved because of their adaptive value to fundamental life-tasks (Ekman, 1992). To surmount social barriers or conflicts (Izard, 1992) anger is linked to defensive initiatives (Berkowitz, 1990) and protective behaviors to improve safety (Bowlby, 1973). Thus, "*anger can motivate us to stop or change whatever caused us to feels anger. Anger at injustice motivates action to bring about change*" (Ekman, page 140, 2007) to help us dealing with stressful and potential dangerous situations (Ekman, 1992). Thus, mimicry of anger signals the intention to not affiliate with the other (Bourgeois & Hess, 2008), anger signals that the interaction is obnoxious and not acceptable (Ekman, 2007).

aggression are still missing to clarify if facial mimicry can escalate conflict.While these results are surprising, they call for a new understanding of facial mimicry, especially for facial mimicry of anger and perhaps other emotions.

Towards a new understanding of facial mimicry: the case of anger

Facial mimicry of anger seems to be larger towards ingroups than outgroups, however, the meta-analysis also revealed significant heterogeneity in the group membership effect on facial mimicry of anger. In most studies, participants mimicked ingroup anger more than outgroup anger. However, some studies show the opposite effect: larger facial mimicry of anger towards outgroups than ingroups. To explain these results we propose that facial mimicry of anger most likely serves the purpose of emotional decoding, in order to select an adaptive and appropriate response. Thus, it is reasonable to think that facial mimicry of anger may vary between intergroup contexts according to the demands imposed by each context. As a first approach, we suggest that anger expressed by ingroup members and outgroup members signals two different threats: ingroup ostracism (Williams, 2007; Williams & Nida, 2011) and intergroup aggression (Berkowitz, 1962), respectively. Facing both threats may require the mimicking of anger.

First, individuals need to mimic ingroup anger to understand other ingroup members' intentions and emotions, which is necessary to act accordingly, and in the case of anger in particular to reduce ingroup aggression or ostracism. Such an ability to detect ingroup anger may be considered part of the so called ostracism detection system (Spoor & Williams, 2007) that humans have developed to avoid social exclusion from their groups (Williams & Nida, 2011; Wesselman, Nairne, & Williams, 2012).The fear of ingroup ostracism may lead individuals to look for ostracism cues to prevent future ostracization (Williams, 2007). Ostracized individuals seem to be more sensitive to social cues signalling affiliation. For instance, they are better than non-ostracised individuals in detecting real as compared to faked smiles (Bernstein, Young, Brown, Sacco, & Calypool, 2008). Likewise, we suggest that detecting anger in the facial expression of ingroup members may play a similar role in preventing ostracism and in preserving the affiliation to the ingroup. Indeed, a set of two recent studies has shown that individuals show more ostracism-related feelings, such as feeling excluded, bad, tense and sad (Williams, Chueng, & Choi, 2000) after facing an angry face than after facing a happy or neutral face (Murteira & Waldzus, 2020d). We suspect that studies showing stronger facial mimicry of ingroup anger as compared to outgroup anger may have been conducted in a context in which such risk of being ostracized was particularly relevant.

On the other hand, mimicking of anger expressed by outgroup members might be necessary to avoid aggression from outgroups due to conflict (Struch & Schwartz, 1989). Mimicking outgroup anger could at least serve the epistemic function of facial mimicry to help individuals to understand the outgroup anger and then act accordingly. Several authors have suggested that intergroup anger is a strong and undoubtable predictor of aggression between individuals (Mackie, Devos, & Smith, 2000; Maitner, Mackie, & Smith, 2006; Smith, Seger, & Mackie, 2007), probably due to the high arousal caused by anger (Rydell, et al., 2009). Even though, mimicking anger would not serve the affiliative purpose, it would at least serve the epistemic one to help individuals to avoid or respond to a tense situation when anger is expressed by outgroups. However, these post-hoc explanations are so far only speculation, as the present analysis does not allow to test these hypothesis due to the absence of data. Future studies testing these possible moderators of facial mimicry of ingroup and outgroup anger would be interesting.

Cultural background of the group membership effect on facial mimicry

Differences in the group membership effect on facial mimicry between countries were found. The group membership effect on facial mimicry was only reliable for the USA and Canada. The lack of country representation in this meta-analysis does not allow for a conclusion about how the extent of facial mimicry in interpersonal vs. in intergroup relations varies between culture. Nevertheless, the results suggest that in Canada the group membership effect of facial mimicry is stronger than in the USA. Most of the studies on the group membership effect on facial mimicry were conducted in western countries. Thus, there is little information about such a group membership effect in eastern populations.

Individuals define themselves based on the relation with others and belonging to groups, thus, the self is more than just an individual self, it is also a social self (Brewer & Gardner, 1996). Cultural background influences the way individuals perceive themselves in the relationship with others (Markus & Kitayama, 1991). While in Western societies individuals tend to define themselves more according to their unique personal attributes, individuals in eastern societies tend to define themselves more based on how their self is related to others (Markus, Mullaly, & Kitayama, 1997). Given the assumed social function of facial mimicry, one could expect that the way individuals perceive themselves and the community they live in would shape their facial mimicry behavior. Individuals that possess an independent self-construal (e.g., Americans) show reduced behavioral mimicry compared to individuals who possess interdependent self construals (e.g., Japanese) (van Baaren, Maddux, Chartrand, De

Bouter, & van Knippenberg, 2003). Such main effects of self-construal on behavioral mimicry do not allow, however, for conclusions about cultural variation of the group membership effect.

Self-construal was briefly considered in the study of facial mimicry in intergroup relations. Mondillon and colleagues (2007) conducted a study in France to assess how Chinese immigrants in that country would vary their facial mimicry towards French and Chinese. The group membership effect on facial mimicry was not evident when Chinese individuals mimicked Chinese (ingroup) and French (outgroup) models (Mondillon, et al., 2007). The authors have suggested that the absence of a replication of the group membership effect may be due to the fact that participants want to affiliate with French individuals, because they were Chinese immigrants in France, but also because they have a more dependent self-construal that probably would make the Chinese individuals want to belong and be incorporated in the French society and culture (Mondillon, et al., 2007). Yet, despite such anecdotal evidence, it is still unclear whether the meta-analytical findings can or cannot be generalized to eastern populations.

Statistical power and publication bias in facial mimicry studies

Studies on the group membership effect on facial mimicry have usually small sample sizes, which can result in a lack of statistical power (Baguley, 2004). From this review we can conclude that the average effect size of the group membership effect on facial mimicry is $r = .13$ ($\eta^2 = .02$) for an average sample size of 79 participants. Most of these studies applied a within-subject design. In this case, to detect such an effect with a significance level of .05 and a statistical power of .80, 119 participants would be required. Thus, it seems that the studies on the group membership effect on facial mimicry may be underpowered. The absence of proper statistical power is related to an increase of Type I Error. Moreover, small sample sizes are related with larger effect sizes that may lead to Type M Error, which is an error of magnitude of the ES (Baguley, 2004; Button, et al., 2013). Some of the studies that reported the existence of group membership effect on facial mimicry may be severely biased and report a large significant effect by chance. This emphasizes the need of replication studies in the field of facial mimicry in intergroup relations.

When looking for publication bias, variance between published and unpublished studies was found. A reliable effect of group membership on facial mimicry was found for published studies, but not for unpublished studies. Thus, we cannot exclude the possibility that a file drawer effect may be responsible for the alleged group membership effect on facial mimicry. This results speak for the urgent need to avoid the file drawer effect in social psychology. The

encouragement of null results publication is key to reduce the file drawer effect on science. Further research is needed to understand what is the role of group membership on facial mimicry and how that is implicated on affiliation function of facial mimicry.

Methodological challenges in facial mimicry studies

This meta-analysis has shown that larger effect sizes are reported in Facial Electromyography (f-EMG) studies than in other studies. Facial Electromyography studies measure facial mimicry directly by the assessment of the facial muscles' activity implied with the emotion. Facial Electromyography does not consider any cognitive processes, but only physiological processes that are then interpreted by the experimenter. Some authors have pointed that higher activity in *Corrugator Supercilii* may be due to attentional processes, annoyance, fear, sadness or anger (Ekman, 2003; Seibt, et al., 2015). Thus, while the group membership effect is stronger in f-EMG studies, there are reasonable doubts about the validity of this particular type of measure. It is necessary to consider other indicators in the study of the group membership effect on facial mimicry, such as measuring more muscles during the experiment, before strong conclusions can be reached.

The Facial Action Coding System (FACS) groups facial muscles in action units. FACS could be a good alternative of measurement, however, facial mimicry studies do not consider all related action units for each emotion, instead they only consider one or two action units per emotion to assess facial mimicry. The economical and temporal cost to implement the method is high; however, some technological solutions have been developed, such as FaceReader (Noldus Information Technology, 2017). Typically, these software packages rely on the FACS system to do the face categorization. Unfortunately more subtle movements that occur during facial mimicry may not be easily captured by these systems, and environmental constrains, such as contrast and light during recording, challenges the quality of the analysis.

Time bisection task methodology assumes that the increase in time perception in emotional vs. neutral displays (Droit-Volet, Brunot, & Niedenthal, 2004; Droit-Volet & Meck, 2007; Gil, Niedenthal, & Droit-Volet, 2007; Droit-Volet & Gil 2009; Yamada & Kawabe, 2011) is related to the facial mimicry process. When individuals have their facial mimicry restricted they do not over-estimate the presentation time of facial expression compared to individuals that could freely mimic (Effron, Niedenthal, Gil, & Droit-Volet, 2006). The overestimation of time perception for negative emotions, compared to neutral and positive emotions, may be related to facial mimicry, however, in our view it is not a clear measure of

the extent of facial mimicry. Thus, we suggest how bisection task and f-EMG outcomes are related should be assessed.

Conclusion

A reliable small effect size of group membership of targets (ingroup vs. outgroup) on facial mimicry was found. On average, individuals mimic ingroup members' facial expressions more than outgroup members' facial expressions. However, this effect is only reliable for facial mimicry of anger. Despite the general effect, we cannot conclude that the meta-analytical results does not support an affiliation function for facial mimicry. The small number of studies make the interpretation of the results inconclusive, and more studies to assess the affiliation function of facial mimicry are highly recommended.

Limitations and Future Directions

This meta-analysis was the result of collecting published and unpublished studies to summarize evidence for a group membership effect on facial mimicry in intergroup relations, to analyze the reliability of this effect and how it is moderated by methodological (e.g., facial mimicry method of measurement) and social variables (e.g., type of emotion). Despite the initial contribution to the area, results should be interpreted with caution due to independence problems and low number of studies available for analysis.

Future studies should be dedicated to the replication of the group membership effect on facial mimicry to provide solid evidence about the effect, but also to understand the nature of that effect, for instance, by studying relevant moderators. We suggest that future facial mimicry studies should test how need to belong and need to avoid aggression moderate facial mimicry, especially for anger displays. Mimicking anger is crucial to understand individuals and select the response to face the situation, however, as far as we know, nothing is known about the facial expressions adopted after the facial mimicry of anger. It is very difficult to disentangle the facial mimicry reflex from the facial response towards an emotional expression (Hess & Fischer, 2014), thus, it remains unclear how mimicry of anger is related to angry behaviors in the mimicker towards the mimicked. We suggest that after mimicking anger, appeasing facial expressions may be adopted to avoid aggression or to avoid exclusion. Thus, studies considering a more comprehensive assessment to facial expressions during mimicry would provide the information needed to learn whether facial mimicry of anger is related to aggressive or affiliative facial responses. Finally, to clarify the role of facial mimicry as an affiliation mechanism, we recommend to design studies that manipulate the perception of threat or stress.

Individuals under stress or perceiving threat have been shown to have an increased need for affiliation (e.g., Smeets, et al., 2009; Taylor, et al., 2000), thus, if facial mimicry is for affiliation, one could expect to see it augmented under perception of threat.

CHAPTER 6

Chapter 7

The role of perceived intergroup threat on mimicry of anger towards ingroup an outgroup members

Abstract

Facial mimicry is the automatic and unconscious mirroring of emotional facial expressions. Facial mimicry is suggested to be related to emotional decoding and affiliation between individuals during social interactions. However, little evidence is provided for its affiliative nature. Research about mimicry in intergroup relations suggests that individuals mimic ingroup members more than outgroup members due to needs for affiliation, although the small effect size associated with a large heterogeneity call for more research for a better understanding of facial mimicry in intergroup relations and its role in affiliation. In a set of two studies, we assess mimicry in intergroup relations and how it is moderated by the perception of intergroup threat. Perceived threat is related to an increase in the need for affiliation, thus we expected that individuals mimic anger from ingroup members more than outgroup members when intergroup threat is perceived. Results are complex. Our prediction for mimicry of anger was not supported, as it was stronger in response to outgroup targets than to ingroup targets. Mimicry of other emotions such as happiness and sadness was neither affected by group membership nor by perceived intergroup threat. We conclude that the affiliation function of facial mimicry is not clear, and we discuss the results regarding intergroup relations literature.

Keywords: facial mimicry, intergroup threat, anger, affiliation

CHAPTER 7

The role of perceived intergroup threat on mimicry of anger towards ingroup and outgroup members

Mutual understanding and sharing of experiences build social relations. Sharing feelings and emotions is the base of human sociability (Oatley, 2016). Several bio-psychological processes have evolved to help sharing pieces of mind; one of those processes that probably evolved with that function is mimicry. Mimicry is an automatic and unconscious mirroring of other people's behaviors such as facial, vocal and postural expressions (Chartrand & Lakin, 2013; Duffy & Chartrand, 2015; van Baaren, Janssen, et al., 2009). Facial mimicry is defined as the mirroring of facial emotional expressions (Hess & Fischer, 2013; Seibt, et al., 2015).

Emotional expressions reveal the expresser's motivations, feelings and behavioral intentions (Hess & Fischer, 2017; Oatley, 2016). Although we know that mimicry is related to positive consequences for relationships, such as affiliation and communication enhancement (Chartrand & Lakin, 2013), it remains unclear how facial mimicry is related to affiliation and understanding. The lack of empirical evidence on the relationship between facial mimicry and affiliation calls for new studies to clarify this relation (Murteira & Waldzus, 2020a). Studies on facial mimicry in intergroup relations can help close this gap, as individuals can be assumed to show a stronger need to belong with ingroup members than with outgroup members. Thus, if facial mimicry is related to affiliation one could expect to find stronger facial mimicry towards ingroup members than outgroup members.

Facial mimicry varies in intergroup relations (Murteira & Waldzus, 2020b), however, contrary to what is often assumed in the literature (e.g., Bourgeois & Hess, 2008; Hess & Fischer, 2013, 2014) the ingroup effect is only reliable for mimicry of anger. Yet, large heterogeneity characterizes those studies. While some studies have shown increased mimicry of anger towards ingroup vs. outgroup members, others have shown the opposite effect (Murteira & Waldzus, 2020b). Such variability calls for studies to test what may moderate the mimicry of anger in intergroup relations. In a set of two studies, we test the novel hypothesis that mimicry of anger in intergroup relations is moderated by the perception of intergroup threat. We examine whether people mimic ingroup members' anger more than outgroup members' anger and whether this difference is amplified in function of the perceived intergroup threat from the outgroup.

Mimicry and social interactions

Mimicry most likely evolved to facilitate cooperative social interactions (Chartrand & Bargh, 1999; Lakin, et al., 2003). Therefore, it has been suggested that mimicry is related to affiliation and to the understanding of other people's emotional states (Hawk & Fischer, 2016). Indeed, mimicry seems to facilitate the communication and the understanding of shared information (Chartrand & Lakin, 2013; Duffy & Chartrand, 2015; Lakin & Chartrand, 2003), emotional recognition (Coles, et al., 2017, 2019; Niedenthal, 2007), empathy (Iacoboni, 2009; Hess, et al., 1999; Levenson & Ruef, 1992), cooperation between people (Chartrand & Lakin, 2013), and pro-social actions (van Baaren, et al., 2003; van Baaren, et al., Knippenberg 2004). Thus, one could say that mimicry is related to social cognition (Barsalou, 2008; Seibt, et al., 2015) and positive consequences for the relationship would always arise from mimicry. Consequences such as liking, interdependence and rapport among people (Chartrand & Bargh, 1999; van Baaren, et al., 2004) would make mimicry likewise a form of 'social glue' that improves social interactions (Lakin, et al., 2003).

While some theories suggest that facial mimicry is a simulation process where the mimicker and the mimicked match their facial expressions (e.g., Gallese, 2009; Hess & Blair, 2001; Schilbach, 2016), other theories consider that facial mimicry is dependent on social context due to its affiliation goals (e.g., Fischer, et al., 2012; Hess & Fischer, 2013, 2014; Wang & Hamilton, 2012). The latter approach has some testable implications. First, if facial mimicry is related to affiliation one could expect that not all people are mimicked equally. For instance, it is often mentioned in the literature that more mimicry is associated to tighter relationships such as stronger mimicry of friends (Hess & Fischer, 2014; Bourgeois & Hess, 2008) and ingroup members (e.g., Bourgeois & Hess, 2008; Guéguen & Martin, 2009; Mondillon, et al., 2007; Lakin, et al., 2008; van der Schalk, et al., 2011; Yabar, et al., 2006). Second, if facial mimicry aims for affiliation, then we could expect that not all emotions are mimicked equally due to their different consequences for affiliation (Hess & Fischer, 2013, Bourgeois & Hess, 2008). Mimicking happy facial expressions improves mood, and mimicking sadness and fear improves the closeness and empathy between individuals (Hess, et al., 2016). The mimicking of these affiliative emotions leads to positive consequences for relationships, such as reciprocity and closeness, although sadness and fear may also trigger feelings of schadenfreude depending on the type of relationship stablished with the mimicked (Hess & Fischer, 2013). Competitive emotions such as anger and disgust characterize

competitive and non-affiliative relations. Thus, if facial mimicry is related to affiliation, it would be expected that affiliative emotions invite mimicry while competitive emotions do not (Hess, et al., 2016). However, despite the suggestion that those emotions are unlikely to be mimicked due to hazardous consequences for affiliation between individuals (e.g., Bourgeois & Hess, 2008; Fisher, et al., 2012; Hess & Fisher, 2014; Hess, et al., 2016; Roseman, et al., 1994), they are in fact mimicked (e.g., Achaibou, et al., 2007; Dimberg, et al., 2000; Dimberg, et al., 2002; Hess & Blairy, 2001) probably, at least, for epistemic reasons.

A review of research on variables that moderate facial mimicry has shown that social context variables such as liking (van der Schalk et al., 2011), empathy (Mondillon, et al., 2007), and the type of emotions (van der Schalk, et al., 2011) seem to moderate the group membership effect on mimicry. Greater differences in liking, empathy and negative emotions are associated with an increase of the difference of facial mimicry between ingroup and outgroup targets. We have decided to assess how perceived intergroup threat can change the difference in the extent of facial mimicry between ingroup and outgroup targets to test its affiliative function.

Perception of intergroup threat and facial mimicry

Stressful events change affiliative needs (Kulik & Mahler, 2000). A set of studies has shown that stress is related to an increase in the need to affiliate (e.g., Smeets, et al., 2009; Taylor, et al., 2000). For instance, when individuals perceived a threatening situation, such as danger or physical threats, which are usually experienced as stressful, they have a higher probability of showing affiliative behaviors towards the available individuals (e.g., Sarnoff & Zimbardo, 1961). Increased affiliative behaviors, such as agreeableness (White, et al., 2012), facial mimicry (Gump & Kulik, 1997), and reported need to belong (Fay & Maner, 2015) increase following threat. However, this increased affiliation behavior could depend on who are the people available for affiliation. In other words, affiliation could be more likely towards certain individuals than others.

Other people's opinion or reaction may have a powerful impact on the way people react to threat and look for affiliation. When individuals face a new threat, they have the tendency to compare their own assessments with other people's assessments (Social Comparison Theory, Festinger, 1954). However, not all people are considered equally capable of producing a successful assessment. When facing a new threat, people tend to compare and affiliate with others that are

facing the same threat (Schachter, 1959). As Kulik and Mahler (2000) put it, this preference suggests that the:

(…) needs for emotional self-evaluation are induced by the novel threat and are met through social comparison or, more specifically, through emotional comparison with similarly threatened ones (p. 296), (…) affiliative behavior increases as a function of the perception that the other person is facing the same situation (p. 302).

This preference for individuals that are facing a similar threat is justified because individuals are unclear about how they should arouse, react and feel towards the threat, and those individuals represent the best chance to evaluate the situation in terms of intensity, nature of threat and the aptness of their emotional response towards the threat (Kulik & Mahler, 2000). Indeed, several laboratory experiments have consistently shown that individuals prefer to affiliate (e.g., eye gaze, self-reporting measures) or to be in the company of people that face a similar threat (e.g., electric shock, shame, surgery), instead of being alone or with people that do not experience the same threat (for a review see Kulik & Mahler, 2000).

In the case of group relations, it is known that groups tend to develop and share a common identity (Tajfel & Turner, 1979) that helps the group members survive threatening events together. Groups differ in terms of attitudes, physical characteristics or even proximity. However, independently of the group's type and origin, group members tend to experience the need to protect the group and maintain its distinctiveness from other groups to preserve the group's identity. Ingroup identity may be subject of different types of threat, such as realistic threat and symbolic/cultural threat[10]. Perception of intergroup threat probably changes individual's behaviors. Perceived threat from outgroup members leads to negative attitudes and prejudice towards outgroup members (Zarate, Garcia, Garza, & Hitlan, 2004), which can result in derogation of outgroup members and stronger proximity to ingroup members.

As self and group protection behaviors increase, a strong need for affiliation accompanies those behavioral changes (Kulik & Mahler, 2000). To our knowledge, no research has verified the

[10] Symbolical/cultural threat is defined as the perceived harm caused by outgroup members (e.g., immigrants, Arabs) that behave according to different morals, norms and values (Stephan, Ybarra, & Bachman, 1999; Stephan, Ybarra, Martinez, Schwarzwald, & Tur-Kaspa, 1998), on the other hand realistic threat refers to the competition for limited resources (e.g. housing, social benefits, jobs) (Stephan, et al., 1999).

role of perceived intergroup threat on affiliative behaviors such as facial mimicry, although the studies on stress and social threat mentioned suggest that perceived intergroup threat may moderate facial mimicry. It is not clear how the intergroup context could change the extent of facial mimicry towards ingroup and outgroup members. Considering that perceived threat is related to an increased affiliation with similar individuals (Kulik & Mahler, 2000), one could expect that the perception of intergroup threat moderates the facial mimicry in intergroup contexts, expressed by more facial mimicry towards ingroup than outgroup members. When individuals perceive threat towards their own group, they will tend to affiliate with similarly threatened people such as ingroup members, thus, we expect that individuals increase facial mimicry towards ingroup members compared to outgroup members when they perceive intergroup threat from outgroups. Not just affiliation would be supported, but also the communication of emotions between ingroup members would be improved. In Schachter's words (1959, page 24) "misery doesn't love just any kind of company, it loves only miserable company". Thus, it would not be surprising that under perception of intergroup threat from outgroups individuals will aim for affiliation towards a similar kind, such as ingroup members.

Overview of the studies

In a set of two studies we assessed how mimicry of anger varies in an intergroup context depending on perceived intergroup threat. Perceived realistic and symbolic intergroup threat (Stephan, Ybarra, & Bachman, 1999) were assessed as moderators of the effect of group membership (ingroup target versus outgroup target) on facial mimicry.

Study 1 and Study 2 were conducted in Portugal to assess facial mimicry towards ingroup (Portuguese) and outgroup members (Arabs). Study 1 aimed to test whether the difference in outgroup vs. ingroup mimicry of anger may be explained by the perceived intergroup threat. Larger mimicry of anger towards ingroups than outgroups was expected when individuals perceived intergroup threat. Study 2 aimed to replicate findings of Study 1 with an improved design to test the impact of perceived intergroup threat on mimicry of anger. Mimicry was assessed using Facial Electromyography.

Study 1

In this study we assessed mimicry towards ingroup (Portuguese) and outgroup members (Arabs) across 4 different emotional displays: fear, anger, sadness and happiness, applying facial electromyography (f-EMG). Specifically, considering the theoretical proposals about facial mimicry and affiliation, the study tested the hypothesis that anger, happiness, fear, and sadness would be mimicked more towards ingroup than outgroup members. Despite this hypothesis, we also considered a previous meta-analysis that suggested that the effect is only reliable for anger, and no differences were found for the remaining emotions as function of the social category of the target (Murteira & Waldzus, 2020b). Based on this evidence from the meta-analysis, we designed a moderation hypothesis to test that the perceived intergroup threat from outgroups is related to an increase in the difference of mimicry of anger towards ingroups vs. outgroups, more specifically, we expected to find an increase in mimicry of anger towards ingroup members by perceived intergroup threat. Mood was entered as a control variable, as people reduce mimicry when they experience negative mood states compared to positive mood states (van Baaren, Fockenberg, Holland, Janssen, & van Knippenberg, 2006).

Method

Design and sample size calculation

Seventy participants took part in the study. Participants were recruited on campus, 27 were Psychology students that received course credit for participation and the remaining participants were other students who received a 5euro voucher in exchange for their participation. Seven participants were excluded because they guessed the purpose of the study or because they understood the purpose of facial electromyography, and two participants were excluded because they were not Portuguese. From the remaining sample (N = 61), 57 were White, two were Black, one was Asian, and one was mixed-race Black/White. None of the participants was Arab or had an Arab origin. Forty-two were female and 19 were male, and the average age was 22.61yrs (SD = 5.05).

The study used a 4 (emotions: happiness vs. sadness vs. fear vs. anger) x 2 (social category of the target: Portuguese vs. Arabs) within-subject design. Mimicry was assessed using f-EMG. To compute the necessary sample size to test the expectation that mimicry would be stronger towards ingroup members than towards outgroup members, a power analysis was conducted based on an effect size for the effect of group membership on emotional mimicry derived from the meta-analytical review (Murteira & Waldzus, 2020b). G*Power 3.1 (Faul, et al., 2007) was used to conduct the power analysis on a within-subject design (*F*-test, repeated measures, within-subject design). Input parameters were: effect size $f = 0.24$, $\alpha = .05$, power = .80, number of groups = 1, number of measurements = 4, correlation among repeated measures = .5, and nonsphericity correction = 0.75[11] (Faul, et al., 2007). The output parameters resulting from this analysis showed that for a critical *F* of 3.01, 31 participants are required to achieve the statistical power of .80.

An exploratory prediction that mimicry of anger is moderated by perceived intergroup threat as a continuous variable was tested. As it was an exploratory hypothesis, no power analysis was conducted, leaving space for a planned conceptual replication in Study 2.

Stimuli

Participants were shown videos with dynamic facial expressions, which means that each video displayed the development from neutral to full emotional expression in 5000ms, each video lasted 6000 ms. Models were selected from the ADFES database with Mediterranean ancestry (van der Schalk, Hawk, et al., 2011). Models performed the displays of four emotions: anger, fear, sadness and happiness. The videos showed each model performing the emotion with a head-turning movement and direct eye gaze. Head-turning videos were selected over direct videos, in which models look toward the camera from the beginning to the end of the sequence, because the perception that the emotion is directed towards the observer is stronger in the head-turning movement videos compared to direct videos, which is associated with higher mimicry levels (van der Schalk, Hawk, et al., 2011).

11 Sphericity correction aims to correct the degrees of freedom when the condition of homogeneity of the variances is not met between the levels of each factor. Sphericity varies between 0 and 1: the smaller the value the greater is the sphericity problem. We applied the recommended value of 0.75 for sphericity correction instead of 0.5 (Lower-Bound Estimate: *K*-1=3-1=0.5). Lower-Bound Estimate is the most conservative correction for sphericity; however, it is not recommended due to the increased risk of Type I error. Greenhouse-Geisser correction is the second most conservative correction, which is recommended when sphericity equals or is below 0.75 (Laerd Statistics, 2019).

All models were pre-tested for the Portuguese population for the attractiveness and sympathy level and for their perceived ethnic identity (Portuguese vs. Arabic). Twenty Portuguese participants fully completed the pre-test survey (M_{age} = 30.09; *SD* = 9.92), 14 participants were females. The survey started assessing demographic variables such as age, nationality and gender. It followed the randomized presentation of 10 videos, each video was performed by a different model (5 males and 5 females) showing a neutral facial expression. After each video participants were asked to rate the models' attractiveness on a scale from 1 "*not attractive*" to 10 "*very attractive*", their sympathy looking level on a scale from 1 "*not sympathetic*" to 10 "*very sympathetic*", and their ethnic origin on a scale from 1 "*Portuguese*" to 10 "*Arab*". Two female and two male models that showed average values closest to the midpoint scale of 5.5 (average *SD* = 1.95) on all three scales were selected after the pre-test to avoid a possible attractiveness confound (van Leeuwen, Veling, van Baaren, & Dijksterhuis, 2009) in the mimicry extent between models.

Procedure

Participants were seated in front of a computer. Informed consent was obtained and a brief explanation about electrodes attachment and skin preparation was provided to each participant. Participants were told that the study aimed to observe the influence of personality traits on perception and communication of emotions. The experiment consisted of three parts. A survey developed in Qualtrics (Qualtrics, 2015) started by assessing demographic variables such as age, nationality and gender. A measure of inter-individual differences in perceived intergroup threat (Stephan, et al., 1999) was followed by a mood assessment (Watson, Clark, & Tellegen, 1988) prior to facial mimicry measurement. All items were presented to participants in random order.

In the second part, participants were prepared to assess facial mimicry with facial electromyography (f-EMG) (see more details about the preparation below). Then, participants were shown a set of videos and told that their task was to indicate which emotional expression they saw. Videos were presented using e-Prime version 2.0 (Psychological Software Tools, 2012). During the video presentation, participant's facial mimicry was assessed. To make the social category salient, participants were provided with a social categorization label before video display. More precisely, to manipulate social category, video models were presented using Portuguese (e.g., João,

Maria) and Arab (e.g., Muhammad, Samira) first names. Each trial started with a blank screen (1000 ms), followed by a fixation cross (500 ms) and the social category manipulation (i.e., showing the name on the screen for 500 ms), during which the f-EMG's baseline measure was taken before the experimental measurements. The trial proceeded with the video presentation, each video lasted 6000 ms, however, the video remained frozen for an extra 6000 ms to prevent missing mimicry responses. Thus, each stimulus presentation lasted 12000 ms in total. Stimuli were shown in two different blocks, each block representing one social category condition. Blocks were presented in counterbalanced order, and emotional expressions were displayed in random order without replacement. The social category was counterbalanced across models. Each video was repeated three times (24 stimuli per block and 48 stimuli in total). During stimulus presentation f-EMG data was collected synchronized with stimulus onset and offset. The trial ended with the manipulation check for emotion, that is, with a decoding task for each presented emotion.

In the last part, participants returned to the initial survey and answered remaining questions about the familiarity, liking and perceived similarity of the models in the video as a manipulation check of social category (e.g., van der Schalk, et al., 2011). Finally, the participant was debriefed. In the debriefing several questions were asked to verify if the participant: 1) understood the purpose of f-EMG measurement, 2) if they noticed the social category, and 3) if they guessed the hypotheses. After the debriefing, the participant was thanked. The experiment lasted 60 minutes on average.

Facial Electromyography (f-EMG) measurement

Before electrodes were attached, the skin was gently cleaned with cotton and Ethyl Alcohol 70% solution. During video presentation, the facial muscle activity was measured by bipolar placement of Ag/AgCl surface electrodes on the left side of the face with SignaGel electrode gel, one ground electrode was placed on the neck. Following Fridlund and Cacioppo's (1986) guidelines, the electrodes were placed to measure activity of the *Corrugator Supercilii* (which assesses the lowering of the eyebrow) and of the *Zigomaticus Major* (which measures the muscle activation caused by smile behavior). *Corrugator Supercilii* activity was used as an indicator of facial mimicry behavior for anger, sadness and fear displays, and *Zigomaticus Major* was the

measure of facial mimicry for happiness displays (e.g., van der Schalk, et al., 2011; Hühnel, Fölster, Werheid, & Hess, 2014).

The EMG signal was measured with a Biopac EMG amplifier, digitized with 24-bit resolution, sampled at 2 kHz, and recorded on a PC. After the data collection, the data was offline filtered with a 30–250 Hz band pass filter and a 50 Hz notch filter as data was collected in Europe (Biopac, 2019).

Measurements

Perceived intergroup threat (α = .85; *M* = 4.97; *SD* = 1.35) was assessed with the Intergroup Threat Scale (Stephan, et al., 1999) in the Portuguese version (Murteira, 2020) that was adapted to measure perceived threat by Syrian refugees in Portugal. Participants provided their answer on a scale from 1 "*Completely disagree"* to 10 "*Completely agree*", where higher scores represent stronger perceived threat. The scale has two sub-scales: *perceived realistic threat* (α = .87; *M* = 4.49; *SD* =1.77) and *perceived symbolic threat* (α = .65; *M* = 5.46; *SD* = 1.33).

Perceived realistic threat was composed by the following items: "Syrian refugees get more from this country than they contribute.", "The children of Syrian refugees should have the same right to attend public schools in the Portugal as the Portuguese do." (reverse coded), "Syrian immigration has increased the tax burden on Portuguese.", "Syrian refugees are not displacing Portuguese workers from their jobs." (reverse coded), "Syrian refugees should be eligible for the same health-care benefits received by the Portuguese" (reverse coded), "Social services have become less available to the Portuguese because of Syrian refugees.", "The quality of social services available to the Portuguese has remained the same, despite Syrian refugees." (reverse coded), "Syrian refugees are as entitled to subsidized housing or subsidized utilities (water, sewage, electricity) as poor Portuguese are." (reverse coded). Perceived symbolic threat was composed by the following items: "Syrian refugees should learn to conform to the rules and norms of Portuguese society as soon as possible after they arrive", "Immigration from Syria is undermining Portuguese culture", "The values and beliefs of Syrian refugees regarding work are basically quite similar to those of most Portuguese" (reverse coded),"The values and beliefs of Syrian refugees regarding moral and religious issues are not compatible with the beliefs and values of most Portuguese", "The values and beliefs of Syrian refugees regarding family issues and socializing children are basically quite similar to those of most Portuguese" (reverse coded), "The values and beliefs of Syrian

refugees regarding social relations are not compatible with the beliefs and values of most Portuguese", "Syrian refugees should not have to accept Portuguese ways" (reverse coded). Higher responses imply stronger perceived intergroup threat.

Mood was assessed before mimicry with a Portuguese version of the Positive and Negative Affect Scale (PANAS) using a scale from 1"*Completely disagree"* to 5 "*Completely agree"* (Watson, et al., 1988; for the Portuguese version Galinha & Pais-Ribeiro, 2005). Positive mood (α = .69; *M* = 3.37; *SD* = 0.71) and negative mood (α = .69; *M* = 1.94; *SD* = 0.72) were calculated by averaging responses on the four items for each category. Positive mood comprised "good-mood", "excited", "satisfied" and "happy". Negative mood comprised "bad-mood", "depressed", "sad" and "bored". Participants showed stronger positive mood than negative mood before mimicry measurement t (58) = 9.01, $p < .001$. Thus, mimicry was not reduced by a negative mood state.

Other variables were assessed. However, they are out of the scope of this chapter. To consult them please see supplemental materials for Study 1 (Appendix 1).

Manipulation checks

Emotions decoding. Participants rated the intensity of fear, happiness, sadness, and anger after each emotional stimulus on a scale from 1 ("*not intense at all*") to 5 ("*very intense*") to assess the degree to which participants saw each emotion in each stimulus (van der Schalk, et al., 2011).

Considering the previous research conducted by van der Schalk and colleagues (2011) and Guéguen & Martin (2009), we measured perceived familiarity with, similarity to and liking of the models shown in the videos as proxies for the check of the social category manipulation.

Familiarity. Participants were asked to rate their perceived familiarity with each model using a 7-point scale, 1 "*not familiar at all*" 7 "*very familiar*".

Similarity. Participants were asked to rate their perceived similarity to each model using a 7-point scale from 1 "*not similiar at all*" to 7 "*very similar*.

Liking. Participants were also asked to rate their liking of each model using a 7-point scale, 1 "*do not like at all*" 7 "*like a lot*".

By default individuals feel more familiar with, more similar to and like more ingroup members than outgroup members due to early socialization and learning experience with ingroup

members (Kavanagh & Winkielman, 2016). Thus, higher familiarity with, stronger similarity to and more liking of ingroup models than outgroup models would indicate a successful social category manipulation.

Results

Manipulation checks

Emotions decoding. Emotion decoding for each display was analyzed with a 4 (presented emotions: happiness vs. sadness vs. anger vs. fear) x 4 (decoding emotions: happiness vs. sadness vs. anger vs. fear) x 2 (social category: Portuguese vs. Arabs) repeated measures GLM with three within-subject factors. When the assumption of Sphericity was violated, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom. Main effects of presented emotions, F (2.36, 132.0) = 17.66, p< .001, η^2 = .24, decoding emotions, F (2.40, 134.5) = 51.9, p < .001, η^2 = .48, and social category, F (1, 56) = 8.81, p = .004, η^2 = .13, were found. More importantly, the predicted interaction of presented emotions x decoding emotions was strong and significant, F (2.77, 154.8) = 613.1, p < .001, η^2 = .92 and the remaining interactions were not significant. Separate analyses for the four decoded emotions showed main effects of displayed emotion: participants rated happiness displays as happier than the other displayed emotions, F (1,56) = 1897.7, p < .001, η^2 = .97, anger displays were rated as angrier than other displayed emotions, F (1,56) = 589.6, p < .001, η^2= .91, sadness displays were rated as sadder than other displayed emotions, F (1,56) = 644.1, p < .001, η^2 = .92, and finally fear displays were rated as more fearful than other displayed emotions, F (1,56) = 775.9, p < .001, η^2 = .93. Also, participants rated happiness displays as happier than angry, sad or fearful, F (1,56) = 1785.7, p < .001, η^2 = .97, anger displays were rated as angrier than happy, sad or fearful, F (1,56) = 378.0, p < .001, η^2 = .87, sadness displays were rated as sadder than happy, angry or fearful, F (1,56) = 631.7, p < .001, η^2 = .92, and finally fear displays were rated as more fearful than happy, angry or sad, F (1,56) = 935.9, p < .001, η^2 = .94 (for detailed information about descriptive statistics please see Table 9 and Table 10).

Familiarity. Participants rated ingroup models as more familiar (M = 3.59, SD = 1.11) than outgroup models (M = 3.27, SD = 1.78), t (60) = 2.37, p = .02, which shows that the social category

manipulation was successful, even though the models for Portuguese and Arabic targets were the same.

Liking and Similarity. Participants on average did not show differences in perceived similarity and liking between ingroup and outgroup models, which does not support the conclusion of a successful manipulation. Given the mixed results on these manipulation checks for social category, in order to stick to a more conservative approach to the test of the main hypotheses, it was decided to continue analyzing the data based on the tentative assumption that the manipulation was successful.

Table 9:
Decoding for each emotion presented in Study 1.

Emotion Displayed	*Emotion* [o]	*Social Category* [o]	*Emotion x Social category* [o]
Happiness	F (1.17, 66.66) = 1686.07, $p < .001$, $\eta^2 = 0.97$.	F (1, 57) = 2.05, p =.16, $\eta^2 = 0.04$	F (1.36, 77.24) = 1.43, p = .24, $\eta^2 = 0.02$
Anger	F (1.72, 97.82) = 266.70, $p < .001$, $\eta^2 = 0.82$	F (1, 57) = 2.71, p = .11, $\eta^2 = 0.05$	F (1.41, 80.09) = 0.47, p = .56, $\eta^2 = 0.008$
Sadness	F (2.08, 120.46) = 352.63, $p < .001$, $\eta^2 = 0.86$	F (1, 58) = 8.65, p = .005, $\eta^2 = 0.13$	F (2.11, 122.32) = 1.36, p = .26, $\eta^2 = 0.02$.
Fear	F (2.01, 116.80) = 626.90, $p < .001$, $\eta^2 = 0.92$	F (1, 58) = 3.14, p = .08, $\eta^2 = 0.05$	F (32.24, 129.68) = 1.12, p = .34, $\eta^2 = 0.02$.

Note: Assumption of Sphericity was violated, thus, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom.

[O] Omnibus effect for the 4 (decoding emotions: happiness vs. sadness vs. anger vs. fear) x 2 (social category: Portuguese vs. Arabs) Repeated Measures GLM for each displayed emotion separately.

Table 10:
Descriptives of the decodings for each emotion presented in Study 1.

Emotion Displayed	Happiness	Anger	Sadness	Fear
Decodings	*M (SE)*	*M (SE)*	*M (SE)*	*M (SE)*
Happiness	4.31 (0.08) [a]	1.09 (0.02) [a]	1.09 (0.04) [a]	1.12 (0.03) [a]
Anger	1.07 (0.02) [b, c]	3.72 (0.11) [b]	1.18 (0.04) [a]	1.15 (0.04) [a]
Sadness	1.07 (0.02) [b, c]	1.68 (0.08) [c]	4.01 (0.10) [b]	1.58 (0.09) [b]
Fear	1.08 (0.03) [b, c]	1.49 (0.08) [d]	2.10 (0.12) [c]	4.30 (0.10) [c]

[abcd] Decodings with different superscripts for each displayed emotion differ significantly from each other ($p < .05$, two-tailed) in pairwise comparisons.

EMG data treatment

Data extraction. Stimulus-Data extraction was conducted for each stimulus with 1000 ms epoch (time window) across the 6000 ms of the video (please see Figure 5 for facial mimicry responses). Data collected during the additional 6000 ms after the video of each trial were not included in the analysis as they did not add any relevant information. Stimulus-Data was z-transformed within-subjects.

For Baseline-Data extraction, the first 2000 ms of each experimental trial (i.e., when the fixation cross and the social category are displayed) was extracted with 1000 ms epoch (time window) across the 2000 ms of the baseline. Baseline-Data was z-transformed within-subjects.

EMG data across the three repetitions for each stimulus and for the baselines were aggregated by mean. A final index for each muscle and stimulus was computed by subtracting the Baseline-Data from the Stimulus-Data.

Data quality. A-priori contrasts were performed to test the quality of the data. As expected, stronger activity of *Zygomaticus Major* than of *Corrugator Supercilii* was observed in response to happiness displays for ingroup and outgroup videos. Also as expected, for anger and sadness displays the reverse pattern was found across groups, that is, stronger activity of *Corrugator Supercilii* than of *Zygomaticus Major* was found for anger and sadness displays across groups.

Unexpectedly, for fear displays the latter pattern was only found for outgroup videos but not for ingroup videos (for detailed information on statistics please see Table 11).

Table 11:
Data quality per emotion and social category for Study 1.

Ingroup members

	Zigomatic Major *M (SD)*	*Corrugator Supercilii* *M (SD)*	*t*
Displays			
Happiness	0.10 (0.36)	-0.40 (0.38)	t (60) = 6.78, $p < .001$
Anger	-0.06 (0.36)	0.14 (0.34)	t (60) = 2.78, $p = .007$
Sadness	-0.10 (0.39)	0.13 (0.29)	t (60) = 3.60, $p < .001$
Fear	0.00 (0.38)	-0.01 (0.33)	t (60) = -0.13, $p = .90$.

Outgroup members

	Zigomatic Major *M (SD)*	*Corrugator Supercilii* *M (SD)*	*t*
Displays			
Happiness	0.14 (0.50)	-0.40 (0.33)	t (60) = 7.30, $p < .001$
Anger	-0.04 (0.38)	0.30 (0.31)	t (60) = 5.32, $p < .001$
Sadness	-0.00 (0.36)	0.17 (0.31)	t (60) = 2.65, $p = .01$
Fear	-0.05 (0.31)	0.08 (0.22)	t (60)= 2.31, $p = .02$

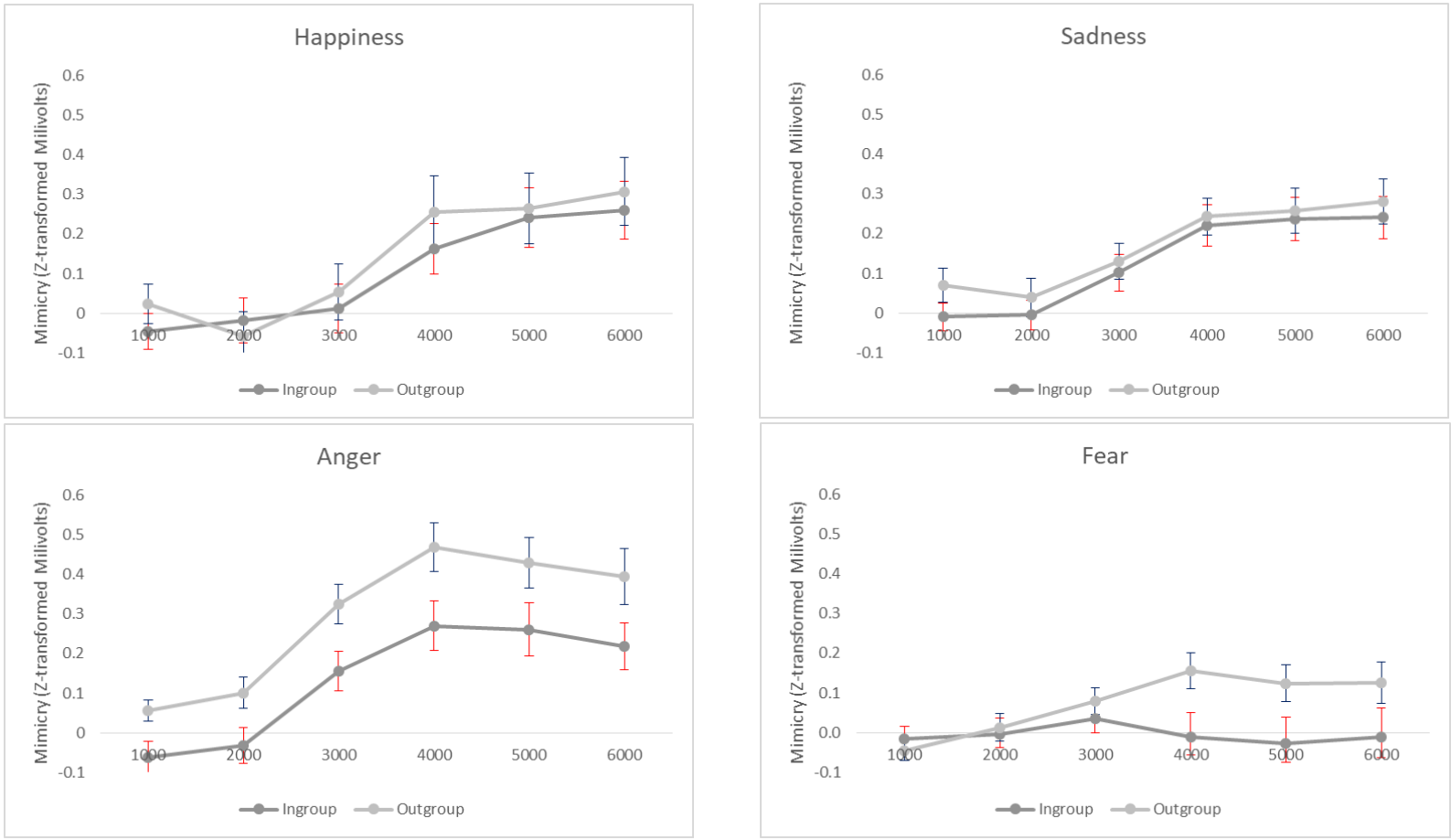

Figure 5: Mimicry response between ingroup and outgroup members by relevant muscle activation in Happiness (*Zigomatic Major*), Sadness, Anger and Fear displays (*Corrugator Supercilii*) across video length (6000ms), Study 1. Each time point is the mean activation of each1000ms interval, for instance, at 1000 ms it is average activation between 0 and 1000ms.Standard errors in the error bars.

Analysis of EMG data

Zigomatic Major. Stronger *Zigomatic Major* activity would indicate facial mimicry of happiness if it was stronger than baseline in response to happiness videos. A Repeated Measures GLM was run to assess the effects of emotion and social category on *Zigomatic Major* muscle's activation in a 4 (emotions: happiness vs. sadness vs. anger vs. fear) x 2 (social category: Portuguese vs. Arabs) within-subject design. When the assumption of Sphericity was violated, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom.

A significant effect of emotion was found, F (2.65, 180) = 4.44, p = .005, η^2 = .07, showing higher *Zigomatic Majo*r activity for happiness ($M_{Happiness}$ = .12; $SE_{Happiness}$ = 0.04) than sadness ($M_{Sadness}$ = -.05; $SE_{Sadness}$ = 0.03), anger (M_{Anger} = -.05; SE_{Anger} = 0.03) and fear (M_{Fear} = -.02; SE_{Fear} = 0.03). Pairwise comparisons adjusted with Bonferroni correction showed significant mean differences in *Zigomatic* activation between happiness and anger displays (M = -0.17, SE = 0.06, p = .05), between happiness and sadness displays (M = -.017, SE = 0.06, p = .05), and between happiness and fearful displays (M = -.15, SE = 0.06, p = .10).

Social category had no significant effect, F (1, 60) = 0.34, p = .56, η^2 = .01, and the 2-way interaction between emotion and social category was also not significant, F (3, 180) = 0.86, p = .46, η^2 = .01. Thus, social category did not change the intensity of *Zigomatic Major* activation. A planned contrast to test the hypothesis of a stronger activation of the *Zigomatic Major* for happiness vs. sadness, anger and fear combined across social categories was run. Results showed again that happiness displays lead to stronger activation of the *Zigomatic Major* than the other emotions combined, F (1, 60) = 8.70, p = .005, η^2 = .13 (see Figure 6).

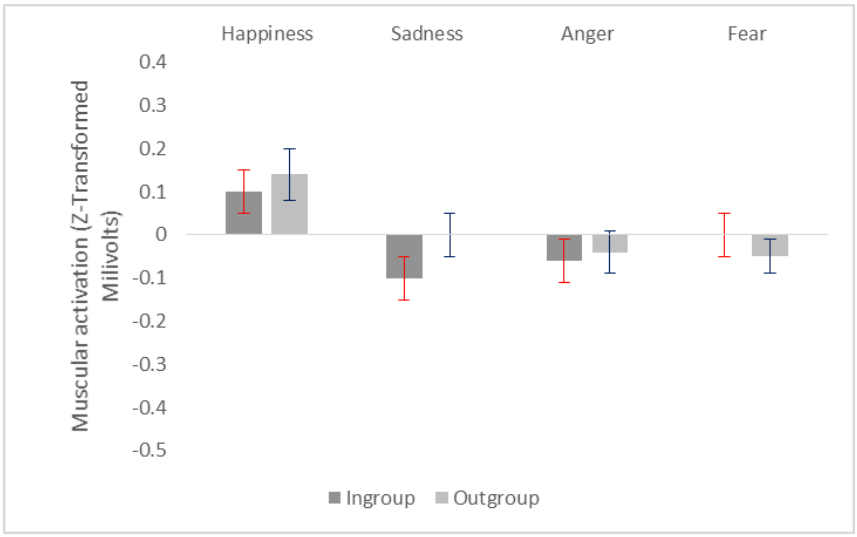

Figure 6: Mean activation of *Zigomatic Major* muscle in Happiness, Sadness, Anger and Fear displays, Study 1. Standard errors in the error bars.

Corrugator Supercilii. Higher *Corrugator Supercilii* activity would indicate mimicry of sadness, anger and fear if it was stronger than baseline in response to sad, angry and fearful faces, respectively (e.g., van der Schalk, et al., 2011). A Repeated Measures GLM was applied to assess the effect of social category at *Corrugator Supercilii* activation in a 4 (emotion: happiness vs. sadness vs. anger vs. fear) x 2 (social category: Portuguese vs. Arabs) within-subject design. When the assumption of Sphericity was violated, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom.

A significant effect of emotion, F (2.36, 141.56) = 68.90, p < .001, η^2 = .54, and a significant effect of social category, F(1, 60) = 5.10, p = .03, η^2 = .08, were found. The 2-way interaction between emotion and social category was not significant, F (3, 180) = 1.54, p = .21, η^2 = .03.

About the main effect of emotion, descriptive statistics show stronger *Corrugator Supercilii* activity for anger displays (M = 0.22, SE = 0.03), sadness displays (M = 0.15, SE = 0.02) and fear displays (M = 0.03, SE = 0.03) than for the happiness displays (M = -0.40, SE = 0.03). Pairwise comparisons adjusted with Bonferroni correction showed significant mean differences at *Corrugator* activation between anger and happiness displays (M = 0.61, SE= 0.06, p< .001), between sadness and happiness displays (M = 0.55, SE = 0.06, p <.001), between anger and fear

(M = 0.18, SE = 0.05, p < .001), between sadness and fear (M = 0.12, SE = 0.04, p < .01), and between happiness and fear (M = 0.43, SE = 0.04, p < .001). However, the differences between sadness and anger displays were not significant, (M = 0.07, SE = 0.04, p = .65). Finally, a planned contrast to test the hypothesis of a stronger activation of the *Corrugator Supercilii's* for sadness, anger and fear combined vs. happiness across both social categories was run. Results showed that combined sadness anger, and fear displays lead to stronger *Corrugator Supercilii's* activation than happiness, F (1, 60) = 151.29, p < .001, η^2 = .72.

Regarding the main effect of social category, pairwise comparisons showed significant mean differences in *Corrugator* activation between ingroup and outgroup members' displays. Participants showed stronger *Corrugator* activation in response to outgroup than to ingroup members ($M_{ingroup}$ = -0.04, $SE_{ingroup}$ = 0.02, $M_{outgroup}$ = 0.04, $SE_{outgroup}$ = 0.02, p = .03). Finally, pairwise comparisons to assess the 2-way interaction between emotion and social category showed that *Corrugator* activation between social categories varies only for anger ($M_{ingroup}$ = .14, $SE_{ingroup}$ = 0.04, $M_{outgroup}$ = 0.30, $SE_{outgroup}$ = 0.04, p < .01), no differences were found for the other emotions between social categories (Sadness: $M_{ingroup}$ = 0.13, $SE_{ingroup}$ = 0.04, $M_{outgroup}$ = 0.17, $SE_{outgroup}$ = 0.04, p = .54; Fear: $M_{ingroup}$ = -0.01, $SE_{ingroup}$ = 0.04, $M_{outgroup}$ = 0.08, $SE_{outgroup}$ = 0.03, p = .12; Happiness: $M_{ingroup}$ = -0.40, $SE_{ingroup}$ = 0.05, $M_{outgroup}$ = -0.40, $SE_{outgroup}$ = 0.04, p = .97) (see Figure 7).

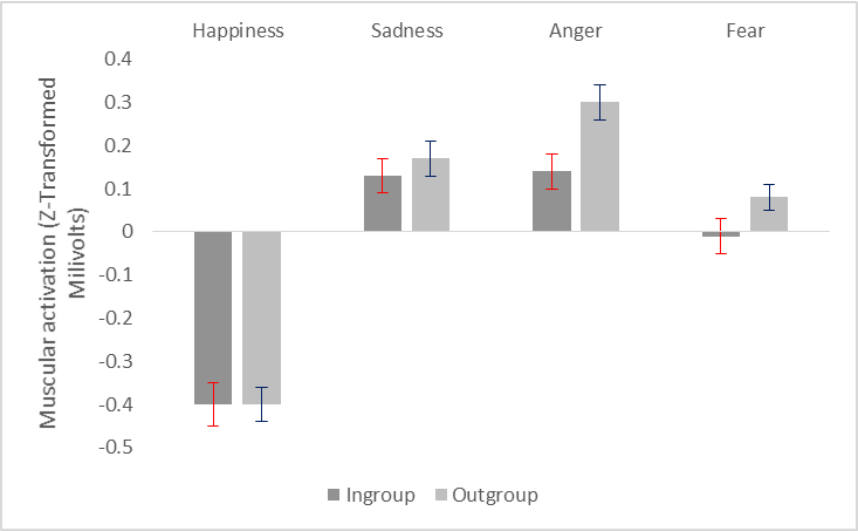

Figure 7: Mean activation of *Corrugator Supercilii* muscle in Happiness, Sadness, Anger and Fear displays, Study 1. Standard errors in the error bars.

For the sake of simplicity, a Repeated Measures GLM was conducted to analyze the effect of social category for each emotion separately. Contrary to our hypothesis, in response to anger displays results showed stronger *Corrugator* activation for outgroup members than for ingroup members F (1, 60) = 11.04, p = .002, η^2 = .16; $M_{ingroup}$ = 0.14, $SD_{ingroup}$ = 0.34, $M_{outgroup}$ = 0.30, $SD_{outgroup}$ = 0.31). For happiness, sadness and fear no significant differences were found F (1, 60) = 0.00, p = .97, η^2 = .00, F (1, 60) = 0.39, p = .54, η^2 = .01, F (1, 60) = 2.46, p = .12, η^2 = .04.

From the analysis of muscle activity in the *Zigomatic Major* and *Corrugator Supercilii*, it is possible to conclude that there are no differences in the strength of mimicry between ingroup and outgroup members in response to happiness, sadness, and fear displays. Results did show higher mimicry of anger towards outgroup members than ingroup members (see Figure 8).

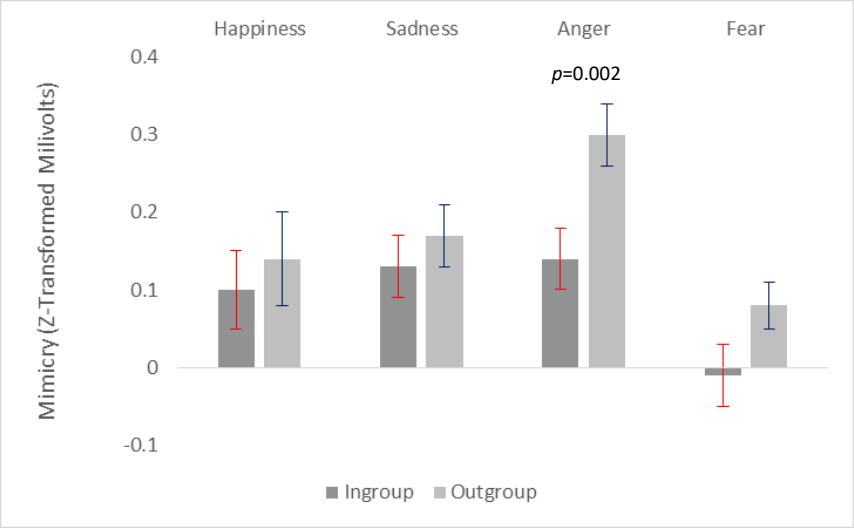

Figure 8: Average mimicry response between ingroup and outgroup members by relevant muscle activation in Happiness (*Zigomatic Major*), Sadness, Anger and Fear displays (*Corrugator Supercilii*), Study 1. Standard errors in the error bars.

Does perceived intergroup threat predict mimicry of anger towards ingroup members?

To better understand the nature of the social category effect on mimicry of anger, two moderation analysis were conducted to verify the moderation of perceived intergroup threat on mimicry of anger in intergroup context. Multiple regression analysis was conducted to investigate

the hypothesis that perceived intergroup threat predicts mimicry of anger towards ingroup members, but not towards outgroup members. The analysis was conducted considering realistic and symbolic intergroup threat both together and separately. Mimicry of anger towards ingroup members and mimicry of anger towards outgroup members (DV) were regressed on the perceived intergroup threat (realistic and symbolic threat combined) (M) into a multiple regression analysis using the MEMORE macro for SPSS (model 2) (Montoya, 2019). Perceived intergroup threat predicts an increase of the difference in mimicry of anger between ingroup and outgroup targets (yDiff= mimicry of ingroup – mimicry of outgroup), b = 0.09, SE = 0.03, t (59) = 2.48, p = .02, 95% CI [0.02, 0.16], with an R^2 of .09 (adjusted R^2=.04). Simple slope analysis reveals that perceived intergroup threat predicts a marginal increase in mimicry of anger towards ingroup members, b = 0.06, SE = 0.03, t (59) = 1.83, p = .07, 95% CI [-0.01, 0.12], but not towards outgroups, b = -0.03, SE = 0.03, t (59) = -0.94, p = .35, 95% CI [-0.09, 0.03]. Conditional effect analysis showed that under low perceived threat, there is a significant difference of mimicry of anger between groups, t (59) = -4.20, p < .001, 95% CI [-0.41, -0.14], while under high perceived threat the difference between groups does not reach the level of significance, t (59) = -0.68, p = .50, 95% CI [-0.18, 0.09].Thus, under perception of threat there is the tendency to reduce the difference in mimicry between groups due to an increase in mimicry of anger towards ingroup members (Figure 9 and Figure 9.1).

Realistic threat. The same analysis was conducted considering perceived realistic threat as moderator. Perceived realistic intergroup threat predicts an increase of the difference in mimicry of anger between ingroup and outgroup members (yDiff= mimicry of ingroup – mimicry of outgroup), b = 0.06, SE = 0.03, t (59) = 2.45, p = .02, 95% CI [0.01, 0.12], with an R^2 of .09 (adjusted R^2 = .04). Simple slope analysis reveals that perceived realistic threat predicts a marginal increase in mimicry of anger towards ingroup members, b = 0.04, SE = 0.02, t (59) = 1.76, p = .08, 95% CI [-0.01, 0.09], but not towards outgroup members, b = -0.02, SE = 0.02, t (59) = -0.98, p = .33, 95% CI [-0.07, 0.02]. Conditional effect analysis showed that under low perceived realistic threat, there is a significant difference in mimicry of anger between groups, t (59) = -4.17, p < .001, 95% CI [-0.41, -0.14], while under high perceived realistic threat the difference between groups is not significant anymore t (59) = -0.70, p = .49, 95% CI [-0.18, 0.09].Thus, under perception of realistic threat there is the tendency to reduce the difference in mimicry between groups due to an increase in mimicry of anger towards ingroup members (Figure 10 and Figure 10.1).

Symbolic threat. The same analysis was conducted considering perceived symbolic threat as moderator. Perceived symbolic intergroup threat does not predict the difference in mimicry of anger between ingroup and outgroup members (yDiff= mimicry of ingroup – mimicry of outgroup), b = 0.06, SE = 0.04, t (59) = 1.72, p = .09, 95% CI [-0.01, 0.13], with an R^2 of .05 (adjusted R^2 = .00) Simple slope analysis revealed that perceived intergroup threat does not predict mimicry of anger towards ingroup members, b = 0.04, SE = 0.03, t (59) = 1.35, p = .18, 95% CI [-0.02, 0.11], or towards outgroup members, b = -0.02, SE = 0.03, t (59) = -0.60, p = .55, 95% CI [-0.08, 0.04]. Conditional effect analysis showed that under low perceived symbolic threat, there is a significant difference in mimicry of anger between groups, t (59) = -3.60, p < .001, 95% CI [-0.38, -0.11], while under high perceived threat the difference between groups is not significant, t (59) = -1.15, p = .25, 95% CI [-0.21, 0.06].

The same analysis were conducted for the remaining emotions: happiness, sadness and fear. The results revealed no moderation of the group membership effect on mimicry by perceived realistic and symbolic intergroup threat, for the detailed results please see Appendix 2.

Discussion Study 1

In this study we examined how facial mimicry of happiness, sadness, fear and anger varies in intergroup relations. A meta-analytical study (Murteira & Waldzus, 2019b) has shown higher mimicry of anger for ingroup members than outgroups members, however, high heterogeneity characterized that effect. Based on this previous meta-analysis, we expected higher mimicry of anger, but not other emotions, for ingroup members than for outgroup members. We also intended to study the role of perceived symbolic and realistic threat on mimicry of anger as a possible moderator of the group membership effect.

Contrary to what we expected based on literature, no group membership effect for facial mimicry of happiness, fear and sadness were found, and results showed stronger mimicry of anger displays by outgroup members than ingroup members. Interestingly, results also showed that perceived intergroup threat decreased the difference in mimicry of anger between social categories, expressed by an increase of mimicry of anger towards ingroups when intergroup threat was perceived, which was significant for realistic threat but not symbolic threat. In order to clarify these

results, we designed a second study to replicate these initial findings. In an experimental design we manipulated the perception of realistic intergroup threat to test its effect on mimicry of anger in an intergroup context.

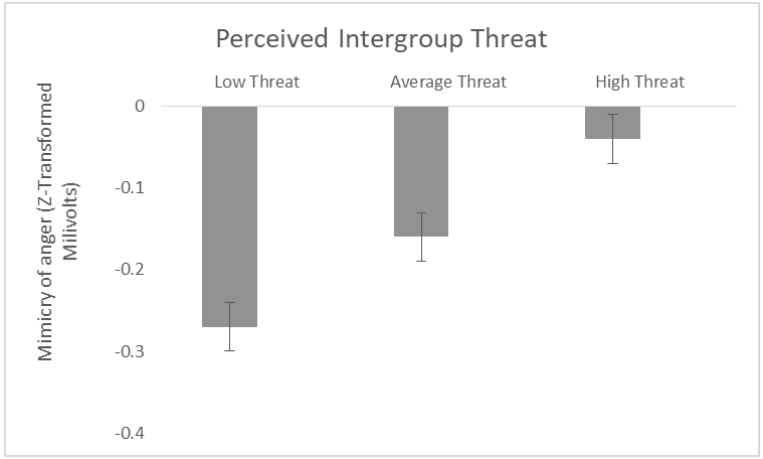

Figure 9: Average difference on mimicry of anger between ingroup and outgroup members under the perception of Intergroup Threat (Realistic and Symbolic Threat combined). Standard errors in the error bars.

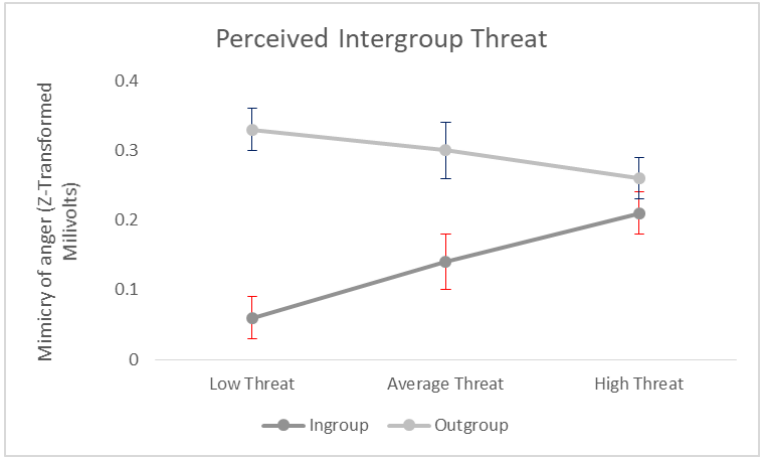

Figure 9.1: Moderation of mimicry of anger towards ingroup and outgroup members under the perception of Intergroup Threat (Realistic and Symbolic Threat combined). Standard errors in the error bars.

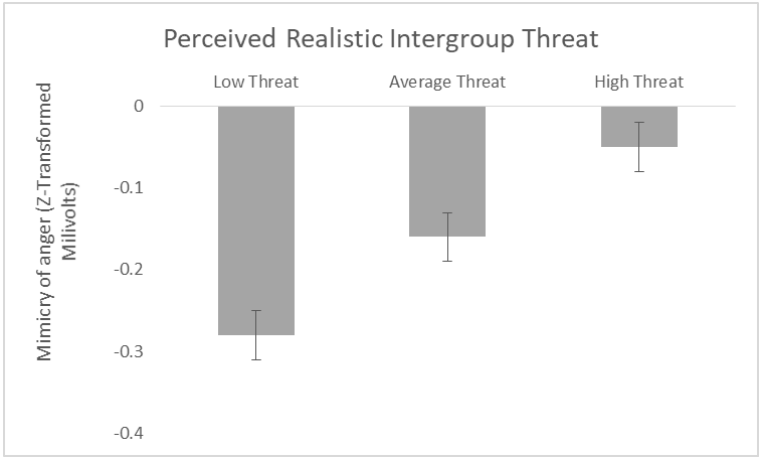

Figure 10: Average difference on mimicry of anger between ingroup and outgroup members under the perception of Realistic Intergroup Threat. Standard errors in the error bars.

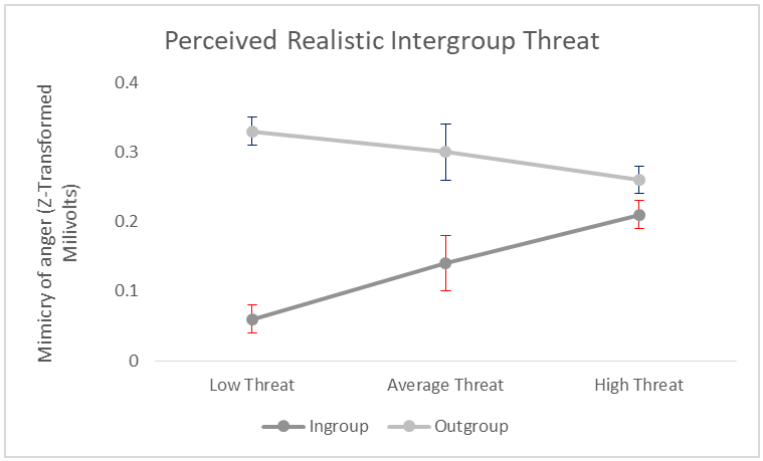

Figure 10.1: Moderation of mimicry of anger towards ingroup and outgroup members under the perception of Realistic Intergroup Threat. Standard errors in the error bars.

Study 2

This study aimed to replicate the findings from the previous study in a new design. In this study we manipulated the perception of intergroup threat by exposing participants to a realistic intergroup threat scenario. Participants were exposed to one of two possible scenarios. In the first scenario we showed a news report about Syrian refugee's arrival to Portugal (control). In the second scenario we induced the perception of realistic intergroup threat by showing the news report about Syrian refugees arriving in Portugal and their allegedly negative impact on the Portuguese economy (intergroup threat condition). We expected stronger mimicry of anger towards ingroup members when participants were exposed to the intergroup threat scenario than in the control condition.

Method

Design and sample size calculation

Ninety one participants took part in the study. Participants were recruited on the campus of a Portuguese university. Thirty-six of the participants were Psychology students that received a credit course for participation; the remaining participants were students and received a 10 euro voucher in exchange for their participation. Thirteen participants were excluded due to technical issues, such as electric noise or detached electrodes, during the data collection. Final analysis was conducted for data of 78 participants, 75 were White, one was Black, one was Asian, and one was mixed White/Black. Forty-nine were female and 29 were male, and their average age was 23.78 yrs (*SD* = 6.12). All participants were Portuguese, and none of the participants was Arab or indicated having an Arab origin.

The study used a mixed 2 (emotion: happiness vs. anger) x 2 (social category: Portuguese vs. Arabs) x 2 (threat perception: realistic intergroup threat vs. control) design with threat perception as between-subjects factor and the other factors within-subjects. Mimicry was assessed using f-EMG. In order to compute the necessary sample size to test the expectation that the difference in anger mimicry towards ingroup members versus outgroup members is moderated by the realistic intergroup threat manipulation, a power analysis was conducted based on an effect size for the effect of Study 1: adjusted R^2 = .04. G*Power 3.1 (Faul, et al., 2007) was used to conduct a power analysis on a mixed design (*F*-test, repeated measures, within and between subjects design).

Input parameters were: effect size $f = 0.20$, $\alpha = .05$, power = .80, number of groups = 2, number of measurements = 2, correlation among repeated measures = .5, and non-sphericity correction = 1 (Faul, et al., 2007). The output parameters resulting from this analysis showed that for a critical F of 4.03, a total sample size of 51 participants was required to achieve the statistical power of .80.

Stimuli

Participants were shown videos with dynamic facial expressions from the ADFES database's models with Mediterranean ancestry (van der Schalk, Hawk, et al., 2011) used in previous study. Models performed the displays of two emotions: anger and happiness.

Procedure

Participants were seated in front of a computer. Informed consent was obtained and a brief explanation about electrodes attachment and skin preparation was provided to each participant. The experiment consisted of three parts. The Qualtrics survey (Qualtrics, 2016) started by assessing demographic variables such as age, nationality and gender, followed by a mood assessment (Watson, et al., 1988) prior to facial mimicry measurement. All items were presented to participants in random order.

In the second part, participants were prepared to assess facial mimicry with facial electromyography (f-EMG). Then, before starting the mimicry measurement, participants were randomly allocated to one of two conditions of the threat perception manipulation: realistic intergroup threat vs. control. After the manipulation, participants were shown a set of videos as in the previous study and asked to indicate which emotional expression is presented. During the video presentation, participants' facial mimicry was assessed. The same experimental trials were presented as in Study 1. Each video lasted 6000 ms, however, the video remained frozen for an extra 4000 ms to prevent missing mimicry responses (as in Study 1, data collected during this additional 4000 ms were not included in the report of the final analysis because they did not add any relevant information). During stimulus presentation, f-EMG data was collected synchronized with stimulus onset and offset. Each trial ended with the decoding task for the presented emotion, as in Study 1.

Stimuli were shown in two different counterbalanced blocks, each block representing one social category condition. Emotional expressions were displayed in random order without replacement, and each video was displayed three times (12 stimuli per block and 24 stimuli in total).

In the third part, perceived intergroup threat (Stephan, et al., 1999) was assessed. Like in the previous study, questions about familiarity, liking, and perceived similarity of the target were presented (e.g., van der Schalk, et al., 2011). Finally, the participant was debriefed and thanked. In the debriefing several questions were asked to verify if the participant: 1) understood the purpose of f-EMG measurement, 2) if they noticed the social category, and 3) if they guessed the hypotheses. Due to the nature of the experimental manipulation, participants were fully clarified about the fake content that was inserted in the news used in the experimental manipulation. The experiment lasted 45 minutes on average.

Experimental Manipulation

News published in a Portuguese newspaper (*Diário de Notícias*) about the arrival of Syrian refuges in Portugal were adapted to the purpose of the study. The control condition presented the original news, which stated that Syrian immigrants were arriving in Lisbon and they would have the opportunity to access professional training and the job market. In the realistic intergroup threat condition fake information about realistic threat was added, such as "Portuguese are going to have an increase in their taxes", "Portuguese will have lower quality social services", "Portuguese will have to share educational and health services with Syrians", "Portuguese will have to compete in the job market with the refugees".

Control and realistic intergroup threat news were pre-tested for the Portuguese population. Twenty-three participants were asked to indicate how they felt about the arrival of Syrian refugees in Portugal. A set of questions were presented after each news: 1) "how much fear do you feel about the arrival of the Syrian refugees?", answers were provided on a scale from 1 "*not fearful"* to 10 "*very fearful*", ($M_{Control}$ = 6.80; *SD* = 0.83; M_{Threat} = 7.09; *SD* = 2.23); 2) "how threatened do you feel about the arrival of the Syrian refugees?", answers were provided on a scale from 1 "*not threatened"* to 10 "*very threatened",* ($M_{Control}$ = 5.92; *SD* = 2.07; M_{Threat} = 6.82; *SD* = 2.09); and 3) "how damaging do you think the arrival of Syrian refugees is for Portuguese?", answers were provided on a scale from 1 "*not damaging"* to 10 "*very damaging",* ($M_{Control}$ = 4.92; *SD* = 2.35;

M_{Threat} = 6.44; *SD* = 0.83). Higher scores suggest stronger fear, threat and perceived damage. A composite score was created by averaging responses to these three questions (α = .69, $M_{Control}$ = 5.88; *SD* = 1.44; M_{Threat} = 6.78; *SD* = 1.44; *U* = 89.50, *p* = .15, η^2 = .10). Despite the fact that the difference between the control and the threat condition was not significant, it was in the expected direction, and the effect size speaks in favor of differences between control and threat condition.

Facial EMG Measurement

Participants' skin was prepared, and electrodes were attached as in the previous study. The electrodes were placed to measure activity of the *Corrugator Supercilii* (which assesses the lowering of the eyebrow) and of the *Zigomaticus Major* (which measures the muscle activation caused by smiling behavior). *Corrugator Supercilii* activity was used as an indicator of facial mimicry for anger, and *Zigomaticus Major* activity was used as an indicator of facial mimicry for happiness (e.g., van der Schalk, et al., 2011; Hühnel, et al., 2014). The EMG signal was measured with a Biopac EMG amplifier, digitized with 24-bit resolution, sampled at 2 kHz, and recorded on a PC. After the data collection, the data was offline filtered with a 30–250 Hz band pass filter and a 50 Hz notch filter as data was collected in Europe (Biopac, 2019).

Measurements

Mood was assessed before the mimicry assessment with a Portuguese version of the Positive and Negative Affect Scale (PANAS) using a scale from 1 "*Completely disagree"* to 5 "*Completely disagree"* (Watson, et al., 1988; for the Portuguese version Galinha & Pais-Ribeiro, 2005). Positive mood (α = .77; *M* = 2.83; *SD* = 0.67) and negative mood (α = .83; *M* = 1.47; *SD* = 0.58) were calculated by averaging responses on the six items for each category. Positive mood comprised "determined", "excited", "interested", "enthusiastic", "charmed" and "warm". Negative mood comprised "irritated", "nervous", "scared", "fearful", "tormented" and "revulsion". Participants showed stronger positive mood than negative mood before mimicry measurement *t* (77) = 16.11, *p* < .001. Thus, mimicry was not reduced by a negative mood state.

Manipulation checks

Perceived realistic threat from Syrian refugees was assessed with Realistic Threat Scale as

in Study 1 (α = .79; *M* = 3.99; *SD* = 1.57) (Stephan, et al., 1999; for the Portuguese version: Murteira, 2020). Scale items assessed realistic threat perception in relation to Syrian refugees (e.g., with regard to crime, jobs, welfare). Participants provided their answers on a scale from 1 "*Completely disagree*" to 10 "*Completely agree*", where higher scores represent stronger perceived threat.

At the end of the experiment, participants were additionally asked to write some sentences about the news they have read in the experiment. All participants referred to the arrival of Syrians in Portugal.

Emotions decoding was assessed as in Study 1.

Familiarity, Similarity and Liking were assessed as in Study 1.

Other variables were assessed. However, they are out of the scope of this chapter. To consult them please see supplemental materials for Study 2 (Appendix 3).

Results

Manipulation checks

Perceived realistic threat from Syrian refugees. We expected stronger perceived *realistic threat* in the realistic intergroup threat condition than in the control condition. However, no statistically significant differences were found, t (77) = -1.38, p = .17, $M_{Control}$ = 3.66; *SD* = 1.59; M_{Threat} = 4.16; *SD* = 1.56, η^2 = .02. In order to maintain a more conservative approach to the test of the main hypotheses, we decided to continue analyzing the data-based on the tentative assumption that the manipulation was successful.

Emotions decoding. Emotion categorization for each display was analyzed with a 2 (displayed emotion: happiness vs. anger) x 4 (decoding emotion: happiness vs. sadness vs. anger vs. fear) x 2 (social category: Portuguese vs. Arabs) x 2 (threat condition: realistic intergroup threat vs. control) mixed GLM with threat condition as between-subjects factor and all other factors within-subject. When assumption of Sphericity was violated, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom. Main effects of displayed emotion, F (1, 76) = 8.92, p= .004, η^2 = .11, and decoding emotion, F (2.47, 187.61) = 44.95, p <. 001, η^2 = .37, were found. The main effect of social category was not significant, F (1, 76) = 2.20,

p=.14, η^2 = .03. The interaction displayed emotion x decoding emotion, F (2.35, 178.73) = 243.89, p < .001, η^2= .76 was significant. No effect of threat perception on emotion decoding was found, F (1, 76) = 1.59, p < .21, η^2 = .02.

Separate analyses for the four decoded emotions showed main effects of displayed emotion; thus, participants rated happiness displays as happier than the other displayed emotions , F (1,76) = 278.78, p < .001, η^2 = .79, and anger displays were rated as angrier than other presented emotions, F (1,76) = 106.5, p < .001, η^2 = .58. Also, participants rated happiness displays as happier than angry, sad or fearful, F (1,76) = 506.5, p < .001, η^2 = .87, and anger displays were rated as angrier than happy, sad or fearful, F (1,76) = 45.62, p < .001, η^2 = .38 (for detailed information about descriptive statistics please see Table 12 and Table 13).

Liking and Familiarity. Participants rated Arab targets as more likeable (M = 3.93, SD = 1.07) than Portuguese targets (M = 3.41, SD = 0.95), t (39) = 3.57, p < .001, which was unexpected. However, participants rated Arab targets as less familiar (M = 2.84, SD = 1.25) than Portuguese targets (M = 3.19, SD = 1.49), t (39) = -2.14, p <. 05, which would be consistent with a successful social category manipulation.

Similarity. Participants on average did not show differences in perceived similarity between Arab and Portuguese models.

Given the mixed results on these manipulation checks for social category, it was decided, following a conservative approach, to continue analyzing the data based on the assumption that the manipulation was successful.

Table 12:
Decoding for each emotion presented in Study 2.

Emotion Displayed	*Emotion* [o]	*Social Category* [o]	*Emotion x Social category* [o]
Happiness	F (1.59, 113.84) = 405.51, p < .001, η^2 = .84.	F (1, 77) = 2.12, p = .15, η^2 = .03	F (1.29, 98.30) = 693.09, p < .001, η^2 = .90
Anger	F (2.38, 181.15) = 42.46, p <. 001, η^2 = .36	F (1, 76) = 0.72, p = .40, η^2 = .01	F (2.48, 188.33) = 83.87, p < .001, η^2 = .53

Note: Assumption of Sphericity was violated, thus, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom.

[O] Omnibus effect for the Repeated Measures GLM (ANOVA) for each emotion separately: 4 (decoding emotions: happiness vs. sadness vs. anger vs. fear) x 2 (social category: Portuguese vs. Arabs) within-subject factors.

Table 13:
Descriptives of the decodings for each emotion presented in Study 2.

Emotion Displayed	Happiness	Anger
Decodings	*M (SE)*	*M (SE)*
Happiness	2.65 (0.04) [a]	1.80 (0.05) [a]
Anger	1.70 (0.03) [b]	2.36 (0.07) [b]
Sadness	1.71 (0.03) [b]	2.17 (0.08) [c]
Fear	1.74 (0.04) [b]	2.08 (0.08) [d]

[abcd] Decodings with different superscripts for each displayed emotion differ significantly from each other (p < .05, two-tailed) in pairwise comparisons.

Data treatment for EMG

Data extraction. Same data extraction and data treatment were performed as in Study 1 (for facial mimicry response across time please see Figure 11).

Data quality. A-prior contrasts were performed to test the quality of the data (Table 5). For happiness displays stronger activity of *Zygomaticus Major* than of *Corrugator Supercilii* was expected and observed for both ingroup and outgroup video displays. For anger the reverse pattern was expected also found for both ingroup and outgroup video displays.

Table 14:
Data quality per emotion and social category for Study 2.

Ingroup members			
	Zigomatic Major *M (SD)*	*Corrugator Supercilii* *M (SD)*	*t*
Displays			
Happiness	0.03 (0.38)	-0.31 (0.38)	t (77) = -5.22, p < .001
Anger	-0.02 (0.37)	0.31 (0.29)	t (77) = 5.55, p < .001
Outgroup members			
	Zigomatic Major *M (SD)*	*Corrugator Supercilii* *M (SD)*	*t*
Displays			
Happiness	0.11 (0.38)	-0.28 (0.34)	t (77) = -6.65, p < .001
Anger	-0.13 (0.33)	0.29 (0.36)	t (77) = 7.66, p < .001

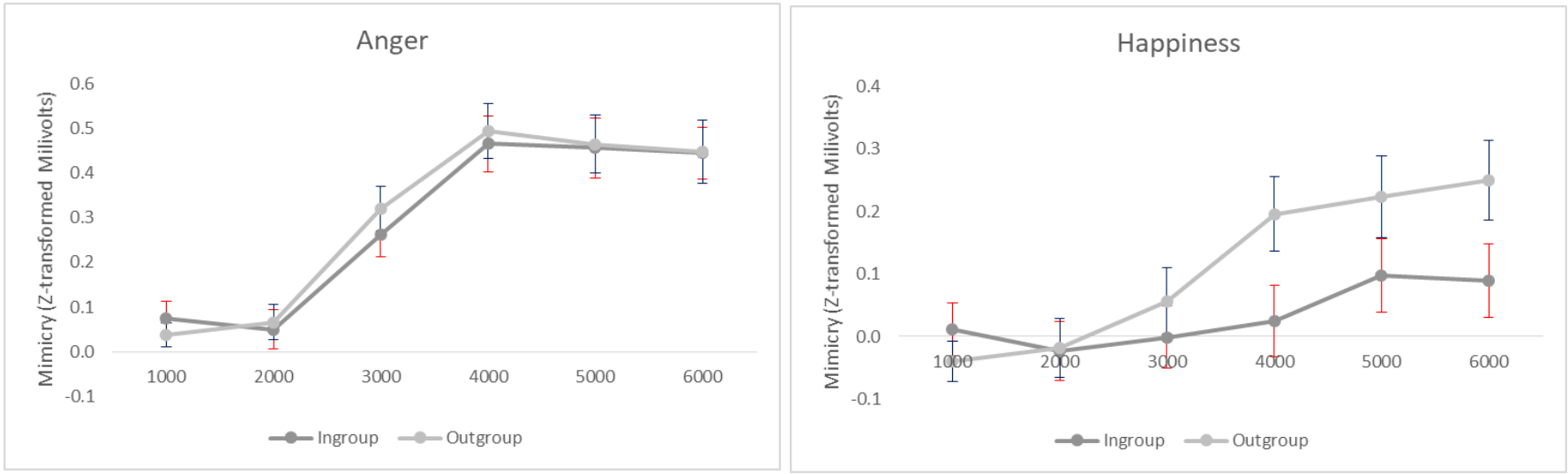

Figure 11: Mimicry response between ingroup and outgroup members by relevant muscle activation in Happiness (*Zigomatic Major*) and Anger (*Corrugator Supercilii*) displays across video length (6000 ms), Study 2. Each time point is the mean activation of each 1000 ms interval, for instance, at 1000 ms it is average activation between 0 and 1000 ms.Standard errors in the error bars.

Analysis of EMG data

Zigomatic Major. To assess the effect of social category and emotion on *Zigomatic Major* muscle activation, a Repeated Measures GLM was run using 3 factors: 2 (displayed emotion: happiness vs. anger) x 2 (social category: Portuguese vs. Arabs) within-subjects x 2 (threat condition: realistic threat vs. control) between-subjects design. The main effect of social category was not significant F (1, 76) = 0.025, p = .88, η^2 = 0.00. A significant effect of emotion was found, F (1, 76) = 1.36, p = .25, η^2 = 0.02. The 2-way interaction between emotion and intergroup threat, F(1, 76) = 1.37, p = .25, η^2 = 0.02, and social category and intergroup threat, F (1, 76) = 2.04, p = .16, η^2 = 0.03, were not significant. The interaction between emotion and social category was significant F (1, 76) = 4.40, p = .04, η^2 = 0.06. Pairwise comparisons showed significant mean differences on *Zigomatic* activation between anger and happiness displays (M_{Anger} = -0.07, SE_{Anger} = 0.03, $M_{Happiness}$ = 0.07, $SE_{Happiness}$ = 0.03, p = .007), but no mean differences between social categories were found per emotion (Anger: $M_{Ingroup}$ = -0.02, $SE_{Ingroup}$ = 0.04, $M_{Outgroup}$ = -0.12, $SE_{Outgroup}$ = 0.04, p = .11; Happiness: $M_{Ingroup}$ = 0.03, $SE_{Ingroup}$ = 0.04, $M_{Outgroup}$ = 0.11, $SE_{Outgroup}$ = 0.04, p = .26 (Figure 12). Finally a 3-way interaction between emotion, social category and intergroup threat was not significant, F (1, 76) = 1.16, p = .29, η^2 = .02. No significant between-subjects effect of intergroup threat, F (1, 76) = 0.04, p = .84, η^2 = .00, was found. However, pairwise comparisons showed mean differences for mimicry of anger between social categories for the control condition, but not for the intergroup threat condition (Control: $M_{Ingroup}$ = 0.01, $SE_{Ingroup}$ = 0.06, $M_{Outgroup}$ = -0.21, $SE_{Outgroup}$ = 0.05, p = .01; Intergroup Threat: $M_{Ingroup}$ = -0.05, $SE_{Ingroup}$ = 0.06, $M_{Outgroup}$ = -0.03, $SE_{Outgroup}$ = 0.05, p = .81), no differences on mimicry of happiness between social categories were found across intergroup threat conditions (Control: $M_{Ingroup}$ = 0.07, $SE_{Ingroup}$ = 0.06, $M_{Outgroup}$ = 0.13, $SE_{Outgroup}$ = 0.06, p = .58; Intergroup Threat: $M_{Ingroup}$ = -0.01, $SE_{Ingroup}$ = 0.06, $M_{Outgroup}$ = 0.09, $SE_{Outgroup}$ = 0.06, p = .31). Also, pairwise comparisons showed no differences for mimicry of anger of ingroup members between intergroup threat conditions ($M_{Conrtol}$ = 0.01, $SE_{Control}$ = 0.06; $M_{Intergroup\ Threat}$ = -0.05, $SE_{Intergroup\ Threat}$ = 0.06, p = .49), and no mean differences for outgroup members ($M_{Conrtol}$ = -0.21, $SE_{Control}$ = 0.05; $M_{Intergroup\ Threat}$ = -0.03, $SE_{Intergroup\ Threat}$ = 0.05, p = .32), no differences on mimicry of happiness were found across intergroup threat conditions for ingroup members ($M_{Conrtol}$ = 0.07, $SE_{Control}$ = 0.06; $M_{Intergroup\ Threat}$ = -0.01, $SE_{Intergroup\ Threat}$ = 0.06, p = .32), and for outgroup members ($M_{Conrtol}$ = 0.13, $SE_{Control}$ = 0.06; $M_{Intergroup\ Threat}$ = 0.09, $SE_{Intergroup\ Threat}$ = 0.06, p = .70).

Corrugator Supercilii. To assess the effect of social category and displayed emotion on *Corrugator Supercilii* activation, we conducted the same Repeated Measures GLM, but with *Corrugator* activation as the dependent variable. The main effect of social category, F (1, 76) = 0.00, p = .99, η^2 = 0.00, and intergroup threat, F (1, 76) = 0.71, p = .40, η^2 = 0.01, were not significant. A significant effect of emotion was found, F (1, 76) = 127.59, p < .001, η^2 = 0.63. Pairwise comparisons showed significant mean differences on *Corrugator* activation between anger and happiness displays (M_{Anger} = 0.30, SE_{Anger} = 0.03, $M_{Happiness}$ = -0.30, $SE_{Happiness}$ = 0.03, p <. 001). The 2-way interaction between emotion and intergroup threat, F (1, 76) = 0.33, p=.57, η^2= 0.00, and social category and intergroup threat, F (1, 76) = 1.30, p=.26, η^2 = 0.02, and emotion and social category, F (1, 76) = 0.40, p=.53, η^2 = 0.01, were not significant. Finally, the 3-way interaction between emotion, social category and intergroup threat was not significant, F (1, 76) = 0.65, p=.42, η^2 = .01. Pairwise comparisons showed no differences for mimicry of anger between social categories across intergroup threat conditions (Control: $M_{Ingroup}$ = 0.26, $SE_{Ingroup}$ = 0.05, $M_{Outgroup}$ = 0.32, $SE_{Outgroup}$ = 0.06, p = .39; Intergroup Threat: $M_{Ingroup}$ = 0.36, $SE_{Ingroup}$ = 0.05, $M_{Outgroup}$ = 0.26, $SE_{Outgroup}$ = 0.06, p = .19), no differences on mimicry of happiness between social categories were found across intergroup threat conditions (Control: $M_{Ingroup}$ = -0.31, $SE_{Ingroup}$ = 0.06, $M_{Outgroup}$ = 0.13, $SE_{Outgroup}$ = 0.06, p = .56; Intergroup Threat: $M_{Ingroup}$=-0.26, $SE_{Ingroup}$= 0.05, $M_{Outgroup}$= -0.32, $SE_{Outgroup}$=0.06, p = .93). Also, pairwise comparisons showed marginal mean differences for mimicry of anger of ingroup members between intergroup threat conditions ($M_{Conrtol}$ = 0.26, $SE_{Control}$ = 0.05; $M_{Intergroup\ Threat}$ = 0.36, $SE_{Intergroup\ Threat}$ = 0.05, p = .10), but no mean differences for outgroup members ($M_{Conrtol}$ = 0.32, $SE_{Control}$ = 0.06; $M_{Intergroup\ Threat}$ = 0.26, $SE_{Intergroup\ Threat}$ = 0.06, p = .53); no differences on mimicry of happiness were found across intergroup threat conditions for either ingroup members ($M_{Conrtol}$ = -0.31, $SE_{Control}$ = 0.06; $M_{Intergroup\ Threat}$ = -0.31, $SE_{Intergroup\ Threat}$ = 0.06, p = .97), or outgroup members ($M_{Conrtol}$ = 0.06, $SE_{Control}$ = 0.08; $M_{Intergroup\ Threat}$ =-0.06, $SE_{Intergroup\ Threat}$ = 0.08, p = .43).

The predicted interaction between emotion, social category and perceived intergroup threat was not significant; however, the valence of emotions in the analysis are different, which may confound the results. For the sake of simplicity, a Repeated Measures GLM was conducted to analyze the effect of social category on mimicry of anger with social category (Portuguese vs. Arabs) as within-subject factor and intergroup threat (realistic threat condition vs. control

condition) as between subject factor. No main effect of social category, F (1, 76) = 0.14, p = .71, η^2 = 0.00, and intergroup threat, F (1, 76) = 0.30 p = .59, η^2 = 0.01, were found. Also, the 2-way interaction between social category and intergroup threat was not significant, F (1, 76) = 2.42, p=.12, η^2 = 0.03. As expected, pairwise comparisons showed marginal mean differences for mimicry of anger of ingroup members across intergroup threat conditions ($M_{Conrtol}$ = 0.26, $SE_{Control}$ = 0.05; $M_{Intergroup\ Threat}$ = 0.36, $SE_{Intergroup\ Threat}$ = 0.05, F (1, 76) = 2.73, p = .10, η^2 = 0.04), but no mean differences for outgroup members ($M_{Conrtol}$ = 0.32, $SE_{Control}$ = 0.06; $M_{Intergroup\ Threat}$ = 0.26, $SE_{Intergroup\ Threat}$ = 0.06, F (1, 76) = 0.40, p = .53, η^2 = 0.01) (Figure 10).

From the analysis on muscle activity on *Zigomatic Major* and *Corrugator Supercilii*, it is possible to conclude that there are no differences in the strength of mimicry between ingroup and outgroup members in response to happiness and anger displays across intergroup threat conditions. Also, results showed that participants tended to mimic anger from ingroup members more in the perceived realistic intergroup threat condition than in the control condition.

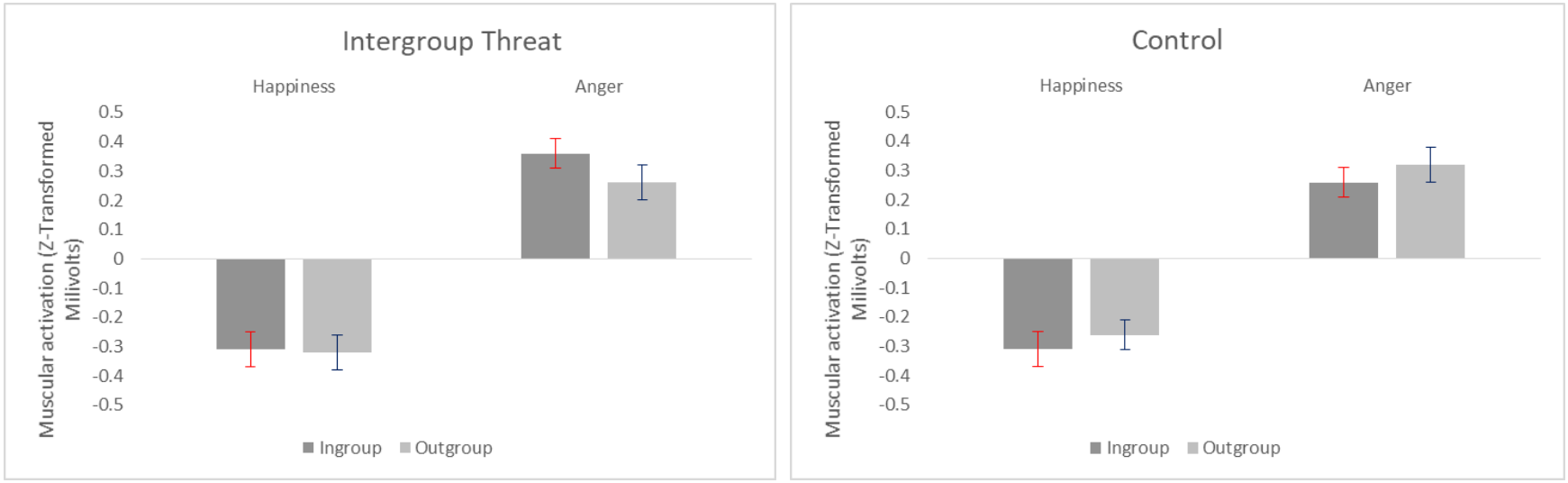

Figure 12: Mean activation of *Corrugator Supercilii* muscle in Happiness and Anger displays across intergroup threat manipulations, Study 2. Standard errors in the error bars.

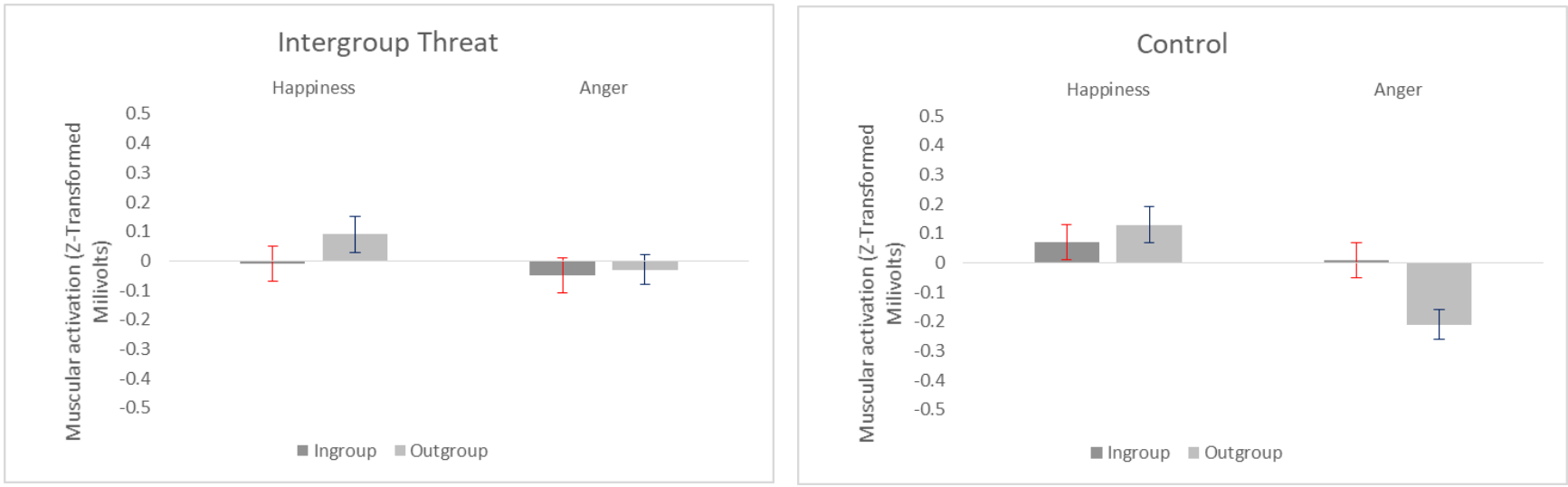

Figure 13: Mean activation of *Zigomatic Major*muscle in Happiness and Anger displays across intergroup threat manipulations, Study 2. Standard errors in the error bars.

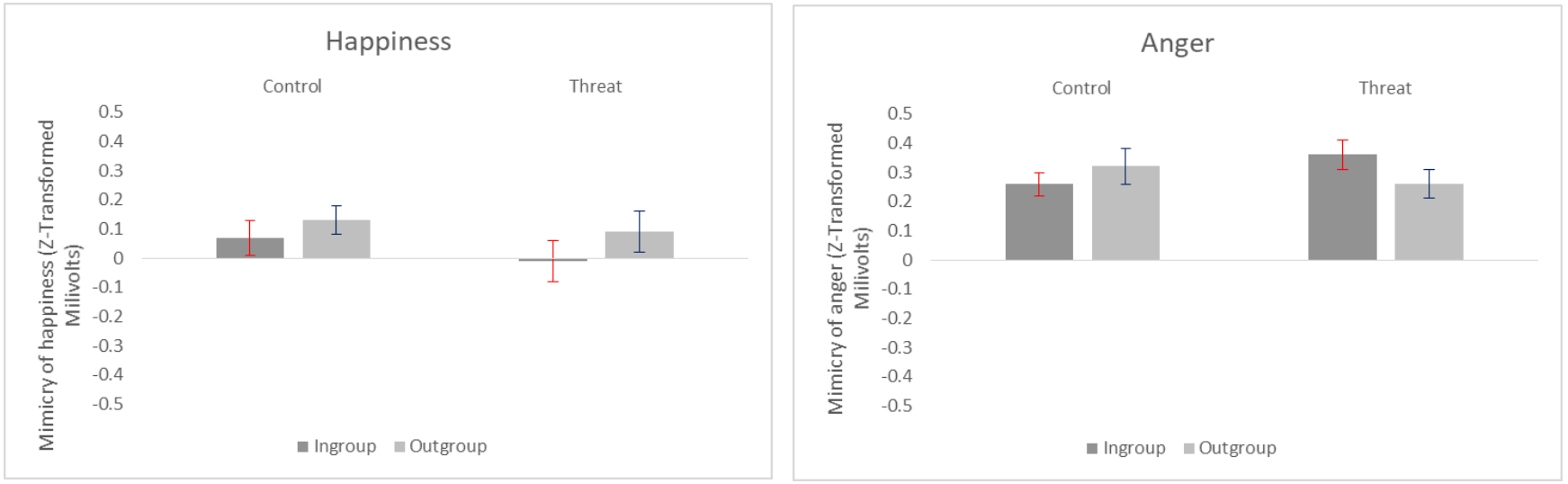

Figure 14: Average mimicry response by relevant muscle activation in Happiness (*Zigomatic Major*) and Anger displays (*Corrugator Supercilii*) for Control and Perceived Intergroup Threat condition, Study 2. Standard errors in the error bars.

Discussion of Study 2

In this study we examined how facial mimicry of happiness and anger varies in intergroup relations, and we also aimed to test experimentally how perceived realistic intergroup threat affects the difference in facial mimicry of anger towards ingroup vs. outgroup members. The previous study showed that perception of realistic intergroup threat increased mimicry of anger towards ingroups vs. outgroup members. Individuals tended to mimic ingroup anger more when realistic intergroup threat was perceived. To replicate this finding, we created an experimental design to manipulate the perception of realistic intergroup threat and to test the effect of this manipulation on mimicry of anger shown by ingroup vs. outgroup faces. Participants were exposed to a realistic threat condition or a control condition. As expected, results showed the absence of group membership effects for the mimicry of happiness, independently of the experimental manipulation.

We replicated the interaction between social category and intergroup threat for anger mimicry. As expected, participants mimicked the anger of ingroup members, but not of outgroup members, more in the realistic threat condition than in the control condition. Results from Study 1 were replicated. Thus, one could say that the perception of realistic intergroup threat moderates the difference in mimicry of anger between ingroup and outgroup members.

General Discussion

Facial mimicry is the unconscious and automatic imitation of other people's facial expressions (Chartrand & Lakin, 2013; Duffy & Chartrand, 2015). Facial mimicry has been suggested to be related to functions such as affiliation and emotional decoding of other people's states (Murteira & Waldzus, 2020a). In the literature on mimicry functions, intergroup relations have been used as proxy to assess how facial mimicry is related to an affiliative function. Some studies showed that individuals have the tendency to mimic ingroup members more than outgroup members, which has been interpreted as evidence for the affiliative function of mimicry. However, our meta-analysis showed that the group membership effect on facial mimicry is only reliable for facial mimicry of anger, but not for sadness, happiness, disgust or fear (Murteira & Waldzus, 2020b). Moreover, the small effect size, together with the heterogeneity of the results on the group membership effects, raised doubts about the affiliative role of facial mimicry. One way to address this ambiguity is to look at what may be moderating

the group membership effect on facial mimicry. For that purpose, two studies were designed to assess how facial mimicry varies in intergroup relations and how perceived intergroup threat may moderate this effect. It is well known that stressful events and perception of threat are related to an increase in affiliative behaviors (e.g., Sarnoff & Zimbardo, 1961; Smeets, et al., 2009; Taylor, et al., 2000; Fay & Maner, 2015; Gump & Kulik, 1997; White, et al., 2012). One could therefore expect that perception of intergroup threat could moderate the relationship between the group membership of the target (ingroup versus outgroup) and the degree of facial mimicry, as under threat individuals also aim for affiliation with similar individuals that are experiencing the threat (Kulik & Mahler, 2000). Thus, if facial mimicry is related to affiliation, then it should increase especially towards ingroup members when intergroup threat is perceived.

Study 1 assessed the facial mimicry of happiness, sadness, fear and anger, and how it varies as a function of group membership in intergroup relations. Consistent with previous research, results showed the absence of a group membership effect for happiness, fear and sadness displays. Contrary to previous results, mimicry of anger was stronger towards outgroup members than toward ingroup members. Yet, consistent with the assumption of an affiliation function of mimicry, this difference was reduced under realistic intergroup threat, because, as expected, participants perceiving stronger realistic intergroup threat tended to mimic ingroup anger more. The same was not found for symbolic threat.

Study 2 was designed to replicate previous findings. Facial mimicry of happiness and anger in intergroup relations was assessed in an experimental design manipulating the perception of intergroup threat. Participants were exposed to a realistic threat condition or to a control condition. Prior findings were partially replicated. Results showed an absence of the group membership effect for happiness independently of the experimental manipulation. Moreover, we found again the interaction between the group membership effect on mimicry of anger and realistic threat. More precisely, intergroup threat increased, though only marginally, mimicry of ingroup anger but not of outgroup anger.

Altogether, these results seem to show that individuals mimic anger differently, depending on the group membership of the target and that the perception of threat can increase the mimicry of anger towards ingroup members while not increasing the mimicry of anger towards outgroup members. This result may be interpreted as at least some evidence for the affiliative function of facial mimicry because it is probably related to an increased affiliative need caused by the perceived threat (Kulik & Mahler, 2000). However, several questions remain unclear. First, if facial mimicry is related to affiliation, it is not clear why mimicry of

fear, happiness and sadness are not moderated by the group membership attributed to the models. Second, considering that anger is a competitive and non-affiliative emotion compared to previous emotions studied, it is not clear why the group membership effect arises in mimicry of anger only and why the moderation by perceived intergroup threat is only significant for mimicry of anger too.

Some authors consider that the absence of the group membership effect on mimicry of happiness may be due to the nature of happiness. Happiness is an affiliative emotion even in intergroup contexts that does not bring high social costs for the self and for the group (Bourgeois & Hess, 2008; Fischer & Hess, 2014). However, sadness and fear are costly emotion as they imply allocation of cognitive resources to empathize with that sadness and fear (Fischer & Hess, 2014). Thus, the costliness explanation cannot explain the lack of a group membership effect on the mimicry of sadness and fear, which indeed renders the suggested affiliative function of facial mimicry problematic. The current research cannot solve this problem with regard to sadness and fear mimicry.

It can, however, contribute to the clarification of the affiliative function of anger mimicry. Anger in itself is a non-affiliative emotion. Anger causes tension and discomfort in people. Mimicry of anger may signal an intention to not affiliate, to exclude and to be aggressive towards the mimicked person (Bourgeois & Hess, 2008; Hess & Fischer, 2013). It is therefore rather contradictory to the affiliation hypotheses that previous results showed stronger anger mimicry towards ingroup than towards outgroup members. However, the results of Studies 1 and 2 showed an increase in mimicry of anger towards ingroup members under perception of intergroup threat. Considering previous research that supports the idea that stressful events and perception of threat are related to an increase of the need to affiliate with others, these results rather suggests that mimicry of anger can under certain circumstances work as an affiliative strategy towards ingroup members. Thus, whether mimicry of anger implies affiliation or the opposite might depend on the particular context. The perception of intergroup threat seems to be such a contextual setting that triggers a need to affiliate with the group, and to be in tune with other ingroup members to surmount the jeopardize against the group.

Whereas the results of these studies can in that way indeed provide at least some support for the affiliative function of facial mimicry, they could, however, also be explained by an alternative explanation referring to the nature of the power-relation between the groups. Given the conflict-escalating implications of anger expressions, group members might be less inhibited to mimic anger towards less powerful targets than towards more powerful targets. Depending on the perceived power-relation between ingroup and outgroup, that may result in

stronger or weaker mimicry towards ingroup than towards outgroup members. More importantly, the perception of intergroup threat might lower the perceived power of the ingroup and therefore increase mimicry towards ingroup members.

To sum up, the reported studies suggest that mimicry of anger is moderated by perceived intergroup threat, this result can be either explained by the need to affiliate with ingroup members or by the threat-induced loss of power attributed to ingroup members. As these two possible underlying mechanisms are confounded in the variation of intergroup threat, they cannot be disentangled with the paradigm used in these studies. Thus, to better understand if mimicry of anger is an affiliative mechanism, we suggest that using perceived ingroup threat could help solve this dilemma. Under ingroup threat, such as being rejected or ostracized, individuals have a strong need to affiliate (e.g., Williams, 2007), but at the same time this should increase rather than decrease the power attributed to ingroup members. Perceived rejection from ingroup members should increase the need to re-affiliate with them, but not reduce the motivation to inhibit anger expressions due to their conflict-escalating consequences. That implies that increase in mimicry of ingroup anger as a result of perceived ingroup threat would rule out the power-related alternative explanation. Thus, experiments manipulating perceived ingroup threat could shed some light on the affiliative function of facial mimicry.

Limitations and future directions

Study 1 and 2 have measured mimicry using f-EMG technique. It has been pointed out by some authors that f-EMG in emotions such as anger may show limitations. Lower activity in *Zygomaticus Major* and high activity in *Corrugator Supercilii* characterizes anger and sadness mimicry (e.g., Hühnel, et al., 2014; van der Schalk, et al., 2011). When mimicry is assessed by electromyography, it is assumed that the muscles' activation is related with the emotion that is displayed. However, that assumption might be wrong under certain circumstances. A high activity in *Corrugator Supercilii* may be due to attentional processes, annoyance, fear, sadness or anger (Ekman & Friesen, 2003; Seibt, et al., 2015). The activation of *Corrugator Supercilii* may even be due to the deactivation of *Zigomaticus Major* when the participant smiles.

Given that we found the evidence for the interaction between the group membership effect on anger mimicry and intergroup threat only in the f-EMG studies, results should be interpreted with caution and new studies testing this interaction should be conducted to better understand the role of mimicry of anger in intergroup contexts.

It is also recommended for future studies to avoid ambiguous intergroup contexts and to control the familiarity and affinity with outgroup members, so that the absence of a group membership effect on anger mimicry can be interpreted unequivocally.

Chapter 8

Mimicry of anger in intergroup relations: the impact of perceived ingroup threat

Abstract

Facial mimicry is the automatic and unconscious mirroring of emotional facial expressions. Facial mimicry is suggested to be related to emotional decoding and affiliation between individuals during social interactions. However, there is little evidence for its affiliative nature. Research on mimicry in intergroup relations suggests that individuals mimic ingroup anger more than outgroup anger due to affiliation needs, but small effect sizes, together with large heterogeneity, indicate that we need to understand better facial anger mimicry in intergroup relations and its role in affiliation. To do this, we designed a study to assess anger mimicry in intergroup relations and test how it is moderated by the perception of ingroup threat. We tested two competing hypotheses, predicting that being ostracized by ingroup members will either (1) increase (increased affiliation need hypothesis) or (2) decrease (perceived reduced power hypothesis) facial anger mimicry towards ingroup members, but, not outgroup members. Results do not support the increased affiliation need hypothesis, but rather speak more in favor of the reduced power hypothesis. We conclude that mimicry in intergroup relations does not provide convincing evidence for the affiliation function of facial mimicry.

Keywords: facial mimicry, ingroup threat, ostracism, anger, affiliation, ostracism

CHAPTER 8

Mimicry of anger in intergroup relations: the impact of perceived ingroup threat

Mutual understanding and sharing of experiences is paramount for human sociability. Mimicry has evolved as a form of synchronism that allows individuals to share feelings and emotions (Oatley, 2016). Facial mimicry is the automatic and unconscious mirroring of emotional expressions in the face (Hess & Fischer, 2013; Seibt, et al., 2015) and it is a process that helps individuals to share their minds with others so as to build the aforementioned mutual understanding and even the sense of belonging.

Mimicry is considered to be related to affiliation and emotional decoding. However, the lack of evidence for the relationship between affiliation and facial mimicry calls for further studies for clarification (Murteira & Waldzus, 2020a). Studies on facial mimicry in intergroup relations may work as a good proxy to assess the role of facial mimicry in affiliation. Individuals have a stronger need to belong to ingroups than to outgroups (e.g., Baumeister & Leary, 1995; Duranton & Gaunet, 2016; Leary, et al., 2013; Kavanagh & Winkielman, 2016), therefore, if facial mimicry is related to affiliation, one could expect to find stronger facial mimicry towards ingroup members than outgroup members (Kavanagh & Winkielman, 2016).

Facial mimicry is affected by intergroup relations (Murteira & Waldzus, 2020b). However, the group membership effect is only reliable for mimicry of anger. Sadness, happiness, disgust, and fear are not affected by group membership, which in itself raises some doubts about the affiliation function of facial mimicry. Moreover, heterogeneity across studies, especially for mimicry of anger, was found. Some studies showed increased mimicry of anger towards ingroups vs. outgroups, while others showed the opposite effect (Murteira & Waldzus, 2020b). Such variability calls for moderation studies to understand what changes the extent of mimicry of anger in intergroup relations.

Perceived intergroup threat moderates the effect of group membership on mimicry of anger. As stress and social threat studies suggest, people under threat show an increased need to affiliate with others (e.g., Gump & Kulik, 1997; Fay & Maner, 2015; Sarnoff & Zimbardo, 1961; Smeets, et al., 2009; Taylor, et al., 2000; White, et al., 2012), which would be especially strong towards ingroup members compared to outgroup members due to the similarities between ingroup members (Mahler & Kulik, 2000). Indeed, in two studies reported in chapter 7 individuals showed an increased mimicry of anger towards ingroup members but not towards outgroup members when they perceived intergroup threat towards ingroup members. More precisely, we designed two studies to assess how facial mimicry is related to affiliation. For

that we assessed how facial mimicry varied between ingroup and outgroup faces, and how this variation was moderated by perception of intergroup threat. From this set of two studies, we concluded that individuals mimic outgroup members' anger more than ingroup members' anger, and that this difference decreases as a function of perceived intergroup threat. Individuals under perceived intergroup threat increased their mimicry of anger towards ingroup members. While those results seem to suggest that facial mimicry is related to affiliation, they also suggest that this only occurs under special circumstances such as perceived intergroup threat.

More problematically, these results could also be explained by an alternative hypothesis: they could be due to possible perceived power differences between ingroup and outgroup members arising from the perceived intergroup threat manipulated in those studies. Expressions of anger can provoke an escalation of conflict, which one might prefer to avoid when facing powerful others from one's own powerless position. Indeed, studies on facial mimicry and hierarchical relations conducted by Carr and colleagues (2014) showed that powerless individuals mimicked happiness towards both powerless and powerful individuals; however, anger was mimicked if shown by powerless individuals only. Taking into account the conflict-escalating implications of anger expressions, it is not surprising that mimicry of anger is reduced towards powerful individuals. In the studies reported in chapter 6, when individuals perceived strong intergroup threat, they showed increased mimicry of anger towards ingroup members. That is suggestive of reduced inhibition of anger expression towards them due to a perception of ingroup members' lack of power towards threatening outgroup members. One limitation of the studies in chapter 7 is that intergroup threat is necessarily confounded with reduced ingroup power. Thus, the alternative hypothesis related to perceived power could not be dismissed without proper testing with a design that disentangles increase in threat from decrease in power attributed to the ingroup targets of mimicry, which is one of the objectives of the studies in the current chapter.

To clarify whether facial mimicry of anger towards ingroup members under perceived threat is related to a need for affiliation or related to participants' empowerment in face of ingroup targets, we designed a study to assess how perceived ingroup threat (i.e., being threatened by ingroup members) affects the group membership effect in anger mimicry. Thus, we test the novel hypothesis that the group membership differences in mimicry of anger are moderated by the perception of ingroup threat, such as being ostracized by ingroup members. By manipulating ingroup threat instead of intergroup threat we reverse the relation between threat and implied changes in relative power. That is, whereas it is plausible to assume that intergroup threat may negatively affect ingroup members' power when facing threats from the

outgroup, and thereby empower participants in face of ingroup members, we assume that the opposite would apply to ingroup threat. That is, we expect that higher threat towards oneself coming from ingroup members is associated with a decrease in one's own power towards them. That should lead to stronger inhibition of anger expressions, resulting in decreased anger mimicry. It is worth mentioning that the powerless feelings that arise from ostracism are certainly different from the ones related to hierarchical structures, such as in the boss-employee relationships (Carr, et al., 2014). When individuals are ostracized their mood, sense of control, meaningful existence and self-esteem decrease, therefore, these are forms of feelings of powerlessness related to a fear of social death (Williams, 2007). However, if anything, these particularly intensive emotional implications of ostracism should lead to even stronger effects on facial mimicry than those of hierarchical structures.

We expect to find stronger mimicry of anger towards ingroup members under ingroup threat as a result of increased affiliation needs. In contrast, we expect to find weaker mimicry of anger towards ingroup members under ingroup threat as a result of reduced perceived own power when in face of threatening ingroup members. By contrasting these two competitive expected outcomes we can disambiguate the threat effects on intergroup anger mimicry, because changes as result of the threat manipulation can be evidence for either need for affiliation (increased ingroup mimicry) or (dis-)empowerment (decreased ingroup mimicry) affecting ingroup anger mimicry, but not both. We tested the two counter-hypotheses by applying an ostracism paradigm to manipulate perceived ingroup threat and its effects on facial mimicry in intergroup relations.

Ostracism and powerless feelings on facial mimicry

Stressful situations and perceived threat are related to an increase in the need to affiliate and affiliative behaviors (Fay & Maner, 2015; Sarnoff & Zimbardo, 1961; Taylor, et al., 2000; Smeets, et al., 2009; Tomova, von Dawans, Heinrichs, Silani, & Lamm, 2014; White, et al., 2012), such as facial mimicry (Gump & Kulik, 1997). As self and group protection behaviors increase, a strong need for affiliation accompanies those behavioral changes, especially towards similarly threatened people (Kulik & Mahler, 2000) such as ingroup members (Chapter 7). Some studies have experimentally induced socially threatening events as a form of danger or physical threats (for a review please see Kulik & Mahler, 2000), and few studies have assessed the effect of ostracism on mimicry behaviors (e.g., Lakin, et al., 2008; Hühnel, et al., 2018; Kowamoto, Nittono, & Ura, 2014).

The need to affiliate with and belong to others is one of the most fundamental needs (Baumeister & Leary, 1995), and it is as important as other basic biological needs, such as food (Baumeister & Leary, 1995; Maslow, 1943). Any form of social exclusion is related to negative affect, perceived threat to basic needs, such as belonging, self-esteem, control, and meaningful existence (Baumeister, Smart, & Boden, 1996; Leary, Twenge, & Quinlivan, 2006). Thus, it is not surprising that being apart from others causes stress and brings pain and behavioural changes such as re-affiliative behaviors to surmount that pain, as well as feelings of powerlessness (Wesselmann, et al., 2016).

Unconscious and automatic affiliative behaviours, such as behavioural and facial mimicry, increase after ostracism (Williams, 2007; Williams & Nida, 2011; for behavioural mimicry: Lakin & Chartrand, 2005; for facial mimicry: Kowamoto, et al., 2014; for facial imitation[12]; Cheung, at al., 2015). Nevertheless, not all people are equally selected to re-affiliate. The sense of identity that arises from social groups brings certainty about what is expected and how to behave in the social world, especially towards ingroup and outgroup members (Bernstein, 2016; Hogg, 1993; Hogg & Smith, 2007; Hornsey, 2008; Tajfel, 1982), which fosters the need for belonging and affiliate to the relevant social group. Therefore, it is not surprising that the *need for belonging* improves mimicry towards ingroup vs. outgroup members as it is driven by the goal to affiliate with one's own group (Lakin, et al., 2008). Indeed, some studies showed that individuals increase behavioral mimicry towards ingroup members after being ostracized by other online players in a cyberball game, compared to outgroup members (e.g., Lakin & Chartrand, 2005; Lakin, et al., 2008, 2013). While this evidence from behavioral mimicry studies suggests that ostracism increases mimicry behaviors, especially towards ingroup members, the same effect is not reported for facial mimicry studies.

In facial mimicry studies, different emotions have been considered in the analysis of how facial mimicry in intergroup relations would vary after ostracism. Despite the fact that facial mimicry increases overall after ostracism compared to inclusion scenarios for happiness and disgust expressions (Kowamoto, et al., 2014), when an intergroup context is considered the results are quite different. In a facial mimicry study using a cyberball game to manipulate the sense of belonging, facial mimicry of happiness, sadness, anger and disgust were assessed (Hühnel, et al., 2018). Distinct from other cyberball paradigms, the authors used ingroup and

[12] Imitation and mimicry are mirroring behaviors, however the level of automaticity, consciousness, controllability and intentionality are different, thus we consider that mimicry and imitation are not the same mirroring phenomena, however, for some research questions we could consider that imitation may be a proxy for mimicry (for a review please see Murteira & Waldzus, 2020c).

outgroup members in the game to design two conditions: 1) complete exclusion where the participant was excluded by the ingroup and the outgroup members, and 2) a partial exclusion where the participant was excluded only by the ingroup members and included by the outgroup member. Results showed no differences for facial mimicry of happiness, anger, sadness and disgust between groups in the complete ostracism condition. In the partial ostracism condition, outgroup members were even more facially mimicked than ingroup members on negative emotions (Hühnel, et al., 2018). While results support the authors' proposal that increased liking of the including outgroup members in the partial exclusion condition may have increased mimicking of their negative emotions, the absence of a group effect in the complete exclusion condition is surprising because affiliation theories would predict stronger facial mimicry of ingroup members vs. outgroup members, as individuals tend to affiliate with individuals that share similarities, especially after being ostracized. Unfortunately, in Hühnel and colleagues (2018) the absence of an inclusion condition does not allow us to compare if facial mimicry increased after ostracism or not and whether ostracism would moderate how the intergroup context shapes facial mimicry. Thus, these questions still need to be investigated.

To sum up, we aim to verify if facial mimicry of anger varies in intergroup relations after individuals are either ostracized or included by ingroup members. Considering that after ostracism individuals feel powerless and in need of affiliation, we aim two test two competing hypotheses to understand if facial mimicry is related to affiliation. If facial mimicry of anger is motivated by affiliation needs, then one could expect to find stronger mimicry of ingroup members' than outgroup members' anger after being ostracized by ingroup members – this is the affiliation hypothesis. On the other hand, if facial mimicry is not related to affiliation, one would expect to find a decrease of mimicry of anger towards ingroup members after ostracism, due to the feelings of powerlessness that accompany ostracism – this is the perceived reduced power hypothesis.

Overview of the study

This study aimed to test our competing hypotheses by measuring facial mimicry in an intergroup context after an ingroup threat situation such as being excluded from a ball-toss game. More precisely, the study assessed mimicry towards ingroup (Portuguese) and outgroup members (Arabs) across 2 different emotional displays: anger and neutral facial expressions, applying facial electromyography (f-EMG) as method of assessment. We expected to find differences between social categories in mimicry for anger displays and that the extent of this difference could be predicted by experimentally induced ingroup threat as a result of being ostracized by ingroup members in a ball-toss game.

Political beliefs and religiosity were entered as descriptive variables of the sample. Mood was entered as a control variable, as research on mimicry has shown that people reduce their mimicry when they experience low mood states compared to high mood states (van Baaren, et al., 2006). Intergroup threat was measured, in order to have the possibility of checking whether results from the studies in chapter 7 would replicate. Finally, we explored how much individuals felt their needs of belonging, self-esteem, control and meaningful existence being threatened, and how that was related to an increase in the desire to affiliate and belong to others.

Method

Design and sample size calculation

Eighty-four participants took part in the study. Participants were recruited on campus. Thirty-nine were Psychology students that received course credit for participation. The remaining participants were other students and received a 7.5 euro voucher in exchange for their participation. None of the participants guessed the purpose of the study or the purpose of facial electromyography. Two participants were excluded due to problems in the data recording, and three were excluded because they were not Portuguese. From the remaining sample (n= 80), 78 were White, and two were Black/White. None of the participants was Arab or had an Arab origin. Fifty-three were females and 27 were males, and their average age was 21.39 (SD=4.65).

The study used a mixed 2 (emotion: neutral vs. anger) x 2 (social category: Portuguese vs. Arabs) x 2 (ingroup threat: ostracism vs. inclusion) design with ingroup threat as between-

subject factor and the other two as within-subject factors. Mimicry was assessed using f-EMG. To compute the necessary sample size, a power analysis was conducted based on the effect size reported in a recent paper that tested the mimicry differences between social categories in a similar experimental design (Hühnel, et al., 2018). G*Power 3.1 (Faul, et al., 2007) was used to conduct a power analysis on a mixed design (*F*-test, repeated measures, within-between subject interaction). Input parameters were: effect size $f = 0.29$, $\alpha = .05$, power = .80, number of groups = 2, number of measurements = 2, correlation between repeated measures = .50, and nonsphericity correction = 1[13] (Faul, et al., 2007). The output parameters resulting from this analysis showed that for a critical *F* of 4.26, with the actual power of 81%, a total sample size of 26 participants is required. Actual statistical power for the assumed effect size with the actual number of participants was above .99, thus there was little probability for type II error in this study. Considering that the study conducted by Hühnel and collegues (2018) did not have a complete exclusion scenario played by ingroup members only, we decided to conduct a similar power analysis do compute the required sample size expecting a small effect size of $f = 0.20$. The output parameters resulting from this conservative analysis showed that for a critical *F* of 4.03, with the actual power of 81%, a total sample size of 52 participants is required. Actual statistical power for the assumed effect size with the actual number of participants was above .94.

Stimuli

Participants were shown videos with dynamic facial expressions. Each video displayed the development from neutral to full emotional expression in 5000 ms, each video lasted 6000 ms. Models were selected from the ADFES database with Mediterranean anscestry (van der Schalk, Hawk, et al., 2011). Models performed the displays of two emotions: anger and neutral. The videos showed each model performing the emotion with a head-turning movement and direct eye gaze. All models were pre-tested for the Portuguese population considering their level of attractiveness, level of sympathy and their ethnic identity - each model's face was rated as belonging to either a Portuguese or to an Arab person. Participants were asked to rate the models' attractiveness on a scale from 1 "*not attractive*" to 10 "*very attractive*", their sympathy

[13] Sphericity correction aims to correct the degrees of freedom when the homogeneity of the variances are not met between the levels of each factor. Sphericity varies between 0 and 1, the smaller the value the greater is the sphericity problem. We have applied 1 because the sphericity problems only arise when there are 23 or more levels per factor (Laerd Statistics, 2019).

on a scale from 1 "*not sympathetic*" to 10 "*very sympathetic*", and their ethnic origin on a scale from 1 "*Portuguese*" to 10 "*Arab*". Two female and two male models that showed average values closest to the midpoint scale of 5.5 (average *SD* = 1.95) on all three scales were selected after the pre-test (for more information please see Study 1 in Chapter 7).

Procedure

Participants were seated in front of a computer. Informed consent was obtained and a brief explanation about electrodes' attachment and skin preparation was provided to each participant. Participants were told that the study aimed to observe the influence of personality traits on perception and communication of emotions during a team game. The experiment consisted of three parts. A survey developed in Qualtrics (Qualtrics, 2018) started by assessing demographic variables such as age, gender and nationality. Mood was assessed (Watson, et al., 1988) prior to facial mimicry measurement, and the items were presented to participants in random order.

In the second part, participants were prepared to assess facial mimicry with facial electromyography (f-EMG) (see more details about the preparation below). Then, participants were randomly allocated to one of the ingroup threat manipulations by playing the Cyberball game (Williams & Jarvis, 2006) (see more details about this experimental manipulation below). The ingroup threat manipulation was followed by the presentation of a set of videos. Participants were asked to indicate which emotional expression they saw in each video. Videos were presented using e-Prime version 2.0 (Psychological Software Tools, 2012). During the video presentation, participant's facial mimicry was assessed. To make the social category salient, participants were provided with the model's name as a social categorization hint before each video display. Video models were presented using Portuguese (e.g., João, Maria) and Arab (e.g., Muhammad, Samira) first names. Each trial started with a blank screen (1000 ms), followed by a fixation cross (500 ms) and the social category manipulation (i.e., showing the name on the screen for 500 ms), during which the f-EMG's baseline measure was taken before the experimental measurements. The trial proceeded with the video presentation; each video lasted 6000 ms, but the video remained frozen for an extra 4000 ms to prevent missing mimicry responses. Thus, each stimulus presentation lasted 10000 ms in total. Stimuli were shown in two different blocks, each block representing one social category condition. Blocks were presented in a counterbalanced order, emotional expressions and model's name were displayed in random order. Also, the pairing of Portuguese and Arab names with the models was

randomized for each participant. Each video was repeated three times (12 stimuli per block and 24 stimuli in total). During stimulus presentation, f-EMG data was collected synchronized with stimulus onset and offset. The trial ended with the manipulation check for the presented emotion, that is, with a decoding task for each presented emotion.

In the last part, participants returned to the initial survey and answered the remaining questions about their desire to affiliate (Maner, DeWall, Baumeister, & Schaller, 2007), threat to their needs (Jamieson, Harkins, & Williams, 2000), and need to belong to a group (Leary, et al., 2003). The survey ended by checking the familiarity, liking and perceived similarity of the models in the video as a manipulation check of social category (e.g., van der Schalk, et al., 2011), and a manipulation check of ingroup threat regarding the tosses in the cyberball game (Williams, Cheung, & Choi, 2000). Finally, the participant was debriefed. In the debriefing, several questions were asked to verify if the participant: 1) understood the purpose of f-EMG measurement, 2) if they noticed the social category, 3) how they had experienced the cyberball game, and 4) if they guessed the hypotheses. To eliminate any negative consequences of the ingroup threat manipulation, participants were clearly informed of the fact that all other players in the Cyberball game were fake and simulated by a computer program. After the debriefing, participants were thanked and told to feel free to contact the experimenter in case of need related to their experience during the experiment. The experiment lasted 45 minutes on average.

Ingroup threat Manipulation

Ostracism was induced in participants using the online game Cyberball. Participants were told that they were gaming online with three other players that were described as ingroup members: Portuguese individuals. However, the game was actually computer-generated, thus, the participant was the only real player (Williams & Jarvis, 2006). The game had two different conditions: exclusion and inclusion. In the exclusion condition, participants only received the ball twice in the beginning of the game, thus they were excluded from the game afterwards. In the inclusion condition, the ball was tossed to the participants as often as to the other players.

Facial Electromyography (f-EMG) measurement

Before electrodes were attached, the skin was gently cleaned with cotton and Ethyl Alcohol 70% solution. During the video presentations, facial muscle activity was measured by bipolar placement of Ag/AgCl surface electrodes on the left side of the face with SignaGel electrode gel; one ground electrode was placed on the left temple. Following the guidelines of Fridlund and Cacioppo (1986), the electrodes were placed to measure activity of the *Corrugator*

Supercilii (which assesses the lowering of the eyebrow) and of the *Orbicularis Occulli* (which measures the muscle activation caused by eye contraction). *Corrugator Supercilii* activity was used as an indicator of facial mimicry behavior towards anger display like in previous research (e.g., van der Schalk, et al., 2011; Hühnel, et al., 2014). *Orbicularis Occulli* was introduced as a new way to assess anger as it is a muscle that also activates during anger (van Boxtel, 2010).

The EMG signal was measured with a Biopac EMG amplifier, digitized with 24-bit resolution, sampled at 2 kHz, and recorded on a PC. After the data collection, the data was filtered offline with a 30–250 Hz band pass filter and a 50 Hz notch filter, as data was collected in Europe (Biopac, 2019).

Measurements

Perceived intergroup threat (α = .87; *M* = 4.56; *SD* = 1.41) was assessed by Intergroup Threat Scale (Stephan, et al., 1999) adapted to measure perceived threat from Syrian refugees in Portugal. Participants provided their answer on a scale from 1 "*Completely disagree"* to 10 "*Completely agree*". The scale has two sub-scales: *perceived realistic threat* (α =.85; *M* =3.59; *SD* =1.67) and *perceived symbolic threat* (α = .71; *M* = 5.52; *SD* = 1.43).

Mood was assessed before mimicry with the Positive and Negative Affect Scale (PANAS) using a scale from 1"*Completely disagree"* to 5 "*Completely agree"* (Watson, et al., 1988; for Portuguese version Galinha & Pais-Ribeiro, 2005). Positive mood (α = .80; *M* = 3.66; *SD* = 0.71) and negative mood (α = .67; *M* = 1.56; *SD* = 0.63) were averaged across the four items for each category. Positive mood comprised "good-mood", "excited", "satisfied" and "happy". Negative mood comprised "bad-mood", "depressed", "sad" and "bored". Across experimental conditions participants showed stronger positive mood than negative mood before mimicry measurement t (79) = 16.01, $p < .001$. Thus, mimicry was not reduced by a negative mood state.

Threat to needs (α =.75; *M* = 3.08; *SD* = 0.50) of belonging (e.g., "I felt disconnected."), control (e.g., "I felt I had the ability to significantly alter events."), meaningful existence (e.g., "I felt meaningless") and self-esteem (e.g., "I felt good about myself.") were assessed by asking participants how much they felt disconnected while watching the facial expressions using a scale from 1"*Completely disagree*" to 5 "*Completely agree*" (Jamieson, et al., 2000).

Desire to affiliate (α = .71; *M* = 5.39; *SD* = 1.31) was assessed by asking participants how much they want to use a service to get together with other students from the university. They were asked to rate how much they wanted to use the service and how much they wanted

to make new friends using a scale 1"*Completely disagree*" to 7 "*Completely agree*" (Maner, et al., 2007).

Need to belong (α =.57; *M* = 3.31; *SD* = 0.63) was assessed by asking participants how much they needed and want to make part of a group using a scale from 1"*Completely disagree*" to 5 "*Completely agree*", which included items such as: "I want other people to accept me"; "If other people don't seem to accept me, I don't let it bother me."; "I try hard not to do things that will make other people avoid or reject me."(Leary, et al., 2003).

Other variables were assessed. However, they are out of the scope of this chapter; to consult them please see the supplemental materials (Appendix 4).

Manipulation checks

Emotions decoding. Participants rated the intensity of fear, happiness, sadness, and anger after each emotional stimulus on a scale from 1 ("*not intense at all*") to 5 ("*very intense*") (van der Schalk, et al., 2011).

Similar to previous research conducted by van der Schalk and colleagues (2011) and Guéguen & Martin (2009), we assessed the perceived familiarity, the perceived similarity and the liking of the models shown in the videos.

Familiarity. Participants were asked to rate their perceived familiarity with each model using a 7-point scale, 1 "*not familiar at all*" 7 "*very familiar*".

Similarity. Participants were asked to rate their perceived similarity to each model using a 7-point scale from 1 "*not similiar at all*" to 7 "*very similar*.

Liking. Participants were also asked to rate their liking of each model using a 7-point scale, 1 "*do not like at all*" 7 "*like a lot*".

As it is assumed that by default individuals feel more familiar with, more similar to, and like more ingroup members than outgroup members due to early learning experience with ingroup members (Kavanagh & Winkielman, 2016), we could expect that higher familiarity with, stronger similarity to and more liking of ingroup models than outgroup models would indicate a successful social category manipulation.

Ostracism. After the game, participants were asked to rate how much they had enjoyed the game. Participants assessed the extent to which they felt 1 bad – 9 good, 1 sad - 9 happy, 1 tense – 9 relaxed, 1 rejected – 9 accepted during the game using a 9-point scale (Williams, et al., 2000). Also, participants were asked to provide an estimate of the number of received ball throws (Williams, et al., 2000).

Results

Manipulation checks.

Emotions decoding. Emotion decoding for each type of display was analyzed with a mixed 2 (emotion: neutral vs. anger) x 4 (decoding emotion: happiness vs. sadness vs. anger vs. fear) x 2 (social category: Portuguese vs. Arabs) x 2 (ingroup threat: exclusion vs. inclusion) GLM with ingroup threat as between subjects factor and the other factors within-subject. The sample was pooled over the two ingroup threat conditions. When assumption of Sphericity was violated, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom. Main effects of emotions, F (1, 77) = 126.64, p < .001, η^2= .62, decoding emotions, F (2.15, 165.84) = 44.28, p <. 001, η^2 = .37, and social category, F (1, 77) = 0.64, p = .42, η^2 = .01, were found. The 2-way interaction between emotion x decoding emotion, F (2.48, 191.08) = 111.80, p < .001, η^2 = .59, was strong and significant, indicating effective emotion decoding. The remaining 2-way interactions between emotion x ingroup threat, F (1, 77) = 1.16, p =.28, η^2 = .02, social category x ingroup threat, F (1, 77) = 1.78, p = .19, η^2 = .02, decoding emotion x ingroup threat, F (2.15,165.84) = 0.47, p = .64,η^2 = .01, emotion x social category, F (1, 77) = 0.42, p = .52, η^2 = .01 and decoding emotion x social category, F (1.87, 144.15) = 2.07, p = .13, η^2 = .03 were not significant. The 3-way interactions between emotion x social category x ingroup threat, F (1, 77) = 2.62, p = .11 ,η^2 = .03, between decoding emotions x emotion x ingroup threat, F (2.48, 191.08) = 0.07, p = .96, η^2 = .00, decoding emotions x social category x ingroup threat, F (1.87, 144.15) = 0.29, p =.74, η^2 = .00, decoding emotions x social category x emotion, F (2.15, 165.67) = 1.25, p =.29, η^2 = .02, were not significant. The 4-way interaction between ingroup threat x decoding emotions x social category x ingroup threat F (2.15, 165.67) = 0.74, p =.49, η^2 = .01, was not significant. Finally, no effect of ingroup threat on emotions decoding process was found, F (1, 77) = 0.93, p < .34, η^2 = .01.

Follow-up analyses revealed that participants rated anger displays as angrier than neutral displays, F (1, 77) = 449.95, p < .001, η^2 = .85. Anger displays were rated as angrier than happy, sad and fearful combined (1/2, -1/6; -1/6; -1/6), F (1, 77) = 93.29, p <. 001, η^2 = .55 (for detailed information about statistics please see Tables 15 and 16).

Liking. Participants rated models with Arab names as more likeable (M = 3.66, SD = 0.95) than models with Portuguese names (M = 3.31, SD = 1.04), t (83) = -3.69, p < .001,

which was unexpected and can indicate that the social category manipulation was not successful. However, this result may also be explained by social desirability as participants may do not want to be seem as prejudiced.

Familiarity and Similarity. Participants did not show average differences in perceived familiarity and similarity between models presented as ingroup and outgroup models.

Ostracism. Ostracized participants (M = 14.42, SD = 9.17) reported a significantly lower percentage of received ball tosses than included participants (M = 55.76, SD = 13.68), t (78) = 16.01, p < .001, d = 3.55, r =.87. Also, participants' mood was compared between conditions. Mood index was calculated by averaging across the four items: 1 bad – 9 good, 1 sad - 9 happy, 1 tense – 9 relaxed, 1 rejected – 9 accepted. Low mood would be characterized by values closer to 1 and good mood by values closer to 9. Results showed lower mood during the game for ostracized participants (M = 5.64, SD = 1.73) than for included participants (M = 8.76, SD = 1.49), t (78) = 8.55, p < .001, d = 1.93, r = .69.

Table 15:
Decoding for each displayed emotion.

Emotion Displayed	*Emotion* [0]	*Social Category* [o]	*Emotion x Social category* [o]
Neutral	F(1.94, 151.59)= 36.48, p=.000, η^2= 0.32.	F(1, 78)= 1.70, p=.20, η^2= 0.02	F(2.27, 177.10)=0.54, p=.61, η^2= 0.01
Anger	F(2.24, 174.94)= 84.31, p=.000, η^2= 0.52	F(1, 78)= 0.10, p=.75, η^2= 0.00	F(1.90, 147.3)=1.95, p=.15, η^2= 0.02

Note: Assumption of Sphericity was violated, thus, Greenhouse-Geisser Correction was adopted to correct the degrees of freedom.

[O] Omnibus effect for the Repeated Measures GLM (ANOVA) for each emotion separately: 4 (decoding emotions: happiness vs. sadness vs. anger vs. fear) x 2 (social category: Portuguese vs. Arabs) within-subject factors. The sample was pooled over the two threat ingroup conditions.

Table 16:
Descriptives of the decodings for each emotion displayed.

Emotion Displayed	Anger	Neutral
Decodings	*M (SE)*	*M (SE)*
Happiness	1.29 (0.13) [a]	1.60 (0.07) [a]
Anger	3.23 (0.09) [b]	1.25 (0.04) [b]
Sadness	2.31 (0.10) [c]	2.03 (0.09) [c]
Fear	1.77 (0.08) [d]	1.58 (0.07) [a]

[abcd] Pairwise comparisons between decodings for each displayed emotion. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed)

EMG data treatment

Data extraction. Stimulus-Data extraction was conducted for each stimulus with 1000 ms epoch (time window) across the 6000 ms of the video. Data collected during the additional 4000 ms after the video of each trial were not included in the analysis as they did not add any relevant information. The data of the 6 epochs was aggregated by mean for the mimicry responses of all six 1000 ms' epochs of the overall 6000 ms period of extraction (Figure 15). Stimulus-Data was transformed within-subjects by dividing the average response of each trial by the within-subject standard deviation of each correspondent epoch and trial.

For Baseline-Data extraction, the first 2000 ms of each experimental trial (i.e., when the blank screen followed by the fixation cross and the model's name were displayed) was extracted by second. Baseline-Data was transformed within-subjects by dividing the average response of each baseline before each trial by the within-subject standard deviation of each baseline before each trial.

EMG data across the three repetitions for each stimulus, and the three baselines of each stimulus, were aggregated by mean. A final index for each muscle and stimulus was computed by subtracting the Baseline-Data from the Stimulus-Data (mimicry response). One severe outlier, 3 *SD* above the mean, was treated by replacing the *Corrugator Supercilii* response by the average sample response for *Corrugator Supercilii* muscle's activation.

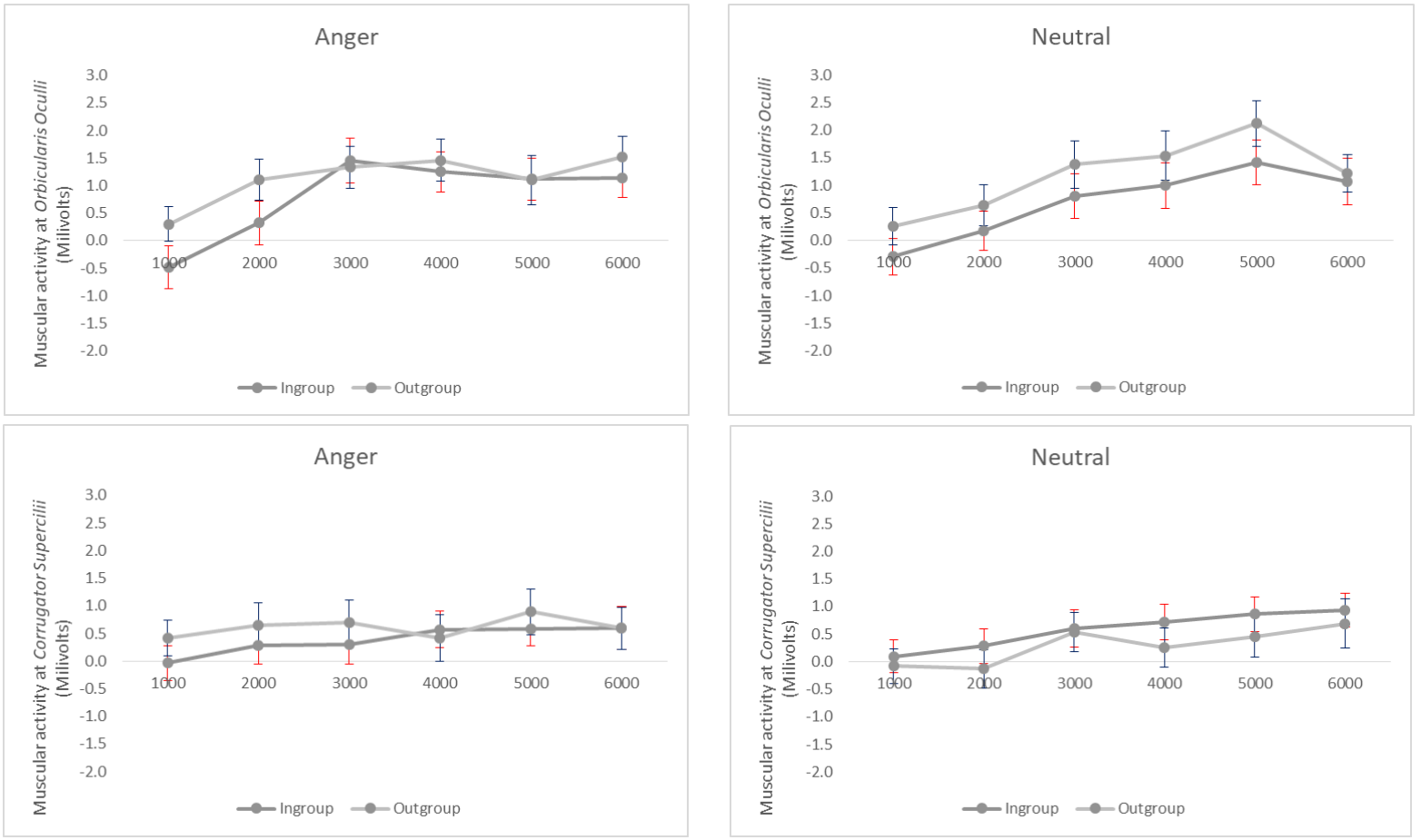

Figure 15: Mimicry response between ingroup and outgroup members muscle activation in anger and neutral displays across video length (6000 ms) for each muscle assessed: *Orbicularis Oculli* (graphs on top) and *Corrugator Supercilii* (graphs in the bottom). Each time point is the average activation of each1000 ms interval, for instance, at 1000 ms it is average activation between 0 and 1000 ms. Standard errors in the error bars.

Analysis of EMG data

Two Repeated Measures GLMs were applied to assess the interaction between ingroup threat and social category in the mimicry of anger for each muscle.

Orbicularis Oculli. The effect on *Orbicularis Oculli* muscle activation was tested using 3 factors in a 2 (emotions: anger vs. neutral) x 2 (social category: Portuguese vs. Arabs) within-subject x 2 (ingroup threat: ostracism vs. inclusion) between-subjects design. No significant main effects of emotion, F (1, 77) = 0.03, p = .88, η^2 = .00, social category F (1, 77) = 1.87, p=.18, η^2 = .02, and ingroup threat, F (1, 77) = 0.74, p = .39, η^2 = .01, were found. The 2-way interaction between emotion and social category, F (1, 77) = 0.10, p = .76, η^2 = .00, the interaction between emotion and ingroup threat, F (1, 77) = 0.37, p = .55, η^2 = .01, and the interaction between social category and ingroup threat, F (1, 77) = 0.67, p = .42, η^2 = .01, were not significant. Finally the 3-way interaction between emotion, social category and ingroup threat was not significant, F (1, 77) = 1.13, p = .29, η^2 = .01. In sum, there were no significant main effects or interactions, for *Orbicularis Oculli* activation (Figure 16), and no mean differences were found (see Table 17 for pairwise comparisons). Due to absence of differences between neutral and anger facial expressions, it is unclear if mimicry of anger occurred, or if individuals had *Orbicularis Oculli* activated during all the experiment.

Table 17:

Pairwise comparisons between emotions, social categories and ingroup threat conditions for Orbicularis Oculli.

	Anger ***M (SE)***	***Neutral*** ***M (SE)***
	0.99 (0.21) [a]	0.95 (0.22) [a]
Ingroup	0.82 (0.27) [c, e]	0.72 (0.30) [c, e]
Outgroup	1.15 (0.27) [c, e]	1.18 (0.30) [c, e]

	Inclusion		*Ostracism*	
	Anger *M (SE)*	*Neutral* *M (SE)*	*Anger* *M (SE)*	*Neutral* *M (SE)*
	1.21 (0.31) [g, i]	1.04 (0.32) [g, i]	0.76 (0.29) [g, i]	0.88 (0.30) [g, i]
Ingroup	1.05 (0.39) [k, m, o]	1.04 (0.43) [k, m, o]	0.58 (0.37) [k, m, o]	0.39 (0.40) [k, m, o]
Outgroup	1.37 (0.39) [k, m, o]	1.04 (0.43) [k, m, o]	0.93 (0.37) [k, m, o]	1.32 (0.40) [k, m, o]

[ab] Pairwise comparisons between emotions. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[cd] Pairwise comparisons between social categories for each emotion. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[ef] Pairwise comparisons between emotions for each social category. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[gh] Pairwise comparisons between emotions for each ingroup threat condition. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[ij] Pairwise comparisons between ingroup threat condition for each emotion. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[kl] Pairwise comparisons between social categories for each emotion and for each ingroup threat condition. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[mn] Pairwise comparisons between emotions for each social category and for each ingroup threat condition. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

Corrugator Supercilii. The effect on *Corrugator Supercilii* muscle activation was similarly tested using a 2 (emotions: anger vs. neutral) x 2 (social category: Portuguese vs.

Arabs) within-subject x 2 (ingroup threat: ostracism vs. inclusion) between-subjects design. No significant main effects of emotion F (1, 77) = 0.10, p = .76, η^2 = .00, social category, F (1, 77) = 0.09, p = .76, η^2= .00, and ingroup threat, F (1, 77) = 0.18, p = .67, η^2 = .00, were found. The 2-way interaction between emotion and ingroup threat, F (1, 77) = 2.89, p = .09, η^2 = .04, was marginal. The interactions between social category and ingroup threat, F (1, 77) = 0.04, p = .85, η^2 = .00, and between social category and emotion, F (1, 77) = 1.48, p = .23, η^2 = .02, were not significant. Finally the 3-way interaction between emotion, social category and ingroup threat was significant, F (1, 77) = 5.18, p = .03, η^2 = .06 (Figure 17). Pairwise comparisons showed only one significant mean difference: In the inclusion condition *Corrugator Supercilii* activation towards outgroup members was stronger for angry faces than for neutral faces (M_{Anger} = 1.04, SE_{Anger} = 0.43, $M_{Neutral}$ = -0.23, $SE_{Neutral}$ = 0.38, p = .02), indicating some anger mimicry only in this particular condition and only towards outgroup faces. No other mean differences were found (see Table 18 for pairwise comparisons).

To further explore the meaning of the significant 3-way interaction, 2 (social category: Portuguese vs. Arabs) x 2 (ingroup threat: ostracism vs. inclusion) GLMs were conducted to analyze the interaction between social category and threat for neutral and angry faces separately. For neutral faces, there were no significant effects, no social category main effect, F (1, 77) = 1.20, p = .27, η^2 = .02, no 2-way interaction between social category and ingroup threat, F (1, 77) = 2.25, p = .14, η^2 = 0.03, and no between subjects effect of ingroup threat, F (1, 77) = 0.52, p = .47, η^2 = .01, ($M_{ostracism}$ = 0.44; SE = 0.23, $M_{inclusion}$ = 0.20; SE = 0.24). For angry faces there was no significant main effect of social category, F (1, 77) = 0.39, p = .53, η^2= 0.01, but the 2-way interaction between social category and ingroup threat, F (1, 77) = 2.89, p = .09, η^2 = 0.04, was marginal. Outgroup members (M = 1.04; SE = 0.43) tend to be more mimicked than ingroup members (M = 0.23; SE = 0.35) in the inclusion condition, however, the means difference was not significant (p = .12). The between subjects effect of ingroup threat was not significant, F (1, 77) = 1.47, p = .23, η^2 = 0.02 ($M_{inclusion}$ = 0.63; SE = 0.30, $M_{ostracism}$ = 0.14; SE = 0.28).

Table 18:

Pairwise comparisons between emotions, social categories and ingroup threat conditions for Corrugator Supercilii.

	Anger ***M (SE)***	***Neutral*** ***M (SE)***
	0.39 (0.20) [a]	0.32 (0.16) [a]
Ingroup	0.28 (0.24) [c, e]	0.50 (0.20) [c, e]
Outgroup	0.50 (0.29) [c, e]	0.14 (0.26) [c, e]

	Inclusion		*Ostracism*	
	Anger *M (SE)*	*Neutral* *M (SE)*	*Anger* *M (SE)*	*Neutral* *M (SE)*
	0.63 (0.30) [g, i]	0.20 (0.24) [g, i]	0.14 (0.28) [g, i]	0.44 (0.23) [g, i]
Ingroup	0.23 (0.35) [k, m, o]	0.63 (0.30) [k, m, o]	0.32 (0.33) [k, m, o]	0.37 (0.28) [k, m, o]
Outgroup	1.04 (0.43) [k, m, o]	-0.23 (0.38) [k, n, o]	-0.05 (0.40) [k, m, o]	0.51 (0.35) [k, m, o]

[ab] Pairwise comparisons between emotions. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[cd] Pairwise comparisons between social categories for each emotion. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[ef] Pairwise comparisons between emotions for each social category. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[gh] Pairwise comparisons between emotions for each ingroup threat condition. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[ij] Pairwise comparisons between ingroup threat condition for each emotion. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[kl] Pairwise comparisons between social categories for each emotion and for each ingroup threat condition. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[mn] Pairwise comparisons between emotions for each social category and for each ingroup threat condition. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

[op] Pairwise comparisons between ingroup threat condition for each emotion and for each social category. Decodings with different superscripts differ significantly from each other ($p < .05$, two-tailed).

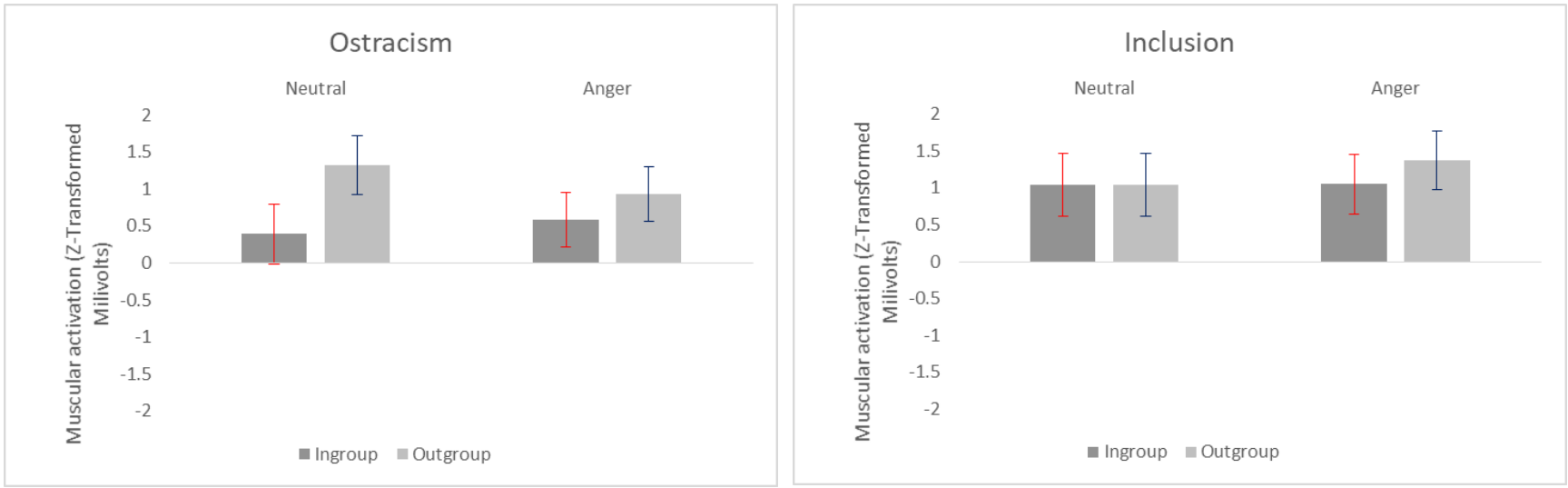

Figure 16: Mean activation of *Orbicularis Oculli* muscle in anger and neutral emotional displays across ingroup threat manipulations: Ostracism and Inclusion. Standard errors in the error bars.

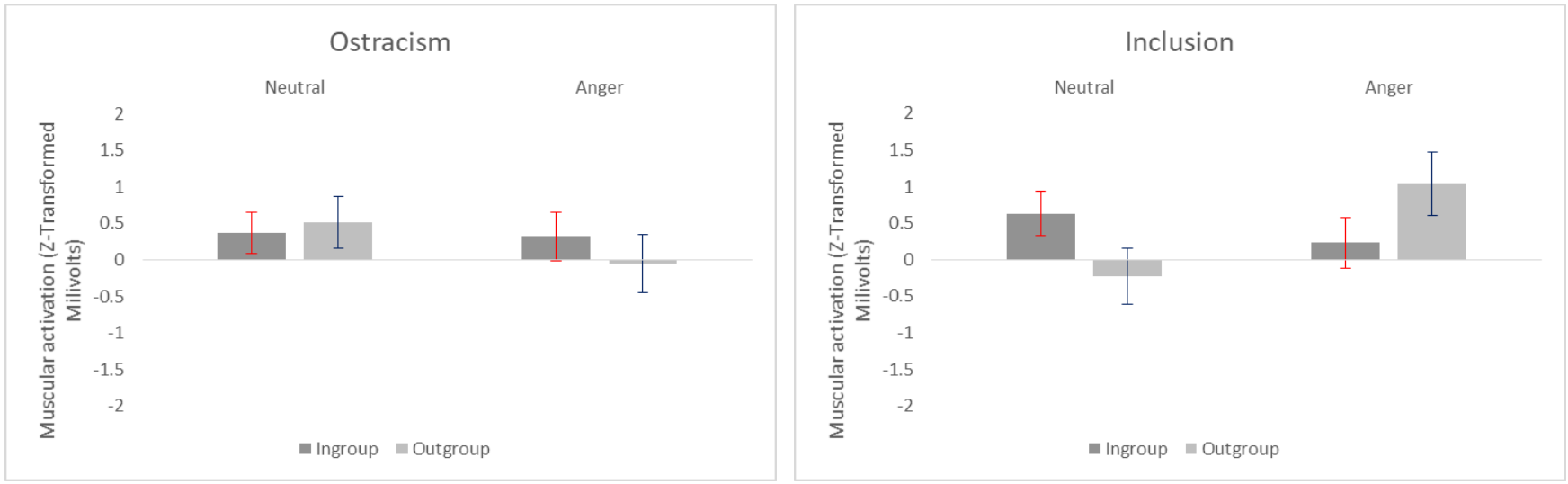

Figure 17: Mean activation of *Corrugator Supercilii* muscle in anger and neutral emotional displays across ingroup threat manipulations: Ostracism and Inclusion. Standard errors in the error bars.

From these results we conclude that none of the hypotheses proposed in the analysis received support. First it was not clear if mimicry of anger occurred for *Orbicularis Oculli*, and it seems that mimicry of anger occurred for *Corrugator Supercilii* only. Considering the *Corrugator Supercilii* activation, no support was found for the affiliation hypothesis as mimicry of anger was not increased for ingroup members after ostracism. Nevertheless, there was no evidence for the reduced-power hypothesis either, as no reduction of mimicry of ingroup anger by ingroup threat was found. Individuals tended to mimic anger less after ostracism than after inclusion; however, that tendency showed up for outgroup mimicry rather than ingroup mimicry. It remains unclear how mimicry of anger varies in intergroup relations and how it is related to affiliation, however, this absence of support for stronger ingroup mimicry after ingroup threat suggests that the function of facial mimicry is not affiliation.

Is mimicry of anger moderated by perceived intergroup threat?

Considering the impact that perceived intergroup threat has on mimicry of anger in intergroup relations as reported in chapter 7, we decided to conduct a moderation analysis by applying the Judd, Kenny and McClelland (2001) recommendations for moderation analysis with within-subjects factors.

A mixed GLM with 2 (social category: Portuguese vs. Arabs) x 2 (muscles: *Orbicularis Oculli* vs. *Corrugator Supercilii*) x 2 (emotion: neutral vs. anger) within-subject x 2 (ingroup threat: ostracism vs. inclusion) between-subjects design and with perceived realistic threat as continuous moderator was assessed. The moderator was mean centered. In this GLM we found a main-effect of muscles, F (1, 75) = 7.97, $p < .001$, $\eta^2 = .10$, but this factor did not interact with any of the other factors. Thus, the remaining effects can be interpreted as effects on anger-expressions as indicated by both muscle activations in parallel. The analysis also showed a marginal interaction between emotion and ingroup threat, F (1, 75) = 2.70, $p = .10$, $\eta^2 = .04$, which was qualified by significant three-way interactions between emotion, ingroup threat and perceived realistic intergroup threat, F (1, 75) = 10.26, $p < .001$, $\eta^2 = .12$, as well as emotion, ingroup threat and social category, F (1, 75) = 4.50, $p = .04$, $\eta^2 = .06$. Finally, the four-way interaction between emotion, ingroup threat, perceived realistic intergroup threat and social category was marginal, F (1, 75) = 2.88, $p = .10$, $\eta^2 = .04$ (Figure 18).

No other effect was significant, not main effects of emotion, F (1, 75) = 0.14, $p = .72$,

$\eta^2 = .00$, social category F (1, 75) = 0.61, p = .44, $\eta^2 = .01$, ingroup threat, F (1, 75) = 0.74, p = .39, $\eta^2 = .01$, nor perceived intergroup threat, F (1, 75) = 0.31, p= .58, $\eta^2 = .00$, nor yet two-way interactions between social category and emotion, F (1, 75) = 0.41, p = .53, $\eta^2 = .01$, muscles and emotion, F (1, 75) = 0.01, p = .91, η^2 = .00, muscles and social category, F (1, 75) = 2.16, p = .15, $\eta^2 = .03$, muscles and ingroup threat, F (1, 75) = 0.19, p = .66, $\eta^2 = .00$, muscles and perceived intergroup threat, F (1, 75) = 0.13, p = .72, $\eta^2 = .00$, emotion and intergroup threat, F (1, 75) = 1.72, p = .19, $\eta^2 = .02$, social category and ingroup threat, F (1, 75) = 0.20, p = .65, η^2 = 0.00, social category and perceived intergroup threat, F (1, 75) = 0.01, p = .92, η^2 = 0.00, and ingroup treat and perceived intergroup threat, F (1, 75) = 0.45, p = .50 $\eta^2 = .01$; nor still three-way interactions between muscles, ingroup threat and perceived intergroup threat, F (1, 75) = 0.86, p = .36, η^2 = .00, muscles, social category and ingroup threat, F (1, 75) = 0.77, p = .38, $\eta^2 = .01$, muscles, social category and perceived intergroup threat, F (1, 75) = 0.03, p = .86, $\eta^2 = .00$, muscles, emotion and ingroup threat, F (1, 75) = 0.62, p =.43, $\eta^2 = .01$, muscles, emotion and perceived intergroup threat, F (1, 75) = 0.09, p = .77, $\eta^2 = .00$, social category, ingroup threat and perceived intergroup threat, F (1, 75) = 1.64, p = .21, $\eta^2 = 0.02$, social category, emotion and perceived intergroup threat, F (1, 75) = 0.30, p = .59, $\eta^2 = .00$, muscle, social category, emotion, F (1, 75) = 1.83, p = .18, $\eta^2 = .02$; nor the four-way interaction between muscles, social category, ingroup threat and intergroup threat, F (1, 75) = 0.90, p = .35, $\eta^2 = .01$, muscles, emotion, ingroup threat and intergroup threat, F (1, 75) = 0.32, p = .57, $\eta^2 = .00$, muscle, social category, emotion and ingroup threat, F (1, 75) = 1.50, p = .22, η^2 = .02, or muscle, social category, emotion and perceived intergroup threat, F (1, 75) = 1.71, p = .19, $\eta^2 = .02$; nor finally the 5-way interaction between muscle, social category, emotion, ingroup threat, and perceived intergroup threat F (1, 75) = 0.01, p = .93, $\eta^2 = .00$.

Simple means comparisons estimated on different levels of perceived intergroup threat within each of the ingroup threat conditions showed significant differences between anger and neutral displays for high levels of perceived intergroup threat (1 *SD* above the mean) for the inclusion condition (Inclusion: M_{Anger} = 1.44; SE_{Anger} = 0.31, $M_{Neutral}$ = 0.43; $SE_{Neutral}$ = 0.31, p <. 001, 95% IC [0.39; 1.63]) , but not in the ostracism condition (Ostracism: M_{Anger} = 0.29; SE_{Anger} = 0.30, $M_{Neutral}$ = 0.78; $SE_{Neutral}$ = 0.30, p = .11; 95% IC [-0.12; 1.10]). No differences were found for low levels of perceived intergroup threat (1*SD* below the mean; Inclusion:

M_{Anger} = 0.42; SE_{Anger} = 0.31, $M_{Neutral}$ = 0.81; $SE_{Neutral}$ = 0.30, p = .21, 95% IC [-0.22; 1.00]; Ostracism: M_{Anger} = 0.61; SE_{Anger} = 0.31, $M_{Neutral}$ = 0.52; $SE_{Neutral}$ = 0.301, p = .76; 95% IC [-0.71; 0.52]). Thus, mimicry of anger only occurred for medium to high levels of perceived intergroup threat in the inclusion condition, and no mimicry of anger was verified for ostracism.

Similar simple means comparisons for each social category separately showed significant differences between anger and neutral displays towards outgroup members for high levels of perceived intergroup threat (1 *SD* above the mean) in the inclusion condition (Inclusion: M_{Anger} = 2.08; SE_{Anger} = 0.41, $M_{Neutral}$ = 0.16; $SE_{Neutral}$= 0.46, F (1, 75) = 15.57, p <. 001, η^2 =.17, 95% IC [0.95; 2.89]) and in the ostracism condition (Ostracism: M_{Anger} = 0.05; SE_{Anger} = 0.40, $M_{Neutral}$ = 1.02; $SE_{Neutral}$ = 0.45, F(1, 75) = 4.09, p = .05, η^2 = .17; 95% IC [0.01; 1.92]). These differences were not significant for mimicry of ingroup members (Inclusion: M_{Anger} = 0.80; SE_{Anger} = 0.38, $M_{Neutral}$ = 0.70; $SE_{Neutral}$ = 0.42, F (1, 75) = 0.05, p = .83, η^2 = .00, 95% IC [-1.05; 0.84]; Ostracism: M_{Anger} = 0.52; SE_{Anger} = 0.38, $M_{Neutral}$ = 0.53; $SE_{Neutral}$ = 0.41, F (1, 75) = 0.00, p = .98, η^2 = .00; 95% IC [-0.92; 0.94]) and no differences were found for low levels of perceived intergroup threat from outgroup (1*SD* below the mean), neither in response to outgroup members (Inclusion: M_{Anger} = 0.35; SE_{Anger} = 0.41, $M_{Neutral}$ = 0.65; $SE_{Neutral}$ = 0.46, F (1, 75) = 0.39, p = .54, η^2 = .01, 95% IC [-0.66; 1.26]; Ostracism: M_{Anger} = 0.84; SE_{Anger} = 0.41, $M_{Neutral}$ = 0.80; $SE_{Neutral}$ = 0.46, p = .94; 95% IC [-1.00; 0.93]), nor in response to ingroup members (Inclusion: M_{Anger} = 0.48; SE_{Anger} = 0.38, $M_{Neutral}$ = 0.97; $SE_{Neutral}$ = 0.41, F (1, 75) = 1.05, p = .31, η^2 = .01, 95% IC [-0.45; 1.42]; Ostracism: M_{Anger} = 0.38; SE_{Anger} = 0.38, $M_{Neutral}$ = 0.23; $SE_{Neutral}$ = 0.42, F (1, 75) = 0.11, p = .74, η^2 = .00; 95% IC [-1.10; 0.79]). Thus, mimicry of anger only occurred for medium to high levels of perceived intergroup threat in the inclusion condition for outgroup members, and no mimicry of anger was verified in the ostracism condition for either of the social categories (Figure 18).

Differences between responses to angry ingroup faces and responses to angry outgroup faces were significant for high levels of perceived intergroup threat (1 *SD* above the mean) in the inclusion condition (*Diff.* = -1.28, F (1, 75) = 6.53, p = .01, η^2 = .08, 95% IC [0.28; -2.27]) but not in the ostracism condition (*Diff.* = 0.47, F (1, 75) = 0.91, p = .34, η^2 = .01, 95% IC [-0.51.; 1.45]). Thus, stronger mimicry of anger towards outgroup members than ingroup members was found in the inclusion condition at high levels of perceived intergroup threat. No mimicry of anger, and no group differences were found in the ostracism condition. There were also no differences between responses to angry ingroup and outgroup faces at low levels of perceived intergroup threat (1*SD* below the mean; Inclusion: $M_{Ingroup}$ = 0.49,

$SE_{Ingroup}$ = 0.38, $M_{Outgroup}$ = 0.35, $SE_{Outgroup}$ = 0.40, F (1, 75) = 0.08, p = .78, η^2 = .00, 95% IC [-0.85; 1.12]; Ostracism: $M_{Ingroup}$ = 0.38, $SE_{Ingroup}$ = 0.38, $M_{Outgroup}$ = 0.84, $SE_{Outgroup}$ = 0.41, F (1, 75) = 0.85, p = .36, η^2 = .01, 95% IC [-1.45; 0.53]; Figure 19).

In simple mean comparisons testing the experimental effects of the ingroup threat manipulation on anger displays towards angry ingroup faces no differences between ingroup threat conditions were found, neither for high, (*Diff* = .28, *SE* = 0.54, F (1, 75) = 0.27, p = .60, η^2 = 0.00, 95% CI [-0.79; 1.35]) nor for low, (*Diff* = .10, *SE* = 0.54, F (1, 75) = 0.04, p = .85, η^2 = 0.00, 95% CI [-0.97; 1.18]) levels of perceived intergroup threat. However, anger display towards angry outgroup faces was stronger in the inclusion condition than in the ostracism condition at high (1 *SD* above the mean) levels of perceived intergroup threat, (*Diff* = 2.03, *SE* = 0.58, F (1, 75) = 12.36, p = .001, η^2 = 0.14, 95% CI [0.88; 3.17]). No differences were found for low (1 *SD* below the mean) levels of perceived intergroup threat, (*Diff* = -.49, *SE* = 0.58, F (1, 75) = 0.73, p = 0.40, η^2 = 0.01, 95% CI [-1.64; 0.66]). Finally, the ingroup threat manipulation had no effects on displays towards neutral faces (for 1 *SD* above the mean: $Diff_{\text{Ingroup}}$ = .17, *SE* = 0.58, F (1, 75) = 0.08, p = .78, η^2 = 0.00, 95% CI [-1.00; 1.33]; $Diff_{\text{Outgroup}}$ = .86, *SE* = 0.65, F (1, 75) = 1.76, p = .19, η^2 = 0.00, 95% CI [-0.43; 2.15]); for 1 *SD* below the mean: $Diff_{\text{Ingroup}}$ = .74, *SE* = 0.59, F (1,75) = 1.60, p = .21, η^2 = 0.02, 95% CI [-43; 1.90]; $Diff_{\text{Outgroup}}$ = .16, *SE* = 0.65, F (1, 75) = 0.06, p = .81, η^2 = 0.00, 95% CI [1.46; 1.13]).

Perceived symbolic threat was also considered for a moderator analysis of mimicry of anger in intergroup context. However, no moderation effects were verified.

Need to re-affiliate and perceived threat to the needs

Ostracized participants (*M* = 3.06, *SD* = 0.53) did not report stronger perceived threat to the needs compared to included participants (*M* = 3.10, *SD* = 0.48), t (78) = 0.36, p = .72. Also, contrary to what was expected, ostracized participants (*M* = 5.38, *SD* = 1.52) did not report stronger need for re-affiliation compared to included participants (*M* = 5.41, *SD* = 1.05), t (78) = 0.07, p = .94, or stronger need to belong, t (78) = 0.30, p = .77, (Inclusion: *M* = 3.33, *SD* = 0.58; Ostracism: *M* = 3.29, *SD* = 0.69).This may be explained by the previous mimicry assessment which helped to surmount the affiliation need, even if the primary purpose of facial mimicry is not affiliation.

Table 19:
Correlations between variables for each ingroup threat condition and anger for each social category and muscle.

Inclusion

	1	2	3	4	5	6	7	8
Orbicularis Oculli								
1. Ingroups	-	.33*	-.05	.26	.14	-.11	-.02	.16
2. Outgroups	-	-	.22	.19	-.18	.11	.26	-.01
Corrugator Supercilii								
3. Ingroups	-	-	-	.24	.30^{+}	-.14	.17	.12
4. Outgroups	-	-	-	-	-.00	-.13	.35*	.03
5. Desire to affiliate	-	-	-	-	-	-.07	.10	.17
6. Need to belong	-	-	-	-	-	-	.04	.34*
7. Perceived realistic intergroup threat	-	-	-	-	-	-	-	-.07
8. Threat to the needs	-	-	-	-	-	-	-	-

Ostracism

	1	2	3	4	5	6	7	8
Orbicularis Oculli								
1. Ingroups	-	.25	-.15	-.03	.14	-.02	.11	.16
2. Outgroups	-	-	.08	.10	.28^{+}	-.11	-.21	.06
Corrugator Supercilii								
3. Ingroups	-	-	-	.03	-.01	-.01	-.08	.01
4. Outgroups	-	-	-	-	.13	.05	-.17	-.08
5. Desire to affiliate	-	-	-	-	-	.16	-.11	-.25^{+}
6. Need to belong	-	-	-	-	-	-	.13	.19
7. Perceived realistic intergroup threat	-	-	-	-	-	-	-	.08
8. Threat to the needs	-	-	-	-	-	-	-	-

Note: $^{+}$ $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

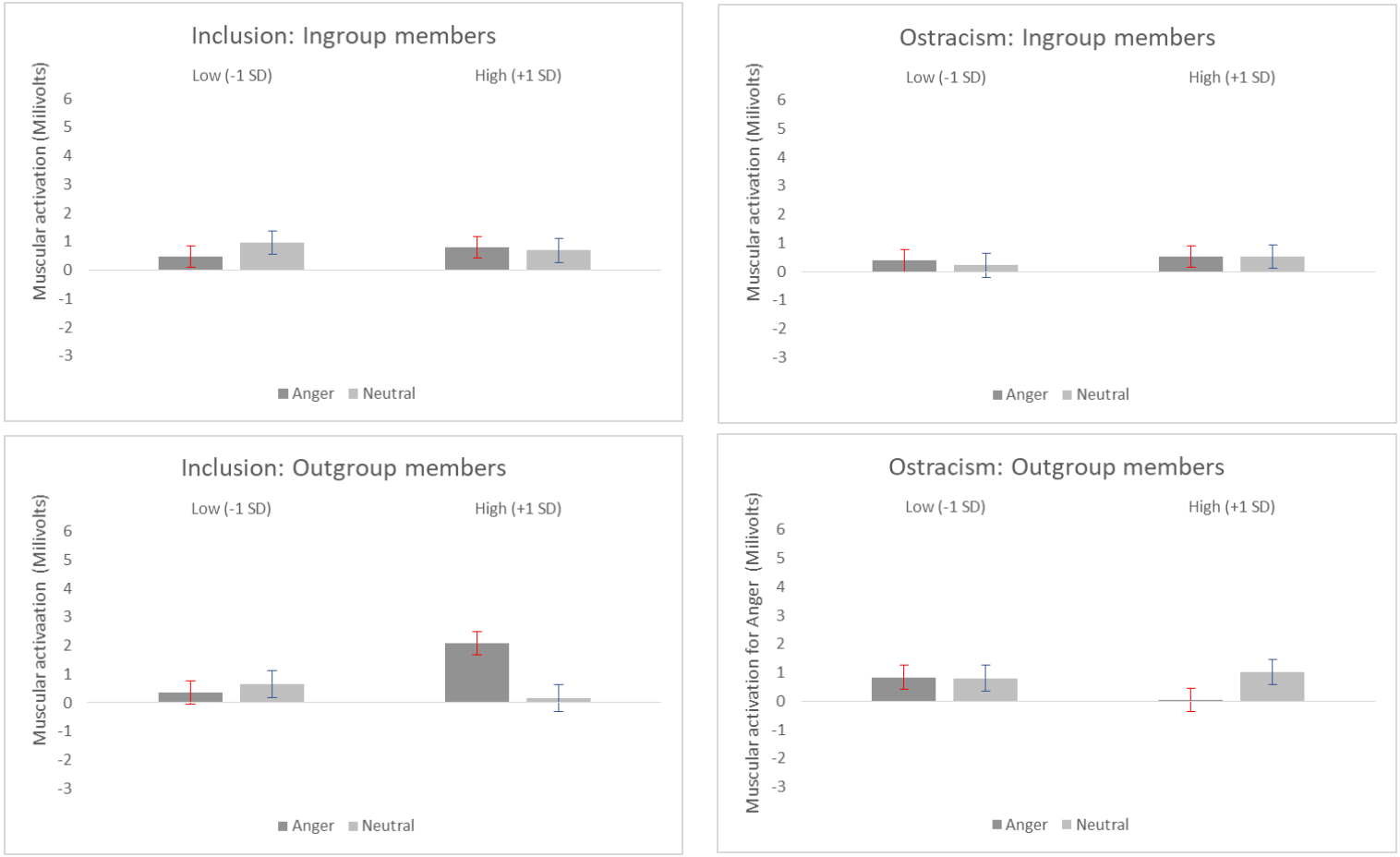

Figure 18: Moderation of the social category effect on muscular activation by perceived realistic threat across ingroup threat conditions for the *Orbicularis Oculli* and *Corrugator Supercilii* muscles (pooled). Standard errors in the error bars. Moderation by perceived realistic intergroup threat is documented for low threat values (-1*SD* below the mean) and high values (+1*SD* above the mean).

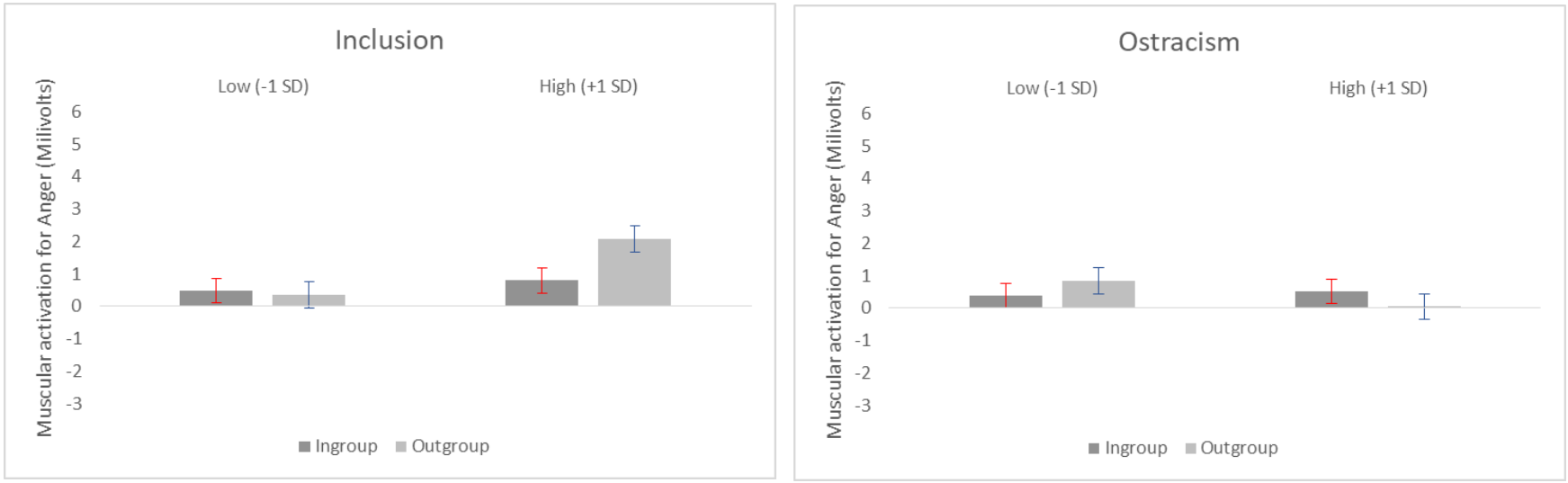

Figure 19: Moderation of the social category effect on anger mimicry by perceived realistic threat across ingroup threat conditions for the *Orbicularis Oculli* and *Corrugator Supercilii* muscles (pooled). Standard errors in the error bars. Moderation by perceived realistic intergroup threat is documented for low threat values (-1*SD* below the mean) and high values (+1*SD* above the mean).

Discussion

Facial mimicry is the unconscious and automatic mirroring of other people's facial emotional expressions (Duffy & Chartrand, 2015; Chartrand & Lakin, 2013). Affiliation and emotional decoding are the functions attributed to facial mimicry. However, the empirical evidence for the affiliation function of facial mimicry is inconclusive (Murteira & Waldzus, 2020a). Two studies reported in chapter 7 found that intergroup threat increased anger mimicry towards ingroup members, but not of outgroup members' anger. Although anger is not an affiliative emotion, this result could still be interpreted as evidence for an affiliative function of mimicry. But there is an alternative explanation, namely that intergroup threat can have reduced the perceived power of ingroup targets, which would have decreased the inhibition of the expression of anger towards the ingroup. This alternative explanation could only be ruled out in a design in which threat (as a proxy for affiliation needs) is not confounded with the empowerment of participants towards ingroup targets (as a factor reducing the inhibition of the expression of anger). In the research reported in the current chapter we therefore aimed again to examine whether facial mimicry of anger is related to affiliation in intergroup relations by testing how perceived ingroup threat may moderate mimicry of ingroup anger as compared to mimicry of outgroup anger. Additionally, we explored how perceived intergroup threat could moderate that relation.

We applied an ostracism paradigm to test two competing hypotheses. Considering ostracism a form of ingroup threat, this study was designed to assess facial mimicry of anger in intergroup relations after being ostracized or included by ingroup members during a cyberball game. First, ostracism can be used to manipulate affiliation needs because it causes social pain (Chen, et al., 2008). Following ostracism, individuals perceive negative affect, perceived threat to basic needs, such as belonging, self-esteem, control, and meaningful existence (Baumeister, et al., 1996; Leary, et al., 2006). This stress caused by ostracism brings pain and behavioural changes to seek improvement. Therefore, when ostracized by others, individuals show a need to re-affiliate and connect with others to surmount that pain and stress (Wesselmann, et al., 2016). If facial mimicry is motivated by affiliation needs, being ostracized should increase mimicry of ingroup members, but not necessarily outgroup members – this is the affiliation hypothesis. Second, ostracism does not empower participants when facing ingroup members. On the contrary, ostracism produces feelings of powerlessness (Veldhuis, Gordijn, Veenstra, & Linderberg, 2014). The negative feelings harboured as a consequence of ostracism include

humiliation and powerlessness (Veldhuis, et al., 2014). This paradigm therefore allows us to rule out the alternative explanation for the results of chapter 7, because assuming that threat effects on expressions of anger, as those found in chapter 7, are not due to affiliation needs, but only due to effects of perceived power(lessness) on the inhibition of expressions of anger, one would predict that ostracism reduces the expression of anger towards ingroup members – this is the perceived reduced power hypothesis. The current study allowed us to test these hypotheses against each other, because they predict opposite results. Anger mimicry was again, like in chapter 7, measured by EMG (activation of *Corrugator Supercilii*), but we added activation of *Orbicularis Oculli* as an additional indicator, as it is less sensitive to attention effects than *Corrugator Supercilii.*

Results were not clearly consistent with either of the two alternative hypotheses. Overall, little evidence for mimicry of anger was found. On average, individuals did not show a stronger muscular response for *Corrugator Supercilii* and *Orbicularis Oculli* in response to anger displays than in response to neutral facial displays. Due to this lack of mimicry of anger, results are difficult to interpret; however, we consider that the lack of mimicry can be explained as being due to powerless feelings in the case of ostracism, and due to the interdependence with ingroup members in the inclusion condition.

More precisely, mimicry of anger was only evident for outgroup members in the inclusion condition. Participants did not mimic ingroup members more than outgroup members after being ostracized. It seems that ingroup anger was not mimicked at all in this study, whether in the inclusion condition or in the ostracism condition. Also, participants did not increase their mimicry of anger towards ingroup members after ostracism compared to inclusion. This in itself indicates that facial mimicry was not used when individuals were ostracized and in need for affiliation. Thus, there was no evidence for an affiliative function of anger mimicry. However, results did not support the perceived reduced power hypothesis either, because ostracism did not reduce ingroup anger mimicry compared to inclusion, or in other words, the inclusion of participants in the ball toss game did not reduce their inhibition of the expression of anger towards ingroup members as compared to the ostracism condition (as predicted by the perceived reduced power hypothesis). Inclusion as compared to ostracism did, however, increase mimicry of anger towards outgroup members. This unpredicted result could be interpreted as evidence supporting the idea that threat effects on the mimicry of anger are regulated by perceived power rather than by affiliation needs, because there was no mimicry of anger in the ostracism condition at all, and inclusion might have reduced participants' general feelings of powerlessness, and therefore, reduced inhibition of expressions of anger. The plausibility of

such a general disinhibiting effect of inclusion in interaction (i.e., participation in the ball-toss game without being ostracised) can be derived from research on social networks. Research on behaviour in social networks has shown that when individuals interact with friends on Facebook, they report an increase in self-esteem. However, this temporary increase in self-esteem is also associated with an increase of risk-taking behaviours, such as bad nutrition behaviour and risky financial behaviour, due to a temporary reduction of self-control (Wilcox & Stephen, 2013). While Wilcox and Stephen's research on Facebook differs from the research presented in this chapter in many ways, there is a similar component related to the social interaction. Including individuals in a ball-tossing game with ingroup members may in several regards resemble the interaction with Facebook friends. Those Facebook friends can be understood as ingroup members. Having this in mind, we can say that when participants were included in a ball tossing game (without being ostracised), they experienced the blessings of an interaction with ingroup members, that could have increased their self-esteem and probably increased their susceptibility for risky behaviours, such as mimicking anger.

Why that would manifest itself in the mimicry of anger of outgroup rather than ingroup members, however, needs a separate explanation. One possibility is that being included in a game could have had the effect that participants not only feel empowered or boosted in their self-esteem, but also felt an increased empathy and interdependence (Meyer, et al., 2015) between them and ingroup members. Thus, in order to keep that interdependence, individuals could have felt motivated to avoid conflict escalation by inhibiting their mimicry of anger towards ingroup members. That is different from chapter 7, in which participants were not involved in interactions with ingroup members (i.e., no inclusion or ostracism) in the experimental design; thus, it is possible that in the studies reported in chapter 7 mimicry of anger was less inhibited in general, and particularly towards ingroup members, due to less feelings of interdependence with ingroup members.

Crucially, moderation analysis revealed that inclusion, as compared to ostracism, increased outgroup anger mimicry for participants reporting higher levels of intergroup threat, but not for those reporting lower levels of intergroup threat. Accordingly, the differentiation between mimicry of outgroup anger and that of ingroup anger was only shown by participants with high levels of perceived realistic intergroup threat, but not by participants perceiving low levels of realistic threat. That pattern is compatible with the explanation outlined above, because participants reporting lower levels of intergroup threat might be less likely to have the ingroup-outgroup distinction salient during the ball-toss game. Thus, for those participants the stronger feeling of interdependence, and, hence, inhibition of anger expressions, might have generalized

to all targets, including those with Arab names. In contrast, for participants reporting higher levels of intergroup threat the salience of the categorization into ingroup and outgroup can be expected to be chronically more salient, and therefore their feelings of interdependence, and hence inhibition of anger expressions, might have been limited to ingroup targets. That can have freed them to mimic anger of outgroup faces without any restriction.

Another result of this involvement of participants in interactions with ingroup members in the ball-toss game was that we did not replicate the effects of intergroup threat on ingroup anger mimicry reported in chapter 7. In chapter 7, we had observed that group differences in mimicry of anger were moderated by perceived intergroup threat. Individuals had shown increased mimicry of anger towards ingroup members, but not towards outgroup members when outgroup members were perceived as threatening. Accordingly, in chapter 7 we expected to find again increased mimicry of anger towards ingroup members, compared to outgroup members, when high intergroup threat was perceived, at least in the inclusion condition. When individuals are included by ingroup members and intergroup threat is high they would feel stronger affiliation needs (affiliation hypothesis) and feel empowered (decreased perceived power hypothesis) to face anger from ingroup members, and then mimic it. However, the results were, as reported before, different. In the inclusion condition outgroup anger, not ingroup anger, was increased by intergroup threat.

Again, we would explain this effect by the assumption that participants reporting increased perceived intergroup threat would have the intergroup categorization more salient and therefore might limit their inhibition of anger mimicry to ingroup members only. And again, this result is neither consistent with the idea that anger mimicry could be motivated by affiliation needs. If that were the case, mimicry of ingroup anger should have increased in the ostracism condition, particularly with higher levels of the perceived intergroup threat, which did not happen in this study. Another possible outcome that would have been consistent with an affiliation motive would have been stronger outgroup mimicry after ingroup ostracism, particularly at low levels of intergroup threat. After being ostracized individuals behave in ways that help the re-connection with others. In particular, individuals show affiliative signs towards possible interaction partners who show openness to affiliation. Novel targets and individuals that are not related to ostracism are preferred (Bernstein, 2016; Lakin, et al., 2008). Thus, one would expect stronger mimicry of individuals that are not related with the source of ostracism or individuals that do not pose threat, such as a members of a non-threatening outgroup. Yet, also that pattern did not show up in the current study. Ostracism simply eliminated all mimicry of anger. Thus, individuals did not increase their mimicry of anger after ostracism to look for

affiliation, whether towards ingroup members when outgroup members posed a high intergroup threat, or towards outgroup members when they were not threatening.

Given that the actual results of this study were mostly unpredicted; all explanations of the absence of ingroup mimicry in both the inclusion and the ostracism condition are necessarily speculative. One possibility is that the reasons were different in the ostracism than in the inclusion condition and, after all, at least partially compatible with the reduced power hypothesis. Results are consistent with the idea that threat from the ingroup ostracism may cause powerless feelings in individuals in relation to their own group members. Thus, we can suggest that this absence of mimicry towards ingroup members may be due to the fact that individuals do not feel comfortable to mimic anger of a target considered to be more powerful, such as the ingroup ostracizer. However, ostracism eliminated also all the mimicry of outgroup anger. Thus, it can be that the feelings of powerlessness were generalized and not target-specific. Thus, whereas intergroup threat might plausibly affect power attributions to ingroup members and outgroup members differently (as speculated in the discussion of the results in chapter 7), threat produced by ostracism might have produced general overwhelming powerless feelings in the participants rather than specific power attributions to members of the ostracising ingroup. To sum up, results of the current study suggest that mimicry is not ruled by affiliation, but that it is – in a more complex way than predicted – regulated by perceived power differences between the mimicker and the mimicked.

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Limitations and future directions

In the current research facial mimicry was assessed using f-EMG technique, and some limitations associated with this measure should be pointed out. Facial mimicry of anger was assessed by the activation of the *Corrugator Supercilii* muscle, but high activity in *Corrugator Supercilii* may also be due to attentional processes, annoyance, fear, sadness, anger (Ekman, 2003; Seibt, et al., 2015). Thus, results exclusively based on *Corrugator* activation are ambiguous. However, to overcome this issue in the current study an extra muscle was assessed: *Orbicularis Oculli*, and the relevant pattern of results on *Orbicularis* activation did not significantly differ from that on *Corrugator* activation. Thus, it is unlikely that they are due to attention effects or other effects specifically confounded with *Corrugator* activation. Nevertheless, for future research it would be beneficial to assess more facial muscles using software such as FaceReader to have a more comprehensive assessment of individuals' face after ostracism during facial mimicry. Also, it would be beneficial to consider different social

category manipulation checks. In this study we assessed perceived familiarity, similarity and the liking towards ingroup and outgroup members, having the default assumption that ingroup members would rate higher on all dimension due to early learning experience with ingroup members (Kavanagh & Winkielman, 2016). However, this was not verified, which could be the result of social desirably and the need to hide prejudice against outgroups. Thus, it is highly recommended to use manipulation checks that would not be subject of social desirability.

While the results of the current research suggest that function of facial mimicry is epistemic rather than affiliative, it would be beneficial to conduct replication studies. As it seems that both the kind of threat (realistic intergroup threat not involving the participant personally versus ostracism directly threatening the participant as a group member) and the source of the imposed threat (ingroup members, outgroup members, uninvolved third parties) seems to be important, such studies could more systematically vary the relation between the source of threat and the target of mimicry and simultaneously assess how the social identity of the ostracizer changes facial mimicry in an intergroup context. Moreover, it would also be important to measure not only facial mimicry, but also the theorized underlying processes and motivations, such as affiliation needs and motivations on the one hand and dominance attribution and feelings of powerlessness on the other hand. Finally, it would also be interesting to study possible effects with the opposite causal direction, that is, how perception of anger, probably via anger mimicry, affects feelings of being ostracised versus included. The reason is that it could also be that anger mimicry is avoided after ostracism because it could produce re-victimization. Some recent studies showed that when facing anger individuals report feelings of ostracism (Murteira & Waldzus, 2020d), and a tendency to escape such secondary ostracism, now in the form of a facial expression, may have decreased the mimicry of anger in the ostracism condition in general. Such avoidance of mimicking angry faces after being blatantly ostracised immediately before does not necessarily contradict the idea that otherwise facial anger mimicry could be in service of an ostracism detection system, which in the last instance would help individuals to select with whom they may affiliate based on the facial cues. Thus, whereas facial mimicry probably does not have an affiliative function in itself, it could have a function in the regulation of affiliation behaviour, particularly in the detection of ostracism cues.

Overall, despite the fact that none of the hypotheses was clearly supported, it seems clear to us that the evidence speaks more in favour of the perceived reduced power hypothesis than of the affiliation hypothesis. Thus, we conclude that mimicry of anger, and probably other emotions, is not due to affiliation needs and it is conditioned by perceived power differences

between the mimicker and the mimicked. Large part of the reasoning related to the impact of such power differences was rather speculative and post-hoc, but several important context conditions that have been neglected so far could be identified and may inform future research.

Chapter 9

Facial mimicry: function and characterization

Discussion and concluding remarks

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Facial mimicry is a subtle process that probably facilitates communication and understanding between individuals. Facial mimicry is the automatic and unconscious mirroring of facial emotional expressions of other people (Chartrand & Lakin, 2013; Duffy & Chartrand, 2015; van Baaren, Janssen et al., 2009) when the mimicker unconsciously engages in the same behavior, such as mirroring the observed facial expressions, of the mimicked (Cacioppo, et al., 2014). Mimicry is a form of synchronization with others that smoothens social relations by improving social communication (Chartrand & Bargh, 1999; Duffy & Chartrand, 2015; Guéguen, et al., 2009), liking and affiliation between people (Chartrand & Bargh, 1999; Kavanagh & Winkielman, 2016). These assumptions have been proposed for all forms of mimicry; however, it is not clear if they can be extended to facial mimicry, and if the function of facial mimicry is to promote affiliation with others.

In chapter 4 we reviewed the social functions of facial mimicry with the aim of clarifying if the empirical evidence supports the idea that facial mimicry has an epistemic function and an affiliation function. From that review we concluded that the assumption of an epistemic function has some support from empirical evidence, but that the same cannot be said about the assumption of an affiliation function. Moreover, doubts related to the understanding and characterization of facial mimicry were raised in chapter 4. Thus, in the research of this thesis we intended to answer three main questions: 1) what is facial mimicry: is it a reflexive mechanism – the congruent mirroring of facial muscle activation between the mimicker and the mimicked; is it a responsive mechanism – the activation of incongruent but complemental muscles in response to the mimicked emotion; or is it a mixture of both – the activation of congruent and complemental muscles?; 2) Does facial mimicry have an epistemic function?; and finally 3) Is facial mimicry motivated by affiliation?. Some experimental studies were conducted to answer those questions.

The definition of facial mimicry varies according to different theories of mimicry. Some theories defend an epistemic approach, that is, they assume that it serves for the recognition of emotions by decoding of facial expressions. Those theories define mimicry as a congruent match of facial muscular activations during an interaction between the mimicker and the mimicked (e.g., Seibt, et al., 2015, e.g., *Perception-behavior link,* Chartrand & Bargh, 1999;

Simulation Theory, Gallese, 2009). Other theories suggest that mimicry increases liking and affiliation in order to strengthen social bonds (e.g., *Social Top-Down Response Theory*, Wang & Hamilton, 2012; *Implicit Socialization Account Theory*, Kavanagh & Winkielman, 2016) and to smoothen social communication and social interactions. Those theories do not deny the epistemic function of mimicry; however, they imply that not all individuals are going to be equally mimicked due to variation in affiliation goals. Also, they do not deny the possibility of facial mimicry as a pure mirroring or reflexive mechanism that is triggered by the display of emotions on other people faces. On the other hand, a different theoretical approach defines facial mimicry as the mirroring of the understood emotional expression rather than of observed muscular activations (*Context View of Mimicry Theory*, Hess & Fischer, 2013). If individuals mimic what they understand, then it is implied that facial mimicry is not necessary for emotion recognition and, thus, has no epistemic function. This theory considers that facial mimicry is more likely if the emotional expression facilitates affiliation, therefore, for the sake of affiliation and peaceful relationships, emotions of affiliative nature should be mimicked more than competitive ones (Hess, et al., 2016), also to avoid conflict and aggression between individuals (e.g., Fischer, et al., 2012; Hess & Fischer, 2014). This theory makes it possible to consider facial mimicry not only as a reflexive mechanism, but also as a responsive mechanism since individuals do not mirror congruent muscular activations (for a review of these theories please see chapter 2), but what they understood as emotional expression.

The coexistence of these concurrent theoretical approaches indicates that what facial mimicry is is not clear yet, and that different assumptions about its epistemic or affiliative functions may result in contradicting predictions as is the case with competitive emotions. To clarify the theoretical understanding about facial mimicry, it would be beneficial to adopt a more comprehensive operationalization and method of assessment of facial mimicry, which would allow a broader assessment of facial mimicry and thus a better assessment of what is facial mimicry and what its functions are. In the following, we first present and discuss some conclusions from our own research about what facial mimicry is, we then present and discuss some conclusions about the epistemic function of facial mimicry, and finally, we present and discuss some conclusions about the affiliation function of facial mimicry.

1. What is facial mimicry?

One objective of the current research was to verify what characterizes facial mimicry. Thus, we aimed to clarify what facial mimicry is considering three possibilities: 1) it is reflexive - mirroring congruent muscles' activation; 2) it is responsive – mirroring what is understood; 3) it is both reflexive and responsive. In chapter 5, we therefore measured simultaneously congruent (reflexive) and incongruent (responsive) responses to different emotional facial expressions, using the FaceReader comprehensive automatic emotion detection. We assumed that if facial mimicry is more than just a reflexive mechanism, emotional expressions other than the ones congruent with the observed emotion could be detected as well. The simultaneous response with congruent and incongruent emotions would speak for a combined reflexive and responsive characterization of facial mimicry. Results showed that participants responded with some incongruent emotional expressions on top of the mimicry of congruent emotions, and these additional emotional expressions could not be attributed to ambiguity in the stimulus material, because participants unequivocally and correctly decoded the dominant emotional expression by the mimicked target. We therefore concluded that facial mimicry implies some responsive emotional expressions, rather than just a reflex of congruent muscles' activations between the mimicker and the mimicked. This complemental emotional muscles' activation, such as muscle response related to fear when mirroring anger, speaks to a more comprehensive understanding and characterization of facial mimicry than simply a mirroring of congruent muscles' activation that serve an epistemic function. It is also a mechanism where the individual shows complemental emotional responses while mimicking the congruent facial expressions. Despite the fact that some of the methods applied to assess facial mimicry have a precision to the millisecond, this reflexive and a responsive muscular activation cannot be disentangled due to the short time period between stimulus, perception and response. Nevertheless, this extremely short time between reflection and response is particularly advantageous as the individual can regulate, almost immediately, the social interaction based on the complemental emotional response. For instance, when considering the case of competitive emotions, such as anger, the reflection mechanism informs the mimicker about the angry face showed by the mimicked, and almost simultaneously, the mimicker may show a complemental facial emotional expression, such as fear, sadness or happiness, so as to appease the mimicked. If facial mimicry was only characterized by the congruent muscles' activations, then we could say that mimicry of anger could be a trigger for aggression escalation, however, this complemental emotional response may decrease the chances of a conflict escalation that would be associated

to a mimicry of anger. Therefore, this double, reflexive and responsive character of facial mimicry could facilitate the functioning of social relations, as the reflection informs the mimicker about the mimicked emotional state, and the response with complemental facial expressions may serve a relational-regulatory (e.g., an affiliative) purpose by showing an empathic facial expression or a facial expression that complements the one that was mimicked. Moreover, these additional, complemental emotional responses may make it possible to consider that mimicking of non-affiliative emotions does not necessarily imply conflict escalation. Overall, new theoretical developments about the function of facial mimicry are necessary, and there is a need to clarify the impact of facial mimicry in social relations in future research about facial mimicry.

2. Has facial mimicry an epistemic function?

By mirroring emotional expressions, the mimicker gains insights about the emotional states, motivations, feelings and behavioral intentions of the mimicked (Hess & Fischer, 2017; Oatley, 2016). This can explain why all emotions that were considered so far in mimicry studies seem to be mimicked (for sadness and disgust e.g., Hess & Blairy, 2001; for happiness and anger; e.g., Achaibou, et al., 2007; for fear: e.g., van der Schalk, et al., 2011). Thus, facial mimicry is not conditioned by the valence or by the competitive or affiliative nature of emotions. Indeed, several studies showed that facial mimicry is fundamental for the emotional decoding of other people's emotions. Individuals show difficulties in emotional experience and slower emotional decoding when their facial movements are restricted or reduced experimentally (e.g., Oberman, et al., 2007; Niedenthal, 2007) or by cosmetic Botox-treatments (e.g., Lewis, 2018). This speaks in favour of the need for facial muscles' activation for emotion decoding and experience (see Coles, et al., 2017, 2019). Finally, as discussed and concluded in the previous section, facial mimicry is characterized by congruent muscles' activation and the additional incongruent muscles' activation (see chapter 5), can be interpreted as complemental emotional expressions, which implies an epistemic process, probably related to the congruent muscles' activation, that allows the individual to recognize the mimicked emotion and to provide a proper response given the social context.

However, not all evidence speaks in favour of the need for congruent muscles' activation for emotional decoding. For instance, Moebius syndrome patients – i.e. with facial paralysis - seem to have no impairments in emotional decoding (Bogart & Matsumoto, 2009). Also, facial movement suppression studies seem to show that not all emotions are affected equally (for a

review see Hess & Fischer, 2013). However, such evidence does not rule out the epistemic function of facial mimicry, as mimicry might still facilitate emotion recognition even if it is not a necessary condition for it. We suggest that facial mimicry is an important perception channel that facilitates accurate emotional decoding but that facial mimicry is probably not the only channel that facilitates this epistemic process (Hess & Fischer, 2013). Thus, we consider that facial mimicry has an important epistemic function even knowing that it is probably complemented by other perception channels that allow a more comprehensive perception and understanding of emotions.

3. Is facial mimicry for affiliation?

Facial mimicry is associated with several relational benefits, such as increasing liking, cooperation, understanding and empathy between individuals (e.g., Chartrand & Lakin, 2013). All of these positive effects of facial mimicry speak in favor of affiliation and creation of rapport between the mimicked and the mimicked. However, several of these claims were based on research on mimicry and not on facial mimicry specifically. Also the fact that mimicry, and perhaps facial mimicry, has positive outcomes for social relations does not mean that its aim is affiliation or that it serves a conscious or unconscious psychological function of affiliation. Thus, we assessed facial mimicry in different social settings to understand its affiliation role. Some promising research on attachment style and how it impacts facial mimicry (Donges, et al., 2012; Suslow, et al., 2009) is too preliminary to draw conclusions about how facial mimicry is related to affiliation. However, when research on competitive vs. cooperative (e.g., Lanzetta & Englis, 1989) or asymmetrical relationships (e.g., Carr, et al., 2014) and intergroup relations (e.g., van der Schalk, et al., 2011) are considered, serious doubts remain about the affiliative nature of facial mimicry (see chapter 4). In this thesis, we chose to assess if facial mimicry is related to affiliation by using group membership as a proxy for affiliation. Group membership effects are often proposed as evidence for an affiliative function of mimicry, because mimicry is considered to be larger between ingroup members than towards outgroups members, due to the need to affiliate and socialize with ingroup members (Kavanagh & Winkielman, 2016; Wang & Hamilton, 2012).

To clarify the reliability of the group membership effect on facial mimicry, a meta-analytical review was conducted first (see chapter 6). This meta-analytical review aimed to clarify how facial mimicry varies in the intergroup context by analyzing how different

emotional displays are mimicked when the emotion is displayed by an ingroup or an outgroup member. Results showed overall larger facial mimicry towards ingroups than outgroups, however, there was also large heterogeneity. Some studies show more mimicry towards ingroups vs. outgroups (e.g., van der Schalk, et al., 2011), while others do not (e.g., Sachisthal, et al., 2016). Also, only anger is facially mimicked more towards ingroup members than outgroup members; happiness, sadness, disgust, and fear are equally mimicked independently of the group membership (see chapter 6). Based on this meta-analysis we can, therefore, conclude that facial mimicry in intergroup relations may not vary between groups (i.e. ingroups vs. outgroups) as would be expected by several theoretical proposals (e.g., Kavanagh & Winkielman, 2016; Wang & Hamilton, 2012; Hess & Fischer, 2014). While this already suggests that facial mimicry may not aim for affiliation, it clearly shows that mimicry of anger – a non-affiliative emotion – does occur, and it is larger towards ingroups than outgroups. This result, once more, undermines the strong version of the idea that facial mimicry of anger, and probably other competitive emotions, should not occur due to the increased risk of conflict escalation (e.g., Bourgeois & Hess, 2008). We consider that mimicry of anger can be weaker due to a tendency to avoid the risk of conflict escalation, however, we propose that that risk does not undermine mimicry of anger under all circumstances. At least, from this meta-analysis we can say that mimicry of anger does occur and probably has an important epistemic function to prevent or respond to a conflict that is not captured by the affiliation hypothesis. However, in order to not dismiss the possibility of an affiliative function of anger mimicry prematurely, and given the large heterogeneity in the meta-analysis, we advanced with the design of new experimental studies to assess possible moderators of the group membership effect on facial mimicry to clarify its affiliation function. Thus, to give the affiliation hypothesis a fair test, perceived intergroup and ingroup threat were assessed as moderators of facial mimicry in an intergroup context.

Perceived intergroup and ingroup threat as moderators of facial mimicry

Stressful events and perception of threat are related to an increase in affiliative behaviors (e.g., Sarnoff & Zimbardo, 1961; Smeets, et al., 2009; Taylor, et al., 2000; Fay & Maner, 2015; Gump & Kulik, 1997; White, et al., 2012). Thus, perception of threat should be expected to increase facial mimicry if the function of facial mimicry is to promote affiliation between the mimicker and the mimicked. Considering that the perception of intergroup and ingroup threat are stressful and threatening events, we expected them to moderate the relationship between

group membership and facial mimicry, that is, of the strength of facial mimicry as a sign of affiliation towards ingroup members vs. outgroup members.

In chapter 7, the first study assessed how mimicry of anger, sadness, fear and happiness varies as a function of group membership when perceived intergroup threat from the outgroup is considered. First, no differences between groups were found in mimicry of sadness, fear and happiness, and only mimicry of anger was stronger towards outgroup members than ingroup members. These results, confirming previous results from the meta-analysis for sadness, fear and happiness, and contradicting meta-analytic results for anger, again show that the affiliative function of facial mimicry is not clear. When the intergroup threat was considered as continuous moderator of facial mimicry of sadness, fear and happiness towards ingroup as compared to outgroup members, once again the results did not support the hypothesis of an affiliative function. No differences were found between social categories, regardless of whether perceived intergroup threat was high or low. Individuals mimicked ingroup and outgroup members to the same degree independently of the perceived intergroup threat from outgroups. Only the group membership effect on mimicry of anger was moderated by perceived intergroup threat. Here, the difference in mimicry of anger between ingroup and outgroup members decreased when individuals perceived that outgroup members were threatening, due to an increase in mimicry of anger towards ingroup members, but not towards outgroup members. This latter result is consistent with the affiliation hypothesis, because the differential increase in anger mimicry towards ingroup members could be due to the need to affiliate with ingroup members when facing intergroup threat.

In the second study once again the moderation of group effects by intergroup threat was tested for facial mimicry of happiness and anger, but this time the salience of intergroup threat was manipulated. Results once again showed that mimicry of happiness did not differ between ingroup and outgroup members, irrespective of intergroup threat, and mimicry of anger towards ingroup members – but not outgroup members - was stronger when perceived intergroup threat was salient compared to when it was not salient.

From chapter 7, we can tentatively conclude that the perception of intergroup threat increases the mimicry of anger towards ingroup members, which could be justified by an increased affiliative need caused by the perceived intergroup threat. However, it is puzzling that these results are only valid for mimicry of anger, and not for happiness, sadness and fear. Thus, it is counterintuitive that the affiliation function should manifest itself in group membership effects only on the least affiliative emotion in the studies. We therefore searched for an alternative explanation for this moderation effect and proposed that this effect could also be

explained by differences in perceived power caused by the perceived intergroup threat. Perceived intergroup threat could affect perceived power of ingroup members and outgroup members differently. If individuals perceived their group, and therefore other ingroup members, as powerless in face of such intergroup threat, it would not be surprising to see an increase in mimicry of anger towards ingroup members rather than outgroup members, because escalation of conflict with powerless others is less dangerous than with powerful others. If ingroup members are seen as less powerful when they are threatened by the outgroup, it would be less risky to mimic their anger. Thus, intergroup threat would facilitate mimicry of anger towards ingroup members rather than outgroup members, which are the source of the threat and therefore presumably perceived as powerful compared to ingroup members. The implied model of this alternative explanation would assume that individuals mimic anger in order to understand others' emotions, but that the degree to which anger expressions are avoided, in order to prevent conflict escalation, depends on the perceived power of the mimicked target. Accordingly, the group membership effect on mimicry of anger can vary based on the relative perception of ingroup and outgroup power.

In real life, the perception of threat and the perception of power are probably impossible to disentangle, and in the paradigm used in chapter 7, which manipulated threat as intergroup threat, higher levels of threat were presumably confounded with lower levels of ingroup power and maybe higher levels of outgroup power. To address this confound we conducted another study, reported in chapter 8, considering ingroup threat, that is, threat from ingroup members to the participant rather than intergroup threat to the ingroup from outgroup members.

More precisely, in chapter 8 we assessed how perceived ingroup threat moderates facial mimicry of anger in intergroup relations. We applied an ostracism paradigm using the cyberball game to induce the perception of ingroup threat. Ostracism is considered a form of group threat as it causes social pain (Chen, et al., 2008). It increases the need to re-affiliate and connect with others to surmount that pain and stress (Wesselmann, et al., 2016). Thus, if anger mimicry is motivated by affiliation, ingroup threat should increase anger mimicry of ingroup members due to this re-affiliation need. In the experiment we exposed participants to one of two possible conditions: being included by ingroup members in a cyberball game, or being excluded from the game by ingroup members. While threat is still applied as in chapter 7, the confound of threat with perceived power differences between ingroup and outgroup members was the opposite of the one in chapter 7: higher ingroup threat should be associated with increased perceived power of ingroup members, given that they are the source of the threat. Moreover, ingroup threat should also reduce perceived own power of participants compared to these

ingroup members, because ostracism produces feelings of powerlessness (Veldhuis, et al., 2014). Thus, ostracism by ingroup members does not empower participants when subsequently facing ingroup members, as it was suspected to do according to our alternative explanation of results in chapter 7. On the contrary, the reversed relation between perceived relative power of the mimicked ingroup members and threat allowed for testing the two alternative hypotheses related to affiliation or perceived power as two concurrent hypotheses which made opposite predictions. If facial mimicry is motivated by affiliation (i.e. the affiliation hypothesis), then we would expect to find stronger anger mimicry of ingroup members, but not outgroup members, after being ostracized by ingroup members. However, if threat effects on facial anger mimicry were due to a confound with perceived power as suggested as alternative hypothesis in chapter 7, then we should expect to find a decrease in mimicry of anger towards ingroup members after ostracism due to the feelings of powerlessness that result from the ingroup ostracism – this is the perceived reduced power hypothesis.

Results were surprising and not consistent with either of these two concurrent hypotheses, however, they speak more in favour of perceived reduced power hypothesis. First, little mimicry of anger was observed overall when compared to facial responses to neutral emotion displays. Second, there was neither increase nor decrease in mimicry of ingroup anger in the ostracism as compared to the inclusion condition. Finally, mimicry of anger was only evident for outgroup members after inclusion and not after ostracism. This lack of mimicry of anger in most conditions and the fact that threat from ingroup members only had an effect on anger mimicry of outgroup members are surprising and puzzling, particularly in comparison to results of the studies reported in chapter 7. As a post-hoc explanation, however, we consider that the pattern of results can best be explained by different relational concerns that may have inhibited the display of angry expressions in most conditions, and that these relational concerns were different in the ostracism condition than in the inclusion condition. In the ostracism condition the complete lack of anger mimicry can be explained by the feelings of powerlessness following ostracism, which may have affected the perception of relative power of the mimicked targets in comparison to one's own power. These feelings of powerlessness would decrease mimicry of anger towards ingroup members because they were the source of ostracism, but this perceived powerlessness might have been so severe that the effect was generalized to all targets, irrespective of whether they were ingroup or outgroup members. Individuals would reduce their mimicry of anger towards any target after being ostracized because they perceive themselves as inferior or lacking power to risk the possible confrontation that might result from answering an angry face with an angry expression. This explanation would be partially consistent with the

reasoning behind the perceived reduced power hypothesis. In the inclusion condition, the participation in the cyberball game and the experience of being included by other ingroup players might have created feelings of interdependence with other ingroup members, and these feelings of interdependence can explain why mimicry of anger was stronger towards outgroup members than ingroup members. After being included individuals feel the need to keep that connection with ingroup members, so they might avoid escalation of any potential conflict by answering angry expressions with anger. However, they might also have experienced a boost in their self-esteem that could have been accompanied with a reduction of self-control, which allowed risky behaviours such as mimicking outgroup member's anger more (Wilcox and Stephen, 2013). Again, this explanation is more in line with the idea of the regulation of anger mimicry by perceived power rather than with the hypothesis of an affiliative function of anger mimicry. Although more studies are necessary, these results suggest that mimicry of anger, and perhaps of any other emotion, are not related to affiliation in itself.

To update the accumulated evidence, the meta-analysis reported in chapter 6 was conducted again, but adding these last studies. A total of 24 studies with 1845 participants were included (*M*=22.42; *SD*=1.77), 993 females, 607 males, 12 unknown. The data for these studies was collected across 10 countries: Portugal, United Kingdom, New Zealand, USA, Canada, France, Netherlands, Spain, Germany and Italy. Again, larger facial mimicry towards ingroup members than outgroup members was found overall; however, the effect was in this analysis not reliable for any of the individual emotions. Mimicry of happiness, anger, disgust, sadness, and fear were not affected by ingroup vs. outgroup membership (see Table 20). Once again the results the results did not support the idea of an affiliate function of mimicry, based on which we would expect to find larger mimicry towards ingroups than outgroups. Thus, the same analysis was conducted by excluding all studies that showed a previous experimental manipulation to their participants that was not related to facial mimicry in itself, such as ostracism. Here, the facial mimicry seemed to be stronger towards ingroup members than outgroup members (see Table 21). However, not all emotions seem to be equally affected by the group membership and the large heterogeneity in the results suggests that a third variable, beyond the intergroup context and any affiliation goal, may play an important role in the extent of facial mimicry.

Concluding remarks for methodology and mimicry's definition

From the learning experience accumulated during the Doctoral process, several concluding remarks and suggestions can be drawn about the way facial mimicry is operationalized, defined and assessed. Facial mimicry has been defined as the congruent activation of a mimicker's muscles during the expression of an emotional facial expression by the mimicked. This definition limited the way facial mimicry is assessed. Typically, the methods of assessment, such as f-EMG, funnel to the measurement of one of two muscles that are known to be activated for each facial emotional expression. While this was the most convenient and perhaps the most accurate procedure to assess facial mimicry, the advances in the technology of facial recognition allow future studies about facial mimicry to consider more than just one or two muscles. Using facial recognition software, a more comprehensive assessment of facial mimicry is now possible. More than one muscle per evaluated emotion can be used, which allows a more precise assessment of a mimicker's face. First, different emotions share muscles, for instance the *Corrugator Supercilii* (Action Unit 4 on Facial Action Coding System, Ekman, et al., 2004) is activated for anger, fear and sadness. Using face recognition software, we apply a more comprehensive assessment of muscles, which allow to assess the shared muscles plus the muscles that are specific for each emotion. This increases the level of certainty about what is facially mimicked, as it brings the chance to distinguish between different facial expressions that happens to share muscles during the activation. In the traditional methods, the meaning of the activation of *Corrugator Supercilii* would be associated with the displayed emotion. With these methods, however, it is only clear that this muscle was activated and not which precise emotion was displayed in the mimicker's face. Second, the additional muscles can reveal surprising patterns that can characterize facial mimicry, which were not previously considered into research due to the limitation on the number is muscles assessed, such as the activation of complemental muscles that can serve an emotional response towards the mimicked face. Finally, attentional effects could be disentangle from facial mimicry with a more comprehensive approach instead of one muscle emotion approach. For instance to assess anger not just *Corrugator Supercilii*, which is activated not just by emotional but also by attentional processes, would be considered to assess facial mimicry of anger. Other muscles can be assessed with a more comprehensive approach and then eliminate any attentional confound that may occur by using a traditional method such as f-EMG. Thus, we strongly recommend for future research the application of face recognition software to assess facial mimicry.

Concluding remarks for mimicry's theoretical proposals

Considering the three leading questions of the thesis (what is facial mimicry?; 2) Does facial mimicry have an epistemic function?; and 3) Is facial mimicry motivated by affiliation?), we can conclude that facial mimicry implies a reflexive and responsive facial action, which brings the theories of mimicry together, but also pleads for a reformulation of the theory and definition of facial mimicry. A more comprehensive definition of facial mimicry considering a reflexive and responsive mechanism is recommended. As a reflexive mechanism, mimicry helps in the understanding of other people's emotions; but mimicry also contributes to affiliation as it allows individuals to set a complemental response. Thus, we can say that the epistemic function of mimicry is in service of affiliation. However, we cannot say that facial mimicry in itself has an affiliative function. The overall evidence has not shown that facial mimicry aims for affiliation. It seems that affiliation is a consequence of facial mimicry and not a function, as not all mimicked emotions are affected by group membership and the stressful events that should increase the need to affiliate with ingroup members do not uniformly increase the facial mimicry towards ingroup members rather than outgroup members. The overall evidence questions some of the claims suggested by some of theoretical proposals related to affiliation. First, facial mimicry in intergroup relations does not support an affiliative mechanism, nor a preference for mimicking ingroup members compared to outgroup members due to socialization and learning experiences as was suggested by the *Implicit Socialization Account Theory* (Kavanagh & Winkielman, 2016). Second, facial mimicry in intergroup relations does not support an increase in facial mimicry due to social advantages that could be expected from mimicking ingroups more than outgroups as was suggested by the *Social Top Down Response Theory* (STORM) (Wang & Hamilton, 2012). Third, facial mimicry in intergroup relations does not support the idea that competitive emotions, such as anger, would not be mimicked due to conflict implications with ingroup members as was suggested by the *Mimicry in Social Context Theory* (Hess & Fischer, 2013). All emotions are mimicked and it seems possible that the amount of mimicry may vary considering the affiliate implications when power differences between individuals are observed (chapter 7 and 8), thus, we can say that individuals would increase or undermine their facial mimicry in intergroup relations taking into account possible rewarding and punishing experiences as suggested by the *Associated Reactions to Action in Context Model* (Stel, et al., 2016). While the general results do not support an affiliative function of facial mimicry, this does not mean that facial mimicry does not have affiliation as a consequence of its epistemic function as suggested by the *Perception-Behavior link* hypothesis (Chartrand & Bargh, 1999); therefore, we could expect that the

epistemic function (e.g., Chartrand & Bargh, 1999, Gallese, 2009) could be subsequently co-opted into the service of affiliation. We strongly suggest that more studies are conducted to verify the affiliative function of facial mimicry, not just using intergroup relations as an approach, but also considering attachment style, asymmetric relations, and the cooperative vs. competitive nature of relations. This would be beneficial for the understanding the function of facial mimicry and for the improvement of already existing theoretical proposals that have not received support from the study of facial mimicry in intergroup relations.

Conclusion

Considering that "No man is an island."(John Donne, p. 108-109, 1624), the epistemic function of facial mimicry is a valuable mechanism of paramount importance to make the communication flow between individuals easier. We can tell with some level of certainty that facial mimicry is at the service of affiliation for communication and the growth of community due to its epistemic and reflexive-responsive character. As previous conceptions about facial mimicry are challenged throughout this Doctoral Thesis, we can say that new and exciting avenues for the study of facial mimicry are now open.

Table 20.

Meta-analysis results for facial mimicry in intergroup relations. Studies with and without previous experimental manipulation before facial mimicry assessment.

	p	***SE***	***CI***	***Z***	***k***	***Q***
Facial mimicry	.10***	0.03	[0.04; 0.15]	3.31	78	333.13***
Anger	.08^{+}	0.04	[-0.01; 0.17]	1.75	29	
Sadness	.08	0.07	[-0.06; 0.22]	1.12	12	
Fear	.11	0.11	[-0.10; 0.32]	1.00	6	
Happiness	.09^{+}	0.05	[-0.01; 0.19]	1.85	23	
Disgust	.13	0.17	[-0.21; 0.47]	0.76	2	

Note: $^{+} < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 21.

Meta-analysis results for facial mimicry in intergroup relations. Studies without previous experimental manipulation before facial mimicry assessment.

	p	***SE***	***CI***	***Z***	***k***	***Q***
Facial mimicry	.16***	0.04	[0.09; 0.23]	4.22	49	192.00***
Anger	.19**	0.06	[0.07; 0.31]	3.02	16	
Sadness	.06	0.10	[-0.14; 0.26]	0.61	7	
Fear	.11	0.11	[-0.10; 0.32]	0.99	6	
Happiness	.18**	0.07	[0.05; 0.31]	2.67	14	

Note: $^{+} < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

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Appendix 1

List of supplemental materials for Study 1 in Chapter 7:

Political Beliefs (*M* = 2.98; *SD* = 1.03) were assessed by a Portuguese version of the self- placement Liberal-Conservatism Scale (Treier & Hillygus, 2006, June; for Portuguese version see Murteira, 2019) using a scale from 1"*Very liberal*" to 7 "*Very conservative*".

Religiosity (*M* = 2.13; *SD* = 1.15) was assessed by an answer to the question "How religious are you?". Answers were provided on a scale from 1"*Not religious at all*" to 5 *"Extremely religious*".

Essentialist beliefs about ethnic differences (α = .84, *M* = 2.67, *SD* = 0.73***)*** were measured by the Essentialist Entitativity Beliefs (adapted to Portuguese from Roets & van Hiel, 2011; for Portuguese version see Murteira, 2020). The items explains similarities within and differences between ethnic groups based on essence**,** e.g., "Despite apparent differences between members of the same ethnic group, in essence, they are the same." Answers were provided on a scale from 1 = "Completely disagree" to 6 = "*Completely agree.*"

Disgust sensitivity (α = .73; *M* = 3.51; *SD* = 0.81) was assessed by the the 7-item version of Disgust Sensitivity Scale (Olatunji, et al., 2007, for Portuguese version see Ferreira-Santos, Martins, Sousa, & Mauro, 2011). Participants responded using a scale ranging from 1 = "*Not at all/Not disgusting at all*" to 6 = "*Very much/Very disgusting*."

Disease vulnerability (α =.63; *M* = 2.73; *SD* = 0.55) was measured with the Perceived Vulnerability to Disease Scale (Duncan, Schaller, & Park, 2009; for Portuguese version see Murteira, 2019) that assesses beliefs about vulnerability or discomfort in situations where a disease transmission may happen. Participants responded with a scale ranging from 1 = "*Completely disagree*" to 6 = "*Completely agree*."

Interpersonal empathy (α = .64; *M* = 3.78; *SD* = 0.47) was assessed with Interpersonal Reactivity Index (Davis, 1980, 1983; for Portuguese version see: Limpo, Alves, & Castro, 2013). The scale evaluates how the self mirror himself on perceived object. Participants provided their answer in a scale from 1 = "*Completely disagree* "to 6 = "*Completely agree*".

Ethnic empathy (α = .64; *M* = 3.07; *SD* = 0.48) was assessed with Ethnocultural Empathy Scale (Wang, Davidson, Yakushko, Savoy, Tan, & Bleier, 2003; for B-Portuguese version see: Sampaio, Lima, Menezes, & de Carvalho Monte, 2012, applied version was build based on Brasilian version). The scale evaluates the empathy toward people of other racial and

ethnic backgrounds. Participants provided their answer in a scale from 1 = "*Completely disagree* "to 6 = "*Completely agree*".

Empathy towards Syrians (α = .92; *M* = 4.34; *SD* = 1.12) was assessed with a 4–item scale that evaluates the empathy towards Syrians that live the war experience (adapted to Portuguese form Portugal from Brown & Cehajic, 2008). Participants provided their answer in a scale from 1 = "*Completely disagree* "to 6 = "*Completely agree*".

Social Distance towards Arabs (α = .92; *M* = 3.47; *SD* = 0.73) with a 4-item scale, asking participants how favorable they are about having Arabs a) in their neighborhood, b) as colleague workers, c) as neighbors, and finally d) as family members. The answers were provide in a scale form 1 = "*Not in favor at all*" to 5 = "*Very favorable*."

Social categorization was applied to assess distance between Arabs and Portuguese (*M* = 2.69; *SD* = 1.36), self and Portuguese and self (*M* = 3.84; *SD* = 1.93) and Arab (*M* = 2.48; *SD* = 1.72) with the IOS pictorial scale (Schubert & Otten, 2002).

Explicit prejudice towards Arabs was measured by the Feeling Thermometers (e.g., Dasgupta & Greenwald, 2001). Participants provided the warmth of their feelings from 0 = "*very cold*" to 100 = "*very warm*" towards Arabs (*M* = 48.28, *SD* = 24.05). Feelings towards Blacks (*M* = 66.90, *SD* = 22.82), elderlies (*M* = 75.36, *SD* = 19.14), Gypsies (*M* = 32.57, *SD* = 21.39), homeless people (*M* = 65.33, *SD* = 23.10), drug addicts (*M* = 37.93, *SD* = 24.49), politicians (*M* = 35.66, *SD* = 26.58) and homosexuals (*M* = 62.92, *SD* = 22.40) were also collected in order to disguise the purpose of the study. The order of the groups was randomized. Higher scores on this measure indicate warmer feelings towards each group while lower scores suggests negative attitudes and prejudice. To analyze feelings towards Arabs relative to feelings towards Whites, feelings towards Whites (*M* = 71.10, *SD* = 21.16) were included in the analysis. The two indices were negatively correlated (r (61) = .29, p = .02).

Implicit prejudice towards Arabs were measured applying an Implicit Association Task (e.g., Greenwald & Banaji, 1995). The IAT test was programmed in E-Prime (Psychology Software Tools, Inc.) following the procedure described by Teige-Mocigemba, Klauer, & Sherman (2010). Five Arab and five Christian names stimuli were selected to build the social categories in analysis, also pleasant and unpleasant words stimuli were used to build the attribute categories (Nosek, Greenwald, & Banaji, 2005). The IAT consists on the assessment of the association between the social categories and the attribute categories along 7 blocks. Block 1, block 2, block 3, block 5 and block 6 has 24 trials, block 4 and block 7 has 48 trials. In block 1 participants were trained to press a left key for Arab name stimuli and a right key for Christian name. In block 2 they were trained to press the left key for negative stimuli and the

same right key for positive stimuli. Block 3 combined Arab and Christian names with pleasant and unpleasant words, block 4 tested the implicit association. Block 5 trained the participants to press the left key for Christian name stimuli and the right key for Arab name stimuli. Block 6 combined Arab and Christian names with pleasant and unpleasant words. Block 7 was a test block using the same combination with participants responding with left key to negative and Christian name stimuli, and right to positive and Arab name stimuli. The difference in performance between block 4 and the reversed block (block 7) is the IAT effect.

The *D* statistic (*D*-600, *Improved Method*) was used to express the IAT effect (e.g. Greenwald, Nosek, & Banaji, 2003; Gawronski, Deutsch, & Banse, 2011). This measure divides the mean difference between blocks by the standard deviation of latencies in them. It assesses the difference in response times is assigning stimuli to congruent and incongruent categories. *D score* typically ranges from -2 to 2. Higher positive *D* scores indicates shorter response times for pairing "Christian + good" and "Arab + bad" and longer response times for pairing "Christian + bad" and "Arab + good". Thus, higher positive *D* scores indicate an implicit preference for prejudice congruent pairing over incongruent pairing. They express higher implicit preference for Portuguese over Arabs. Negative *D* scores reflect shorter reaction times on the incongruent trials indicating implicit prejudice towards Portuguese in comparison to Arab. Values close to 0 imply neutrality and lack of bias. In the present research *D* value varied between 0.10 and 2.05 (M = 1.13; SD = 0.49).

Collective narcissism was assessed by the Collective Narcissism Scale (α = .84; M = 3.69; SD = 1.01) (de Zavala, Cichocka, Eidelson, & Jayawickreme, 2009). Participants provided their answer in a scale from 1 = "*Completely disagree*" to 7 = "*Completely agree*".

EDA measurement. Skin conductance (EDA) was recorded with Biopac Electrodermal Response Amplifier, model GSR100C (Biopac Systems, Inc., Santa Barbara, CA). The signals was digitized at 1000 Hz. Any filter was applied during data collection. After data collection, raw skin conductance data was submitted to a 10-Hz low-pass filter.

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Appendix 2

Does perceived intergroup threat predict mimicry of sadness towards ingroup members?

To better understand the nature of the social category effect on mimicry of sadness, two moderation analysis were conducted to verify the moderation of perceived intergroup threat on mimicry of sadness in intergroup context. Multiple regression analysis was conducted to investigate the hypothesis that perceived intergroup threat predicts mimicry of sadness towards ingroup members, but not towards outgroup members. The analysis was conducted considering realistic and symbolic intergroup threat together and separately. Mimicry of sadness towards ingroup members (DV) and mimicry towards outgroup members was regressed on the perceived intergroup threat (realistic and symbolic threat combined) (M) into a multiple regression analysis using the MEMORE macro for SPSS (model 2) (Montoya, 2019). Perceived intergroup threat does not predict the difference in mimicry of sadness between ingroup and outgroup targets (yDiff= mimicry of ingroup – mimicry of outgroup), b = -0.04, SE = 0.05, t (59) = -0.86, p=.39, 95% CI [-0.14, 0.05], with an R^2 of .011 (adjusted R^2=.00). Simple slope analysis reveals that perceived intergroup threat does not predict mimicry of sadness towards ingroup members, b = -0.03, SE = 0.03, t (59) = -1.14, p = .26, 95% CI [-0.09, 0.02], or towards outgroups, b = 0.01, SE = 0.03, t (59) = 0.31, p = .76, 95% CI [-0.05, 0.07]. Conditional effect analysis showed that under low perceived threat, t (59) = 0.17, p = .86, 95% CI [-0.16, -0.20], and under high perceived threat, t (59) = -1.05, p = .30, 95% CI [-0.27, 0.09] there is no difference of mimicry of sadness between groups.

Realistic threat. The same analysis was conducted considering perceived realistic threat as moderator. Perceived realistic intergroup threat does not predict the difference in mimicry of sadness between ingroup and outgroup members (yDiff= mimicry of ingroup – mimicry of outgroup), b = -0.05, SE = 0.04, t (59) = -1.37, p = .18, 95% CI [-0.12, 0.02], with an R^2 of .18 (adjusted R^2 =.15). Simple slope analysis reveals that perceived realistic threat does not predict mimicry of sadness towards ingroup members, b = 0.03, SE = 0.02, t (59) = -1.64, p = .11, 95% CI [-0.08, 0.01], or towards outgroup members, b = 0.02, SE = 0.02, t (59) = 0.65, p = .52, 95% CI [-0.03, 0.06]. Conditional effect analysis showed that under low perceived realistic threat, t (59) = 0.53, p = .59, 95% CI [-0.13, 0.23], and under high perceived threat, t (59) = -1.41, p = .16, 95% CI [-0.30, 0.05] there is no difference of mimicry of sadness between groups.

Symbolic threat. The same analysis was conducted considering perceived symbolic

threat as moderator. Perceived symbolic intergroup threat does not predict the difference in mimicry of sadness between ingroup and outgroup members (yDiff= mimicry of ingroup – mimicry of outgroup), b = 0.00, SE = 0.05, t (59) = 0.06, p = .96, 95% CI [-0.09, 0.10], with an R^2 of .01 (adjusted R^2=.00) Simple slope analysis revealed that perceived intergroup threat does not predict mimicry of sadness towards ingroup members, b = -0.00, SE = 0.03, t (59) = -0.16, p = .87, 95% CI [-0.06, 0.05], or towards outgroup members, b = -0.00, SE = 0.03, t (59) = -0.24, p = .81, 95% CI [-0.07, 0.05]. Conditional effect analysis showed that under low perceived realistic threat, t (59) = -0.47, p = .64, 95% CI [-0.22, 0.14], and under high perceived threat, t (59) = -0.40, p = .69, 95% CI [-0.22, 0.15] there is no difference of mimicry of sadness between groups.

Does perceived intergroup threat predict mimicry of fear towards ingroup members?

To better understand the nature of the social category effect on mimicry of anger, two moderation analysis were conducted to verify the moderation of perceived intergroup threat on mimicry of fear in intergroup context. Multiple regression analysis was conducted to investigate the hypothesis that perceived intergroup threat predicts mimicry of fear towards ingroup members, but not towards outgroup members. The analysis was conducted considering realistic and symbolic intergroup threat together and separately. Mimicry of fear towards ingroup members (DV) and mimicry towards outgroup members was regressed on the perceived intergroup threat (realistic and symbolic threat combined) (M) into a multiple regression analysis using the MEMORE macro for SPSS (model 2) (Montoya, 2019). Perceived intergroup threat does not predict the difference in mimicry of fear between ingroup and outgroup targets (yDiff= mimicry of ingroup – mimicry of outgroup), b = -0.06, SE = 0.04, t (59) = -1.71, p = .09, 95% CI [-0.14, 0.01], with an R^2 of .22 (adjusted R^2 =.19). Simple slope analysis reveals that perceived intergroup threat does not predict mimicry of fear towards ingroup members, b = -0.04, SE = 0.03, t (59) = -1.22, p = .23, 95% CI [-0.10, 0.03], or towards outgroups, b = 0.03, SE = 0.02, t (59) = 1.25, p = .22, 95% CI [-0.02, 0.07]. Conditional effect analysis showed that under low perceived threat, t (59) = 0.08, p = .93, 95% CI [-0.14, 0.15], there is no difference of mimicry of fear between groups, however, under high perceived threat, t (59) = -2.34, p = .02, 95% CI [-0.31, -0.02] there are differences on mimicry of fear between groups.

Realistic threat. The same analysis was conducted considering perceived realistic threat as moderator. Perceived realistic intergroup threat does not predict the difference in mimicry of

fear between ingroup and outgroup members (yDiff= mimicry of ingroup – mimicry of outgroup), *b* = -0.05, *SE* = 0.03, *t* (59) = -1.68, *p* = .10, 95% CI [-0.11, 0.01], with an R^2 of .21 (adjusted R^2 =.18). Simple slope analysis reveals that perceived realistic threat does not predict mimicry of fear towards ingroup members, *b* = -0.02, *SE* = 0.02, *t* (59) = -0.87, *p* = .39, 95% CI [-0.07, 0.03], or towards outgroup members, *b* = 0.03, *SE* = 0.02, *t* (59) = 1.73, *p* = .09, 95% CI [-0.00, 0.06]. Conditional effect analysis showed that under low perceived realistic threat, *t* (59) = 0.06, *p* = .95, 95% CI [-0.14, 0.15], there is no difference of mimicry of fear between groups, however, under high perceived threat, *t* (59) = -2.32, *p* = .02, 95% CI [-0.31, -0.02] there are differences on mimicry of fear between groups.

Symbolic threat. The same analysis was conducted considering perceived symbolic threat as moderator. Perceived symbolic intergroup threat does not predict the difference in mimicry of fear between ingroup and outgroup members (yDiff= mimicry of ingroup – mimicry of outgroup), *b* = -0.05, *SE* = 0.04, *t* (59) = -1.22, *p* = .23, 95% CI [-0.13, 0.03], with an R^2 of .16 (adjusted R^2 = .13) Simple slope analysis revealed that perceived intergroup threat does not predict mimicry of fear towards ingroup members, *b* = -0.04, *SE* = 0.03, *t* (59) = -1.31, *p* = .20, 95% CI [-0.11, 0.02], or towards outgroup members, *b* = 0.01, *SE* = 0.02, *t* (59) = 0.24, *p* = .81, 95% CI [-0.04, 0.05]. Conditional effect analysis showed that under low perceived realistic threat, *t* (59) = -0.25, *p* = .80, 95% CI [-0.16, 0.13], and under high perceived threat, *t* (59) = -1.98, *p* = .05, 95% CI [-0.29, 0.01] there is no difference of mimicry of fearbetween groups.

Does perceived intergroup threat predict mimicry of happiness towards ingroup members?

To better understand the nature of the social category effect on mimicry of happiness, two moderation analysis were conducted to verify the moderation of perceived intergroup threat on mimicry of happiness in intergroup context. Multiple regression analysis was conducted to investigate the hypothesis that perceived intergroup threat predicts mimicry of happiness towards ingroup members, but not towards outgroup members. The analysis was conducted considering realistic and symbolic intergroup threat together and separately. Mimicry of happiness towards ingroup members (DV) and mimicry towards outgroup members was regressed on the perceived intergroup threat (realistic and symbolic threat combined) (M) into a multiple regression analysis using the MEMORE macro for SPSS (model 2) (Montoya, 2019). Perceived intergroup threat does not predict the difference in mimicry of happiness between ingroup and outgroup targets (yDiff= mimicry of ingroup – mimicry of outgroup), *b* = 0.00,

SE = 0.06, *t* (59) = 0.09, *p* = .93, 95% CI [-0.11, 0.12], with an R^2 of .01 (adjusted $R^{2\ =}$ .00). Simple slope analysis reveals that perceived intergroup threat does not predict mimicry of happiness towards ingroup members, *b* = 0.03, *SE* = 0.03, *t* (59) = 0.80, *p* = .43, 95% CI [-0.04, 0.10], or towards outgroups, *b* = 0.02, *SE* = 0.05, *t* (59) = 0.47, *p* = .54, 95% CI [-0.07, 0.12]. Conditional effect analysis showed that under low perceived threat, *t* (59) = -0.43, *p* = .67, 95% CI [-0.26, 0.17], and under high perceived threat, *t* (59) = -0.31, *p* = .76, 95% CI [-0.25, 0.18] there is no difference of mimicry of happiness between groups.

Realistic threat. The same analysis was conducted considering perceived realistic threat as moderator. Perceived realistic intergroup threat does not predict the difference in mimicry of happiness between ingroup and outgroup members (yDiff= mimicry of ingroup – mimicry of outgroup), *b* = -0.01, *SE* = 0.034, *t* (59) = -0.13, *p* = .90, 95% CI [-0.09, 0.08], with an R^2 of .02 (adjusted R^2 = .00). Simple slope analysis reveals that perceived realistic threat does not predict mimicry of happiness towards ingroup members, *b* = 0.02, *SE* = 0.03, *t* (59) = 0.66, *p* = .51, 95% CI [-0.04, 0.07], or towards outgroup members, *b* = 0.02, *SE* = 0.04, *t* (59) = 0.62, *p* = .54, 95% CI [-0.05, 0.10]. Conditional effect analysis showed that under low perceived realistic threat, *t* (59) = -0.28, *p* = .78, 95% CI [-0.24, 0.18], and under high perceived threat, *t* (59) = -0.46, *p* = .65, 95% CI [-0.26, 0.16] there is no difference of mimicry of happiness between groups.

Symbolic threat. The same analysis was conducted considering perceived symbolic threat as moderator. Perceived symbolic intergroup threat does not predict the difference in mimicry of happiness between ingroup and outgroup members (yDiff= mimicry of ingroup – mimicry of outgroup), *b* = 0.02, *SE* = 0.06, *t* (59) = 0.34, *p* = .73, 95% CI [-0.09, 0.13], with an R^2 of .04 (adjusted R^2 = .00) Simple slope analysis revealed that perceived intergroup threat does not predict mimicry of happiness towards ingroup members, *b* = 0.03, *SE* = 0.03, *t* (59) = 0.74, *p* = .46, 95% CI [-0.04, 0.10], or towards outgroup members, *b* = 0.01, *SE* = 0.05, *t* (59) = 0.13, *p* = .90, 95% CI [-0.09, 0.10]. Conditional effect analysis showed that under low perceived realistic threat, *t* (59) = -0.61, *p* = .54, 95% CI [-0.28, 0.15], and under high perceived threat, *t* (59) = -0.12, *p* = .90, 95% CI [-0.23, 0.20] there is no difference of mimicry of happiness between groups.

Appendix 3

List of supplemental materials for Study 2 in Chapter 7:

Explicit prejudice towards Arabs was measured by the Feeling Thermometers (e.g., Dasgupta & Greenwald, 2001), Gypsies (*M* = 33.87; *SD* = 25.30); Whites (*M* = 63.71; *SD* = 22.57); Christians (*M* = 56.00; *SD* = 25.56); Refugees (*M* = 54.82; *SD* = 25.80); Politicians (*M* = 33.95; *SD* = 21.80); Arabs (*M* = 45.85; *SD* = 22.03); Drug Addicts (*M* = 30.72; *SD* = 23.60); Immigrants (*M* = 56.59; *SD* = 22.11); Homosexuals (*M* = 59.82; *SD* = 25.65).

Implicit prejudice towards Arabs were measured applying an Implicit Association Task for Portuguese and Arabs as Appendix 1 (e.g., Greenwald & Banaji, 1995). Values close to 0 imply neutrality and lack of bias. In the present research *D* value varied between -0.22 and 2.03 (*M* = 0.88; *SD* = 0.38).

Perception of outgroup's power was measured with the question: "In your opinion, how powerful are the individuals in the next groups?" Christians (*M* = 4.94; *SD* = 1.28); Arabs (*M* = 4.52; *SD* = 1.34), Portuguese (*M* = 3.96; *SD* = 1.13); Syrian Refugees (*M* = 2.25; *SD* = 1.18), Gypsies (*M* = 3.39; *SD* = 1.48), Homeless (*M* = 1.86; *SD* = 1.04). Answers were provided in a scale from 1 "*Not powerful at all*" to 7 "*Extremely powerful*".

Fear of outgroups was measure with the question: "In your opinion, how much do you fear the next groups?" Christians (*M*=2.24; *SD*=1.24); Arabs (*M* = 3.10; *SD* = 1.61), Portuguese (*M* = 1.93; *SD* = 1.17); Syrian Refugees (*M* = 2.57; *SD* = 1.48), Gypsies (*M* = 3.72; *SD* = 1.71), Homeless (*M* = 2.10; *SD* = 1.13). Answers were provided in a scale from 1 "*Not afraid at al*l" to 7 "*Extremely afraid*".

Intergroup emotions were measured by the Intergroup Emotions Scale (Mackie, Devos, & Smith, 2000; Tam, Hewstone, Cairns, Tausch, Maio, & Kenworthy, 2007). Participants provided their answer in a percentage scale to the question: "When you think about Arabs, how many do you think they are:" Honest (*M* = 49.90; *SD* = 22.69); Aggressive (*M* = 40.51; *SD* = 21.47); Hostile (*M* = 42.22; *SD* = 23.68); Intelligent (*M* = 58.14; *SD* = 21.34); Smart (*M* = 60.08; *SD* = 19.72); Warm (*M* = 43.83; *SD* = 23.24); Trustful (*M* = 47.92; *SD* = 21.62); Capable (*M* = 62.81; *SD* = 20.15); Competent (*M* = 60.83; *SD* = 18.66); Friendly (*M* = 51.56; *SD* = 20.23).

Ingroup favouritism was measured by the sub-scale of Ingroup Satisfaction from the Group self-identification scale (α = .92; *M* = 5.29; *SD* = 1.15) (Leach, et al., 2008; for

Portuguese Ramos & Alves, 2011). Participants provided their answer in a scale from 1 = "*Completely disagree*" to 7 = "*Completely disagree*".

Collective narcissism was assessed by the Collective Narcissism Scale (α = .82; *M* = 3.24; *SD* = 1.22) (de Zavala, Cichocka, Eidelson, & Jayawickreme, 2009). Participants provided their answer in a scale from 1 = "*Completely disagree*" to 7 = "*Completely disagree*".

Political Beliefs (*M* = 2.91; *SD* = 1.00) was assessed by the self- placement Liberal-Conservatism Scale (Treier & Hillygus, 2006, June) using a scale from 1 = "*Very liberal*" to 7 = "*Very conservative*" as in Study 1.

Religiosity (*M* = 2.09; *SD* = 1.06) was assessed by an answer to a question "How religious are you?". Answers were provided on scale from 1 = "*Not religious at all*" to 5= "*Extremely religious*" as in Study 1.

EDA measurement. Skin conductance (EDA) was recorded with Biopac Electrodermal Response Amplifier, model GSR100C (Biopac Systems, Inc., Santa Barbara, CA). The signals was digitized at 1000 Hz. Any filter was applied during data collection. After data collection, raw skin conductance data was submitted to a 10-Hz low-pass filter.

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Appendix 4

List of supplemental materials for Study in Chapter 8:

Ingroup favouritism (α =.87; *M* =5.64; *SD* =1.22) was measured by the sub-scale of Ingroup Satisfaction from the Group self-identification scale (Leach, et al., 2008 for Portuguese version Ramos & Alves, 2011). Participants provided their answer in a scale from 1 "*Completely disagree* "to 7 "*Completely disagree*".

Intergroup hostile feelings (α =.87; *M* =1.34; *SD* =0.61) is assessed applying the Intergroup Emotions Scale (Mackie, Devos, & Smith, 2000; Tam, Hewstone, Cairns, Tausch, Maio, & Kenworthy, 2007). A composite measure of hostility towards outgroups was created with the four items: When you think about the outgroup how much do you feel as: displeased, furious, irritated, angry. Participants provided their answer on a scale from 1"*Completely disagree*" to 5 "*Completely disagree*".

Intergroup hostile behaviours (α =.85; *M* =1.70; *SD* =0.94) is assessed asking participants to rate how much they wanted to move against or move away from outgroups using a 7 point scale from 1 "*Totally disagree*" to 7 "*Totally agree*" (Mackie, Devos, & Smith, 2000).

Political Beliefs (*M* =1.91; *SD* =1.05) was assessed by the self- placement on the Liberal-Conservatism Scale (Treier & Hillygus, 2006, June) using a scale from 1"*Very liberal*" to 7 "*Very conservative*".

Religiosity (*M* =3.10; *SD* =1.21) was assessed by an answer to the question "How religious are you?". Answers were provided on scale from 1 "*Not religious at all*" to 5 *"Extremely religious*".

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