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„Zusammenkommen ist ein Beginn,
zusammenbleiben ein Fortschritt,
zusammenarbeiten ist ein Erfolg.“ (Henry Ford)

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Voller Vorfreude gehe ich einen neuen Lebensabschnitt ein, dessen Anfang das Ende dieser Diplomarbeit ist.

Contents

1. Introduction

1.1. Behavioral mimicry – an everyday phenomenon

Although the topic of social group separation has somewhat left a bad taste due to the history of World War II, the ordinary ordering of people into social groups is efficient in our everyday life. Furthermore, humans as social beings depend on their group in order to survive (Capoarel, & Brewer, 1991). Giving in to adaption pressure, the human communication system became more and more complex through evolutionary processes, mainly to facilitate the living together. There is evidence that some of our communicative functions are based on social learning, especially imitation, which allowed us to develop social networks, culture and not least language (Arbib, 2011). While conscious imitation is used to learn or adapt behavior (Bandura, 1962, 1977), behavioral mimicry is the unconscious mirroring of a gesture, posture or movement (Chartrand, & Lakin, 2013). Oftentimes we observe people in bars or public transport interacting with each other, not knowing that they are constantly mirroring each other. These situations can partly be explained by the fact that behavioral mimicry is unconscious, in the sense that the mimicker often has neither the intention to mimic nor the awareness of doing so (Chartrand, & Lakin, 2013; Chartrand, & van Baaren, 2009; Lakin, & Chartrand, 2003). Such fast and automatic reactions to movements of others are possible because of learned links between the observation and the execution of an action, known as the perception-action link (Brass, Bekkering, & Prinz, 2001; Brass, Bekkering, Wohlschläger, & Prinz, 2000; Chartrand, & Bargh, 1999).

Despite its automaticity, the main feature of behavioral mimicry is of communicative nature. Behavioral mimicry causes liking, empathy and affiliation between interaction partners (Chartrand, & Bargh, 1999; Chartrand, & Lakin, 2013; Chartrand, & van Baaren, 2009; Lakin, & Chartrand, 2003) and serves thus as an affiliation signal. Chartrand and Bargh (1999) revealed, that behavioral mimicry is already present in the interaction of strangers. But we do not mimic just randomly. Behavioral mimicry can also be seen as an implicit strategy which is used unconsciously to achieve specific affiliation goals (Lakin, & Chartrand, 2003). Previous work in facial and behavioral mimicry research has shown that social context information influencing the wish to affiliate, like social group membership (Bourgeois, & Hess, 2008; Yabar, Johnston, Miles, & Peace, 2006), social exclusion (Lakin, Chartrand, & Arkin, 2008) or the emotional state of interaction partners (Bourgeois, & Hess, 2008), impact the extent of mimicry in a given situation.

Even though we can already barely make out the flexibility of behavioral mimicry, many influences on this affiliative signal are still to be investigated. A main challenge regarding the investigation of the impact of social context information on behavioral mimicry, is the naturalistic setting in which it is used to be measured. The common observational methods limit the possibilities to manipulate mimicry behavior systematically, because of reduced experimental control. Output measures in terms of observational methods are often hard to quantify and insufficient in their sensitivity.

1.2. Automatic imitation and social context information

Cognitive science instead relies on stimulus-response compatibility (SRC) tasks to measure behavioral mimicry tendencies (Wang, & Hamilton, 2012). In these tasks, participants are asked to react to a cue (e.g. color, shape etc.) with a specific movement (finger lifting, hand opening/closing etc.). Additional to the task-relevant cue, they get confronted with a movement on the computer screen either congruent or incongruent to the actually required response. The observation of the (task-irrelevant) movement on the screen affect the motor execution of the required response, through generating an automatic tendency to imitate the observed action, a phenomenon also known as *automatic imitation* (Brass et al., 2000, 2001; Heyes, 2011; Stürmer, Aschersleben, & Prinz, 2000). As it seems, automatic imitation share the main properties with behavioral mimicry: Both phenomenon are unintentional and automatic reactions, they depend on topographical features of body movements (Heyes, 2011) and they are flexible affiliation signals, sensitive to the social environment (Heyes, 2011; Lakin, & Chartrand, 2003; Leighton, Bird, Orsini, & Heyes, 2010). Thus, it is plausible that behavioral mimicry and automatic imitation depend on the same psychological and neural processes, although this assumption has not yet been confirmed. Some researchers proposed to apprehend automatic imitation as the laboratory model or a covert form of behavioral mimicry (Heyes, 2011). The great benefit of SRC tasks is the possibility to manipulate social context information of the "person" the participant is interacting with, for example through vignettes or videos. Nevertheless, the assumption has been stated that automatic imitation stays comparable to the naturalistic behavioral mimicry (Wang, & Hamilton, 2012). Because we assume automatic imitation investigated in such tasks to be an operationalization or a laboratory model of mimicry (Heyes, 2011), automatic imitation henceforth will be stated as *mimicry.*

A great advantage of SRC tasks is that they are highly quantifiable through the use of reaction times as output measurement (Wang, & Hamilton, 2012). Consequently in the case of

incongruent reactions on the part of the combatant, the tendency to imitate the inadequate behavioral response has to be suppressed, which leads to longer reaction times. On the other hand, the perception of a movement matching to from one's own required action facilitates reaction (measured through faster reaction times), as it can be observed in congruent trials. These processes are also known as response inhibition and response facilitation which, subtracted from each other, are the indicators for the *mimicry effect* (i.e. mean reaction times of incongruent trials minus those of congruent trials) (Brass et al., 2000, 2001; Stürmer, Aschersleben, & Prinz, 2000).

Leveraging the advantages of automatic imitation, Rauchbauer, Majdandžić, Stieger, & Lamm (2015a) used a well-established automatic imitation paradigm (Brass et al., 2000) and combined it with the display of emotional in- and outgroup faces, to investigate further influences of social context information on automatic imitation. Participants were thus confronted with facial stimuli varied with respect to ethnic group membership (White/Caucasian vs. Black/African-American) and emotion expression (happy vs. angry) (Tottenham et al., 2009). Human faces and their expressions are important cues in everyday social life because they provide essential information in the interaction with fellow human beings (Rolls, 2000). The emotional state of a person is one of the main communicative signals human faces can provide. As facial mimicry research reveals, emotion expressions influence mimicry levels by providing implicit information about the intentions of an expresser (Bourgeois, & Hess, 2008; Hess, & Fischer, 2013; Knutson, 1996), like the affiliative intent of an interaction partner. While happy faces are assumed to signal approach and affiliation tendencies, angry faces seem to be perceived as rejection and non-affiliative, especially when shown by male faces (Bourgeois, & Hess, 2008; Frijda, Kuipers, & Ter Schure, 1989). Consequently, there seems to be an interaction between the social signal of emotional expressions and the function of behavioral mimicry to create liking and facilitate affiliation (Bourgeois, & Hess, 2008). In any case, the interpretation of an emotional display can vary depending on other social context information. For example, already in situations providing only little information about the interaction partner, we use stereotypes regarding social group membership to derive simple rules for the likelihood of certain emotional reactions (Hess, Blairy, & Kleck, 2000). An existing sense of belonging, be it established through ethnicity (Bourgeois, & Hess, 2008; Van der Schalk et al., 2011) or shared fundamental values like political attitudes (Bourgeouis, & Hess, 2008), seems to influence the motivation to execute facial mimicry and consequently the wish for affiliation (Van der Schalk et al., 2011). Correspondingly, mimicry as a flexible affiliative signal should, like facial mimicry, vary in response to group membership of the

interaction partner, with an increased mimicry effect in the case of ingroup members compared to outgroup members (Bourgeois, & Hess, 2008; Yabar et al., 2006). While the interaction between group membership and emotional display have not been investigated for mimicry yet, facial mimicry research could show that negative emotions were only mimicked in the case of ingroup members, while happiness has always been mimicked regardless of group membership (Bourgeois, & Hess, 2008; Yabar et al., 2006).

Within its affiliative function, behavioral mimicry seems to have a regulatory role in social interactions. Lakin et al. (2008) showed that participants exhibited increased mimicry behavior when they were socially excluded beforehand. Hence, behavioral mimicry has been unconsciously used to satisfy belongingness needs through the selective mimicry of members of the desired group. Likewise, Rauchbauer et al. (2015a) could show with their social-affective mimicry task (SAMT) that, besides an increased tendency to imitate smiling ingroup members, also angry outgroup faces result in enhanced automatic imitation. Given the fact that African-American outgroup members are stereotyped as threatening by Caucasian participants (Amodio, 2008; Van der Schalk et al., 2011), automatic imitation seems to regulate the social situation through conciliation and appeasement (Keltner, Young, & Buswell, 1997, Rauchbauer et al., 2015a; Van Kleef, De Dreu, & Manstead, 2004). In other words, automatic imitation might be used to de-escalate a threatening social situation by sending affiliation signals usually causing liking and rapport. Particularly, behavioral mimicry might be used to conciliate a situation when the abilities of a person to inflict harm upon somebody are judged higher than one's own (Neuberg, & Cottrell, 2008), like it might be the case for African American outgroup members.

On the whole, automatic imitation, comparable to behavioral mimicry, varies in its extent in response to social context information. Thereby it seems as if the same mimicry behavior is used to create affiliation as well as to conciliate a situation or appease a person. At least on a behavioral basis, the possibly differing processes behind the apparently similar reactions to affiliative and non-affiliative faces cannot be investigated. But additional to the better controllable manipulation of context information, the experimental nature of automatic imitation allows to use SRC tasks also while applying physiological and neuroscientific methods. Consequently, the laboratory nature of automatic imitation offers the opportunity to shed light on the profound processes of the regulation of mimicry by social-affective cues. Rauchbauer (2015b) already implemented the SAMT into a fMRI study to investigate the processes involved in regulation of mimicry in response to socio-affective cues. However, the aim of the actual study is to investigate the temporal neural dynamics

in the course of modulating mimicry according to social-affective cues, entailing distinct affiliative goals. Therefore, the method of choice, mainly because of its high temporal resolution, are event-related potentials (ERPs), which means electroencephalographic (EEG) activity time-locked to the presentation of similar events (Ibanez et al., 2012; Luck, 2005).

1.3. Interference effects and corresponding ERP components

To investigate the temporal neural dynamics of the SAMT further, the question arises at which point automatic imitation could be influenced through task-irrelevant information. To understand automatic imitation processes further, it is useful to rely on theoretical background explaining *interference effects*, a more general term for SRC or mimicry effects. The most influential theory for interference effects is the *dual-route model*, in which it is assumed that action responses can either be activated through an intentional or an automatic route (Proctor, & Vu, 2006). While task instructions produce a short-term link between the cue and its appropriate motor answer via the intentional route, task-irrelevant information, like the movement of an interaction partner, activates automatic routes triggering motor tendencies congruent or incongruent to the expected behavioral answer. Thereby, task-irrelevant information can either influence automatic imitation through early attentional processes (input modulation), or through higher social cognitive processes (output modulation), for what a peripheral presentation of these stimuli is sufficient (Heyes, 2011; Proctor, & Vu, 2006). Hence, to investigate at which point automatic imitation gets influenced by task-irrelevant stimuli, ERP components are required reflecting the task-independent processing of stimuli features. Correspondingly, early ERP components are known to be mainly influenced by characteristics of stimuli, regardless of their relevance to the task at hand (Luck, 2005). Nevertheless already these early components, partially emerging only 100 ms after stimulus onset, are influenced by internal attentional processes (Luck, & Ford, 1998), which make them a useful tool to test the input modulation hypothesis for automatic imitation. To investigate the possibility of a differential attentional shift towards happy ingroup and/or angry outgroup faces, causing an enhanced automatic imitation effect for these stimuli, ERPs time-locked to the first presentation of the facial stimuli were analyzed. Previous studies identified the P100 (P1) (Smith, Cacioppo, Larsen, & Chartrand, 2003), the P200 (P2) (Carretié, Mercado, Tapia, & Hinojosa, 2001; Correll, Urland, & Ito, 2006; Eimer, Holmes, & McGlone, 2003) and the late positive potential (LPP) (Ito, Larsen, Smith, & Cacioppo, 1998) as components reflecting attention allocation towards specific stimulus features. The P1 component is peaking between approximately 100 and

150 ms after stimulus onset (Clark, & Hillyard, 1996; Luck, 2005), while being maximal over the occipital lobe. Strictly speaking, the P1 component derives from activated extrastriate neurons of the visual cortex, recruited to process visual stimuli on which attention is actually allocated. Furthermore attended stimuli provoke more pronounced P1 amplitudes than ignored ones (Clark, & Hillyard, 1996), even when attention is involuntarily manipulated (McDonald, Ward, & Kiehl, 1999). Another ERP component known to show selective attention and visual feature detection processes is the P2 component (O'Donnell, Swearer, Smith, Hokama, & McCarley, 1997), a positive deflection occurring approximately 200 ms after stimulus onset (Hillyard et al., 1973). The P2 component has been shown to be sensitive to threatening images like angry human faces, which is indicated by amplitude enhancement for these stimuli (Carretié et al., 2001; Correll et al., 2006; Eimer et al., 2003). In addition, Ito and Urland (2003) could constrain more pronounced P2 amplitudes as a reaction to Black than White faces, appropriate to the assumption that African American faces are received as more threatening by White participants. Altogether, early visual components (within the first 300 ms) like the P1 and P2 components, are assumed to reflect the covert attentional shift towards evolutionary significant stimuli (Ohman, Lundqvist, & Esteves, 2001). A late component depicting task-independent stimulus properties, namely the LPP component, shares main features with the well-studied P300 component, like its average latency between 300 and 900 ms and its topographic distribution being most pronounced over the parietal scalp area and declining towards more central and frontal areas. While the P300 component is especially sensitive to improbable events (Duncan-Johnson, & Donchin, 1977, 1980), LPP component variation is also observed in evaluative categorization tasks with equal probability of stimuli (Ito et al., 1998). On the whole, the LPP component shows larger amplitudes for pleasant and unpleasant stimuli than for neutral ones (Bublatzky, & Schupp, 2012; Weinberg, & Hajcak, 2010; Wheaton et al., 2013). Moreover, Bublatzky and Schupp (2012) alternately used neutral, pleasant and unpleasant pictures as threat-cues being followed by an electrical shock. The LPP component was divided in two sub-components, which thereby differentiated the original picture category at centro-parietal sites, while the retrospectively added threat imminence of the pictures were reflected in a parieto-occipital LPP amplitude variation, which demonstrates the flexibility of the LPP component to be responsive to threatening cues. In conclusion, stimulus feature sensitive ERP components are an advantageous measure, to investigate the interactive influences of emotion and social group membership on automatic imitation.

Automatic imitation originates from SRC tasks in which, generally speaking, the relationship between the topographical features of task-irrelevant action stimuli (e.g. arbitrary hand or finger movements) and the participants reaction have an impact on the speed and/or accuracy of the performed movement (Heyes, 2011). Following this description of the interference effect of SRC tasks, the question arises how the interference effect of imitation-inhibition tasks depicts itself. Another interference effect can be observed in the Simon task (original task: Simon, 1969), in which the interference effect arises out of the task-irrelevant stimulus position which is either compatible or incompatible to the response location. As Rauchbauer et al. (2015a) already assumed based on the comparison between the SAMT and a Simon task, the mimicry effect may not be a domain-general (in)congruency effect, but specific for a motor resonance process. ERPs following the cue and arbitrary hand/finger movement onset are used to investigate the interference effect of the SAMT further. Most ERP studies investigating interference effects, identified the N2 component family as indicators for conflict monitoring processes (for a review, see Folstein, & Van Petten, 2008). More precisely, the frontocentral N200 component, peaking about 250-300 ms after picture onset, has been found to differentiate between conflicting and non-conflicting stimuli, for example in the Simon task (Böckler, Alpay, Stürmer, 2011). But also inhibition signals, indicating that an original motor intention has to be withhold, like in so-called stop-signal- or no-go-paradigms, are assumed to provoke enlarged N200 amplitudes. While originally the N200 component was thought to represent a mechanism which initiates inhibitory control both for stop and no-go signals (Van Boxtel, Van der Molen, Jennings, & Brunia, 2001), recent studies reveal that the N200 component is more likely involved in conflict monitoring (Donkers, & Van Boxtel, 2004; Enriquez-Geppert, Konrad, Pantev, & Huster, 2010; Nieuwenhuis, Yeung, & Cohen, 2004). The N200 component is commonly linked to the later P300 component, why they are referred to as the "N2-P3 complex" (e.g. Folstein, & Van Petten, 2008). The P3 component can be divided into two sub-components, namely a frontally maximal component sensitive to novel and significant stimuli (P3a) and the P3b component, maximal at parietal electrode sites indexing working memory updating (Courchesne, Hillyard, & Galambos, 1975; Squires, Squires, & Hillyard, 1975). While the P3a component seems to be more stimuli-dependent, P3b component is assumed to "reflect[s] a function that bridges perceptual processing with response processing" (Verleger, Jaskowski, & Wascher. 2005, p. 13). Furthermore Verleger et al. (2005) suppose that P3b component may reflect the consequences of a precedent action decision. Therefore, P3b component amplitude variations could serve as an index of the influence of stimuli varying in their congruency, emotion and/or

ethnicity, on response processing. Thus conflicting stimuli, or rather stimuli triggering inhibition, should have a greater impact on reaction processing and should therefore end in more pronounced P3b component amplitudes. Altogether, the N2-P3 complex is suitable to shed light on the question of how reaction time differences due to cognitive conflict and/or inhibition are reflected in ERPs, depicting processes directly preceding the actual reaction.

1.4. Implementing automatic imitation in an ERP design

For the actual study, we adapted the SAMT of Rauchbauer et al. (2015), to implement it into an EEG paradigm (for details see Methods section). Thereby (1) response time differences were calculated to show variations in the mimicry effect. Furthermore, (2) the explicit and implicit attitude towards Blacks was measured via questionnaires, to prevent from interfering variables and to correlate these racial bias measurements with the behavioral data. Additionally, ERPs (3) following (a) the onset of the facial, task-irrelevant stimuli and (b) the cue onset, which includes the congruent or incongruent movement of the interaction partner on the computer screen, were investigated.

(1) Based on the behavioral results study with three experiments and over 180 participants of Rauchbauer et al. (2015a), we hypothesized that for the actual study a similar pattern of the mimicry effect should arise. This means that the mimicry of arbitrary finger movements should be higher for happy ingroup, as well as for angry outgroup faces, at least for congruent (response facilitation) trials.

(2) Because deviant attitudes towards Blacks could influence the results of the following study, questionnaires were implemented measuring the implicit and explicit attitudes towards Blacks. We hypothesized that participants have a homogenous implicit and explicit attitude towards Blacks, whereat participants significantly deviating from the mean would be excluded from further analysis.

(3) a) For the first frame we hypothesized that, if the mimicry effect is modulated by stimuli input, stimulus-dependent ERP components should indicate the preferential processing of mimicry triggering stimuli-compositions. In this case, P1, P2, LPP1 and LPP2 components should somehow reflect the pattern of the behavioral data of Rauchbauer et al. (2015a), with pronounced amplitudes for happy ingroup and/or angry outgroup stimuli.

(3) b) Additionally, we focused on ERPs known to represent cognitive conflict monitoring (N200) and response processing (P3b), to investigate the nature of the interference effect of the

SAMT. If the domain-general (in)congruency effect is similar to the interference effect of well-established tasks, then N200 amplitudes should be more pronounced for incongruent than congruent stimuli. As already mentioned, the P3b component is assumed to reflect response processing. Because of longer reaction times due to incongruent trials compared to congruent trials, it is reasonable that incongruent stimuli have a greater influence on response processing which could contribute to the response delay. Therefore, more pronounced P3b amplitudes for incongruent than congruent trials were hypothesized for the following study.

2. Methods

2.1. Participants

Thirty White Caucasian participants (20 women, 10 men, *MN* = 25.1 years, *SD* = 3.4 years, range: 20 to 33 years) took part in the EEG-experiment for financial compensation of 25 Euro. The participants were recruited online via the social media platform Facebook (https://www.facebook.com/ProbandInnenGesuchtScanUnitUniwien) and a local job platform (http://www.unijobs.at/). Participants were all right-handed as assessed with the Edinburgh Handedness Inventory (Oldfield, 1971), reported no medical history of neurological, cardiovascular, or psychiatric disorders, and had normal or corrected to normal vision. The procedure of the EEG-experiment was in accordance with the Declaration of Helsinki (revised 2013) and the study was approved by the ethics committee of the University of Vienna.

2.2. EEG-preparation and properties

Participants had to give their written consent and fill in the Handedness Inventory (Oldfield, 1971), before 59 Ag/AgCl electrodes in form of an equidistantly mounted cap (model M10, EASYCAP, GmbH, Hersching, Germany) were applied. Additionally, two electrodes were applied one cm above and below the right eye (measuring vertical electrooculogram; EOG) for off-line eye-movement correction. Furthermore, four facial electromyographic (fEMG) electrodes, respectively two at left Zygomaticus Major area and two at Corrugator Supercillii area, were utilized, to record facial muscle activity. It has to be mentioned that the analysis of the fEMG data is not part of this thesis. EEG-electrode impedance was kept below 4 kΩ with a skin scratching procedure prior to recording (Picton, & Hillyard, 1972). The impedance of the fEMG-electrodes was kept below 10 kΩ, using an abrasive skin preparation gel (nuPrep) on a cotton swab (Welleditsch, 2011), to remove excessive scurf on concerned face areas. During the preparation for the EEG-recording, the participants were informed about the course of the experiment and their task. Additionally, they were asked to concentrate on the middle of the screen and to reduce their head and body movements to a minimum during task performance. Following the application of the EEG-cap, participants were seated in a dimmed, sound attenuated and electrically shielded chamber. They sat about 70 cm in front of a 19″ cathode ray tube (CRT) monitor (Sony GDM-F520; 85 Hz refresh rate), showing stimulus presentation under the control of E-Prime 2.0 (Psychology Software Tools, Inc., Sharpsburg, PA). EEG signals were thus collected with a DC-

amplifier setup (NeuroPrax, neuroConn GmbH, Ilmenau, Germany), recorded within a frequency range of DC to 500 Hz and sampled at 1000 Hz for digital storage.

2.3. Experimental task

The social-affective mimicry task (SAMT) is an adaption by Rauchbauer (2015a) of the inhibition of imitation task, proposed by Brass et al. (2000). Two consecutive frames were shown, including a facial stimuli and a hand executing a middle or index finger movement. In the first frame, the face varied in its social group membership (ingroup: Caucasian, outgroup: African-American) and emotional facial expression (happy/angry), but not in its gender (always female), and originated from the NimStim Set of Facial Expressions (Tottenham et al., 2009). To prevent differential attentional effects for in- and outgroup stimuli, the faces were matched for lumination differences using the SHINE (Spectrum, Histogram, and Intensity Normalization and Equalization) –toolbox (Willenbockel et al., 2010) for Matlab 8.3 (TheMathworks, Inc., MA). The hand stimulus was mirroring participants right hand and was shown wearing a beige glove to prevent perceptional and/or attentional differences between in- and outgroup stimuli sets (see **Figure 1**). This practice is of relevance, because it might be the case that contrast is different for the cue (black number on a

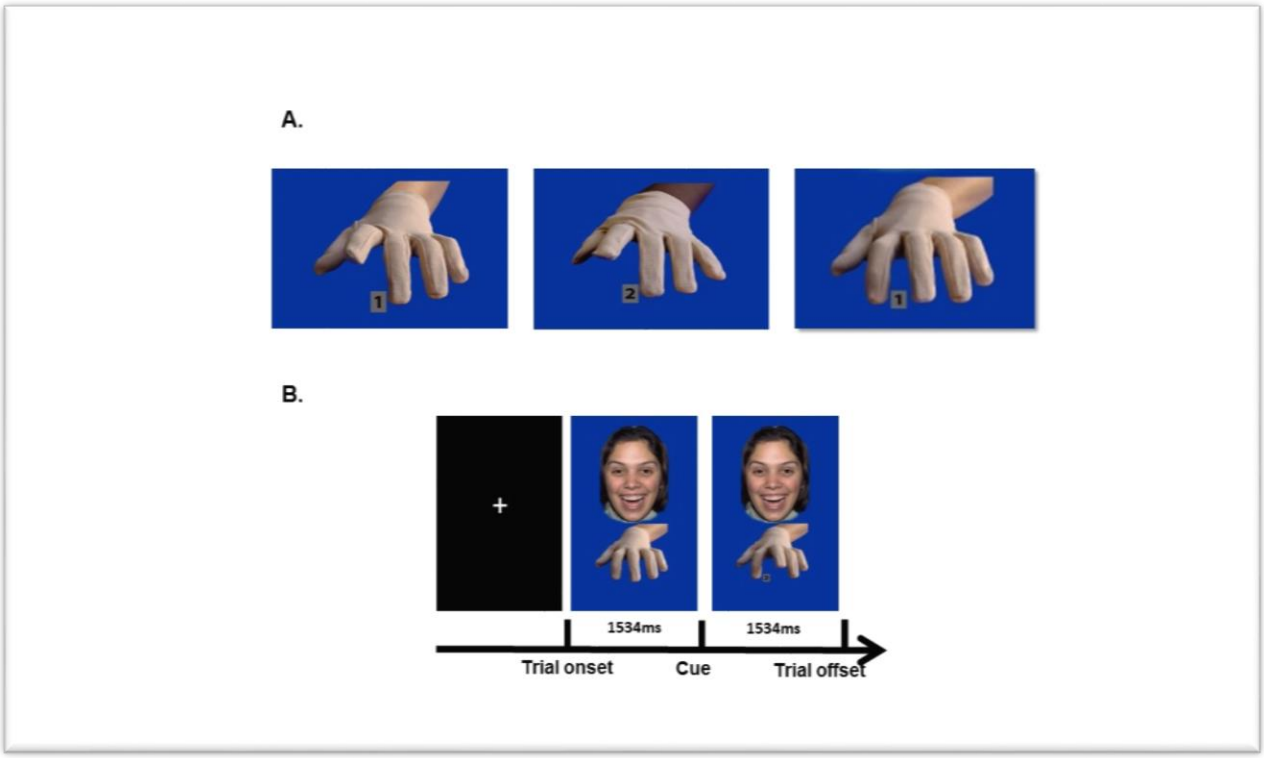

Figure 1: Experimental task: **A**. Examples of a congruent, incongruent and baseline hand stimuli for ingroup and outgroup trials. **B**. Time course of the SAMT adapted for EEG recording. Inter-trial interval was 1200-1800 ms.

grey square) being surrounded by a black or white hand. Additionally, attention towards a bright or dark object moving on a screen might diverge (Rauchbauer et al., 2015a). Nevertheless, skin color and thus ethnicity was still visible at the wrist.

In the second frame, the task-relevant cue was shown between the middle and index finger of the hand, namely a black "1" or "2" in a grey square (see **Figure 1**). The participants got the instruction to press and rest with the right index finger on the "1" and the middle finger on the "2" of a standard keyboard's number pad during the experiment. Participants were instructed to lift their index finger when "1", likewise their middle finger when "2" appeared on the screen. Irrelevant to their task, the hand on the screen executed a congruent, an incongruent or no movement at all. Congruent trials implied that the hand on the screen performed the same movement as required from the participant. Incongruent trials implied that the required movement and the movement of the hand on the screen were contrary. Baseline trials were trials in which the hand on the screen did not move at all. Therefore the current study used a 2 (group: ingroup/outgroup) x 2 (emotional facial expression: happy/angry) x 3 (congruent trials/ incongruent trials/ baseline trials) within-subject study design, with uniformly distributed index and middle finger movements. Fifty trials per condition were conducted (25 index finger/ 25 middle finger), presented randomly mixed, resulting in 600 trials per participant. One trial consisted of two frames (see **Figure 1**). After a variable inter-trial interval (random duration of 1200-1800 ms) with a white fixation cross on a black screen, participants saw a screen with the face and hand stimuli, lasting for 1534 ms. The following frame showed the finger movement, respectively no movement in baseline trials, and the target cue. The second screen lasted for another 1534 ms. Participants completed ten training trials prior to the experiment. Altogether, EEG data acquisition took approximately 60 minutes, dependent on the time participants spent during pauses.

2.4. Post-experimental measurements

2.4.1. Threat/Security - Implicit Association Task (Threat-IAT)

While explicit attitudes can be measured through the evaluation of statements (in this study measured with the Attitudes towards Black Scale, see section 2.4.2), the implicit racial bias is more intuitive and without awareness. Even though people have the tendency to prevent racial biases, the intentions to control them are not always successful (Amodio et al., 2004; Correll et al., 2006; Devine, 1989). This implicit form of racial attitudes has been investigated with the Implicit Association Task (IAT) (Greenwald et al., 1998). Rauchbauer et al. (2015) adapted the original

IAT to the actual stimuli, whereby the association between in- and outgroup (white and black faces) and attributes of "security" and "threat" was measured. The categories of security and threat consisted out of five German nouns, matched for word length and presented as columns in which matching pictures or words had to be assigned. The participants were instructed to press "E" for left category and "I" for right category. They had to respond as quickly as possible regardless of errors. Erroneous responses resulted in a red cross on the screen presented until the right answer was given.

A specific difference measure of reaction times provided the "D- measure" (Greenwald, Nosek, & Banaji, 2003), an indication for implicit associations of Whites and Blacks with the assigned attributes of security and threat. In this case, larger, positive D-values represented a greater association of Blacks with the concept of "threat" and White people with "security". The D-measure is effect-size based. The IAT enabled us to find out whether or not, outgroup faces were implicitly associated with more threat than ingroup faces. Additionally, the aim of the IAT was to verify, that all participants had a comparable implicit attitude towards Black persons. Conspicuous outliers were excluded from further analysis.

2.4.2. Attitudes towards Black Scale

With the German version of the Attitudes towards Black Scale (Kölble, 2012; Paul, 2012; original version: Brigham, 1993), measure participant's explicit attitudes towards Black people was measured. Therefore, following the experimental task and IAT administration, participants had to read statements about attitudes towards Blacks and rated them on a seven-point Likert-scale ranging from a strong disagreement ("1") to a strong agreement ("7"). A low score indicated negative explicit attitudes, a high score positive explicit attitudes. With a Cronbach's Alpha of 0.89, the scale has good internal consistency. The aim of the scale was to control for striking prejudices, which could influence the results of the inhibition of imitation task, and to filter them out before analysis.

2.4.3. Manipulation check

For the manipulation check, participants had to rate the four possible group-emotion variants (angry outgroup/ angry ingroup/ happy outgroup/ angry outgroup) with the aid of positive and negative emotion words (happy, angry, sad and afraid). Additionally, the security- and threat-related words of the IAT were implemented. All words had to be scored on a ten-point Likert-scale ranging from "This is not true" to "This is true". Finally two dipole-scales with ten graduations

were added, ranging from pleasant to unpleasant and from quiet to disquiet, to investigate the arousal elicited by the specific face stimuli. The aim of the manipulation check was to ensure that the emotions of the facial stimuli were correctly identified and to have a general overview over the emotions triggered by the facial stimuli.

2.5. Data Analysis

For statistical analysis IBM SPSS Statistics (Version 21, IBM Corporation, NY) was used. The significance level was set to $p < 0.05$ for all comparisons. Significant ANOVA effects were explored with SPSS multiple comparisons, significant interactions were corrected using Bonferroni's methods. Effect sizes are reported with Partial eta-squared (η_p^2) for significant ANOVA results (Kirk, 1996). If necessary, degrees of freedom were adapted with the Greenhouse–Geisser correction (GG).

2.5.1. Behavioral data

The main focus concerning the behavioral data was to replicate the findings of Rauchbauer et al. (2015a), with increased mean reaction times (RT) for angry outgroup and happy ingroup stimuli. Therefore, mean difference scores (RT for incongruent minus congruent trials) for the face stimuli were generated and included in a two-way repeated measures ANOVA, with the within-subject factors *group* (ingroup/outgroup) and *emotion* (happy/angry). Only correct trials were included in data analysis. Outliers were corrected using a winsorization procedure, applied to the individual mean response time (RT) per facial stimuli condition and per target cue before further statistical analysis. Mean RTs higher than the 75th percentile plus 1.5 times the interquartile range of the conditions per target cue, respectively, mean RTs lower than the 25th percentile minus 1.5 times the interquartile range of the conditions per target cue were replaced with the maximum, respectively the minimum mean reaction time (in ms) in the particular condition.

2.5.2. Questionnaire data

For the IAT, the mean "D-measure" was calculated, for the Attitudes towards Black Scale and the manipulation check mean scores. The data was screened for eventual outliers, relevant participants being excluded from further analysis. Furthermore concerning the Manipulation check, a 4 x 2 repeated-measures ANOVA was conducted with the factors *face stimuli* (angry outgroup/ happy outgroup/ angry ingroup/ happy ingroup) and *IAT words* (security/ threat). Additionally the *emotion words* (happy/ angry/ sad/ afraid) had been compared with respect to the *face stimuli* in a

second repeated-measures ANOVA. Finally the *arousal* measurement of the four face stimuli had been compared to each other in a last repeated-measures ANOVA. Pearson's correlations were calculated between the mean difference scores of each condition, the individual D-measures of the IAT and mean scores of the Attitudes toward Black Scale.

2.5.3. EEG data

For EEG data analysis, EEGLAB 13.3.2b (Delorme, & Makeig, 2004) implemented in Matlab 8.3 (TheMathworks, Inc., MA) was used. Initially, data was re-referenced to linked mastoids, down-sampled to 500 Hz and a high-pass (0.1 Hz) and a low-pass filter (cut-off frequency 30 Hz, roll-off 6dB per octave) were applied. For the EEG analysis concerning the first frame, data segments of the four conditions (angry outgroup, happy outgroup, angry ingroup, happy ingroup) were extracted, 500 ms prior to stimulus onset and lasting for 1600 ms. The mean of the 200 ms prior to cue onset served as baseline interval. For second frame data analysis containing cue onset, the data segments of the twelve conditions (*ingroup/outgroup x angry/happy x congruent/incongruent/baseline*) were extracted from 200 ms prior to cue onset and lasting subsequently for 1600 ms. The mean of the 200 ms prior to cue onset served as baseline interval. Striking artifacts due to body were removed via visual inspection, before extended infomax independent components analysis (ICA; Bell & Sejnowski, 1995; Lee, Girolami, & Sejnowski, 1999) was applied. Subsequently, individual eye blink components were identified and excluded and a semi-automatic artefact correction was applied, eliminating trials with voltage values exceeding ±75 µV or voltage drifts >50 µV. Trials marked by the EEGLAB algorithms were reviewed and excluded when visual inspection also indicated artifact affliction. The now artifact-free segments were averaged participant- and condition-wise.

All ERP component locations and time windows were chosen based on recent literature and visual inspection of the data at hand. ERP components relevant after face stimulus onset were the P1, P2, as well as an early and late LPP components. P1 mean amplitudes were extracted 100 – 140 ms after stimulus onset at R30 and R27 (right hemisphere, corresponding to electrode locations O2 and PO8/P8 of the 10-20 system) and at L28 and L24 (left hemisphere; corresponding to electrode locations O1 and PO7/P7 of the 10-20 system) (Achaibou, Pourtois, Schwartz, & Vuilleumier, 2008; Valdés-Conroy, Aguado, Fernández-Cahill, Romero-Ferreiro, & Diéguez-Risco, 2014). For P1 analysis, a 2 x 2 x 2 repeated measures analysis with the within-subject factors *group* (outgroup/ingroup), *emotion* (angry/happy) and *hemisphere* (right/left) was applied. P2

mean amplitudes were extracted at electrode location Cz within the time range of 150 – 200 ms (Bublatzky, & Schupp, 2012; Carretié et al., 2001). P2 mean amplitudes were analyzed using a 2 x 2 (*group x emotion*) repeated-measure ANOVA. Finally, the LPP has been separated in an earlier and a later component, referred to as LPP1 (early LPP; centro-parietal) and LPP2 (later LPP; parieto-occipital) (Bublatzky, & Schupp, 2012). LPP1 was extracted 300 – 400 ms after stimulus onset at CPz, R20 and L18 (corresponding to electrode locations between CP2/C2 and CP1/C1 of the 10-20 system) (Bublatzky, & Schupp, 2012; Weinberg, & Hajcak, 2010). LPP1 was analyzed using a 2 x 2 x 3 repeated-measure ANOVA with the within-subject factors *group* (outgroup/ingroup), *emotion* (angry/happy) and *electrode* (midline/right/left). LPP2 was extracted at R29 (right hemisphere; corresponding to electrode location between POz/PO4 of the 10-20 system) and L27 (left hemisphere; corresponding to electrode location between POz/PO3 of the 10-20 system) in the time window of 450 – 570 ms after stimulus onset (Bublatzky, & Schupp, 2012). Hence, LPP2 mean amplitudes were analyzed using a 2 x 2 x 2 (*group x emotion x hemisphere*) repeated measures ANOVA. Concerning ERP components of the second frame, N200 mean amplitudes were extracted at electrode location Cz, 200 – 300 ms after cue onset (Nieuwenhuis et al., 2004) and P3b mean amplitudes at Pz, 300 – 400 ms after cue onset (Verleger et al., 2005). N200, as well as P3b mean amplitudes were analyzed using a 2 x 2 x 3 (*group x emotion x congruency*) repeated-measure ANOVA.

3. Results

3.1. Behavioral results

A 2 (*emotion*: happy, angry) x 2 (*group*: in-, out-group) ANOVA concerning the mimicry effect (i.e. reaction time difference of mean RT in incongruent versus congruent trials) of the SAMT revealed no significant main effects for *group* (Ingroup/Outgroup) ($F(1, 771) = 1.50$, $p = .231$) or *emotion* (happy/angry) ($F(1, 61) = 0.14$, $p = .712$). A trend significant interaction effect between *group* and *emotion* ($F(1, 3.91)$, $p = .058$, $\eta_p^2 = 0.13$) was found for the mimicry effect, as expected. Bonferroni-corrected post-hoc tests revealed a more pronounced mimicry effect for happy ingroup than happy outgroup faces ($p = .023$). The comparison between angry and happy outgroup faces did not reach significance ($p = .066$) (see **Figure 2**).

3.2. Questionnaire results

Due to technical errors, the questionnaire data of two participants was missing for the IAT and the Attitudes towards Black Scale, and of six participants for the Manipulation check, why data analysis was conducted with the remaining questionnaire data only.

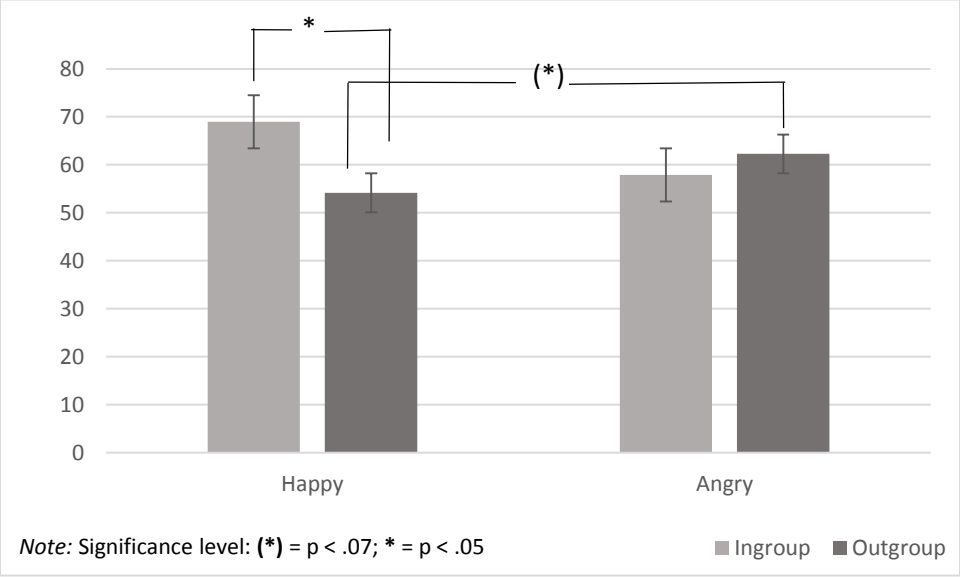

Figure 2: Interaction effect between group and emotion for the mimicry effect. Bars represent the difference between incongruent minus congruent trials for the corresponding condition.

3.2.1. Threat-IAT

The mean D-value revealed a small to medium effect (*M* = 0.29, *SE* = 0.40, see **Fehler! Verweisquelle konnte nicht gefunden werden.**) of Black people being more associated with threat and White people with security. Pearson's correlations of the individual D-measures and mimicry effects indicated a significant relationship between the implicit attitude towards Black and the mimicry effect due to angry white faces (r = .39, p = .038). All other correlations between the mean difference reaction times and D-values were not significant (*all p-values* ≥ .520)

Table 1: Results of the IAT

Block 3 **Compatible Block**	**Block 5** **Incompatible Block**	***t***	**D-measure**
853.94 *(42.79)*	967.55 *(32.89)*	$t(27) = -3.30$**	0.29 *(0.08)*

3.2.2. Attitudes towards Black Scale

The mean score of the Attitudes towards Black Scale (M = 4.07, SE = 0.06) revealed a neutral explicit attitude towards Black. Data bared two outliers at the lower end of the scale (i.e. very positive explicit attitude towards Black). The identified outliers were excluded from EEG data analysis to prevent unwanted influences through conspicuous explicit attitudes towards Black. No significant correlation between the individual Attitudes towards Black scores and mimicry effects were found (*all p-values* ≥ .268). Also the mean score of the Attitudes towards Black Scale and the D-measure of the IAT were not significantly related to each other (p = .598).

3.2.3. Manipulation Check

IAT words. A 4 x 2 repeated-measures ANOVA was conducted with the factors *face stimuli* (angry outgroup/ happy outgroup/ angry ingroup/ happy ingroup) and *IAT words* (security/ threat), which revealed a significant main effect of *face stimuli* ($F(3,69) = 6.89$, $p < .001$, $\eta_p^2 = 0.23$). Post-hoc tests (Bonferroni corrected) showed that angry outgroup faces were generally higher rated for security/threat words than happy outgroup faces ($p = .049$) and happy ingroup faces ($p = .005$), but did not differ from angry ingroup face ratings ($p > 0.999$). Thereby the height of angry ingroup face ratings did not differ from those of happy out- and ingroup faces (*all p-values* ≥ .096). The interaction between *IAT words* and *face stimuli* was highly significant ($F(1.58,36.31) = 208.62$, $p(GG) < .001$, $\eta_p^2 = 0.90$). Bonferroni-corrected post-hoc tests revealed that security and threat *IAT words* differed from each other for every *face stimuli* condition (*all p-values* < .001).

Thereby happy in- and outgroup faces were rated higher in security words than angry in- and outgroup faces (*all p-values* < .001), but did not significantly differ from each other ($p > 0.999$). Also the angry in- and outgroup face ratings did not differ in their security ratings ($p = .749$). While angry in- and outgroup faces did not differ from each other in their threat related ratings ($p > 0.999$), they were rated as more threatening than happy in- and outgroup faces (*all p-values* < .001). The happy in- and outgroup threat ratings did not differ from each other ($p > 0.999$).

Emotion words. In a second repeated-measures ANOVA, the *emotion words* (happy/ angry/ sad/ afraid) had been compared with respect to the *face stimuli*, which revealed significant main effects of *face stimuli* ($F(3,72) = 23.31$, $p < .001$, $\eta_p^2 = 0.49$) and *emotion words* ($F(3,72) = 60.65$, $p < .001$, $\eta_p^2 = 0.72$). The interaction effect of the emotion words repeated-measures ANOVA model was highly significant ($F(5.29,126.96) = 117.65$, $p(GG) < .001$, $\eta_p^2 = 0.83$). Bonferroni-corrected post-hoc tests revealed that angry in- and outgroup face stimuli were generally rated higher concerning emotional words than happy in- and outgroup faces (*all p-values* < .001). However, angry in- and outgroup faces did not differ from each other regarding the emotional words ratings ($p > 0.999$). Also happy in- and outgroup ratings were comparable in their emotional words ratings ($p > 0.999$). Moreover the emotion words happy and angry were more often used to rate the face stimuli than all other words (*all p-values* < .001), while being similarly often used when compared to each other ($p > 0.999$). Additionally the face stimuli were rated as significantly more afraid than sad ($p = .022$). Results are presented in **Table 2**.

Table 2: Results of the Manipulation Check: interaction effect between emotional words and face stimuli

	Angry Outgroup		Happy Outgroup		Angry Ingroup		Happy Ingroup		ANOVA			Post-Hoc (Bonferroni) *
Emotion word	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*F*	*df*	*p* (GG)	
Happy	0.76	1.51	8.00	2.52	0.64	1.19	8.60	0.76	219.36	5.29,126.96	.000	1, 3 < 2, 4
Angry	7.96	1.62	0.60	1.85	8.48	0.92	0.20	0.41	453.17	5.29,126.96	.000	2, 4 < 1, 3
Sad	2.60	2.74	0.40	1.04	2.48	2.40	0.36	1.41	7.26	5.29,126.96	.001	2, 4 < 1, 3
Afraid	4.24	2.89	0.48	0.92	3.20	2.75	0.84	1.38	12.60	5.29,126.96	.000	2, 4 < 1, 3

Note: Significance level = p < .05; (GG) = degrees of freedom were corrected using Greenhouse-Geisser's methods

* 1 = Angry outgroup face stimuli; 2 = Happy outgroup face stimuli; 3 = Angry ingroup face stimuli; 4 = Happy ingroup face stimuli

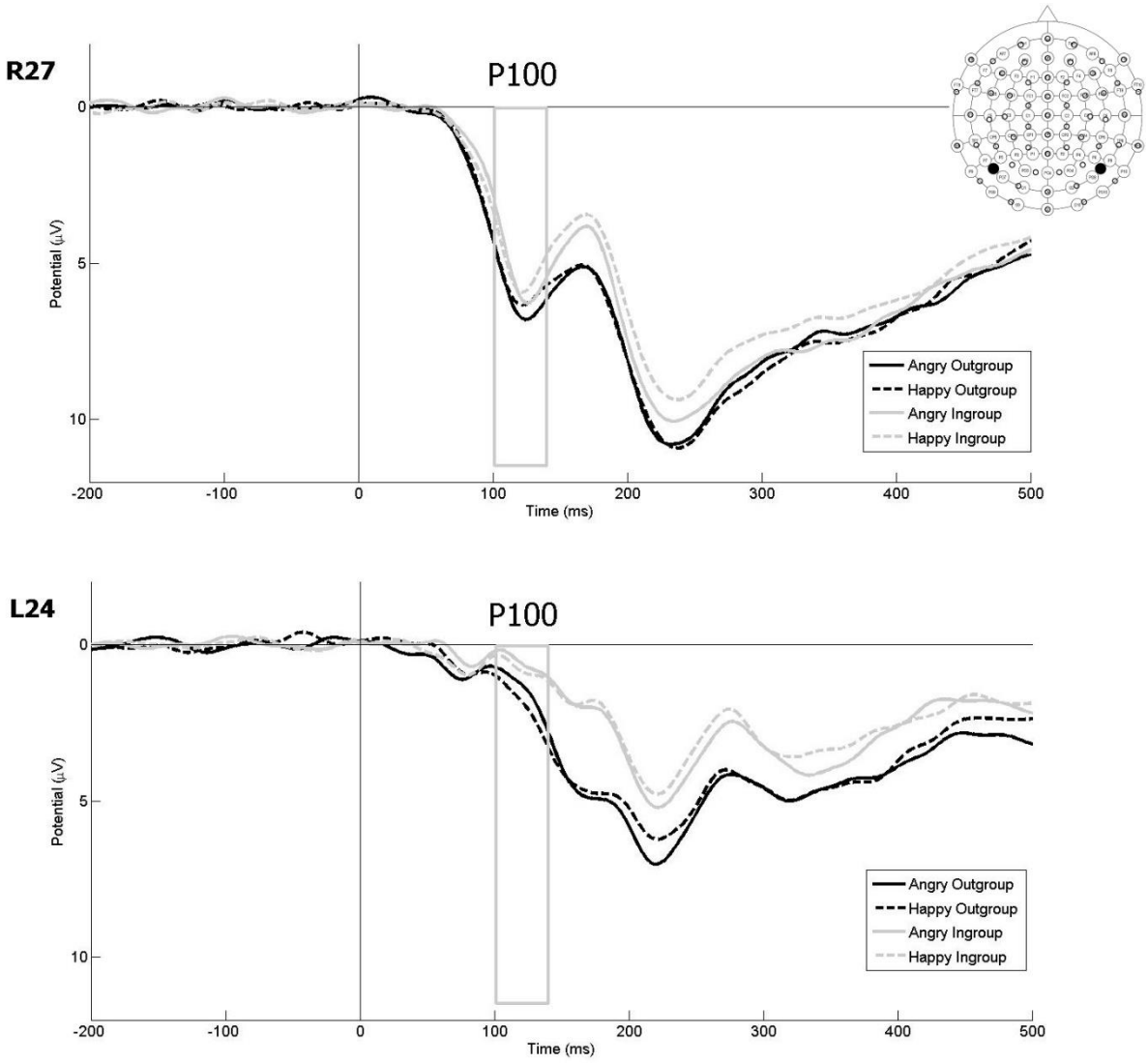

Figure 3: Grand average ERPs of the P100 component at right (R27) and left (L24) electrode site, depicting angry and happy face conditions as well as outgroup and ingroup face conditions. Negative is drawn upward by convention and stimulus presentation started at 0 ms.

Arousal. Repeated-measures ANOVA revealed a significant main effect of *arousal* ($F(2.26,54.20) = 97.47$, $p(GG) < .001$, $\eta_p^2 = 0.80$). Post-hoc tests (Bonferroni corrected) showed that angry in- and outgroup faces were rated as more arousing than happy in- and outgroup face stimuli (*all p-values* < .001), while they did not differ in their arousal ratings from each other ($p > 0.999$). Also happy in- and outgroup faces were rated similarly in their arousal ($p > 0.999$).

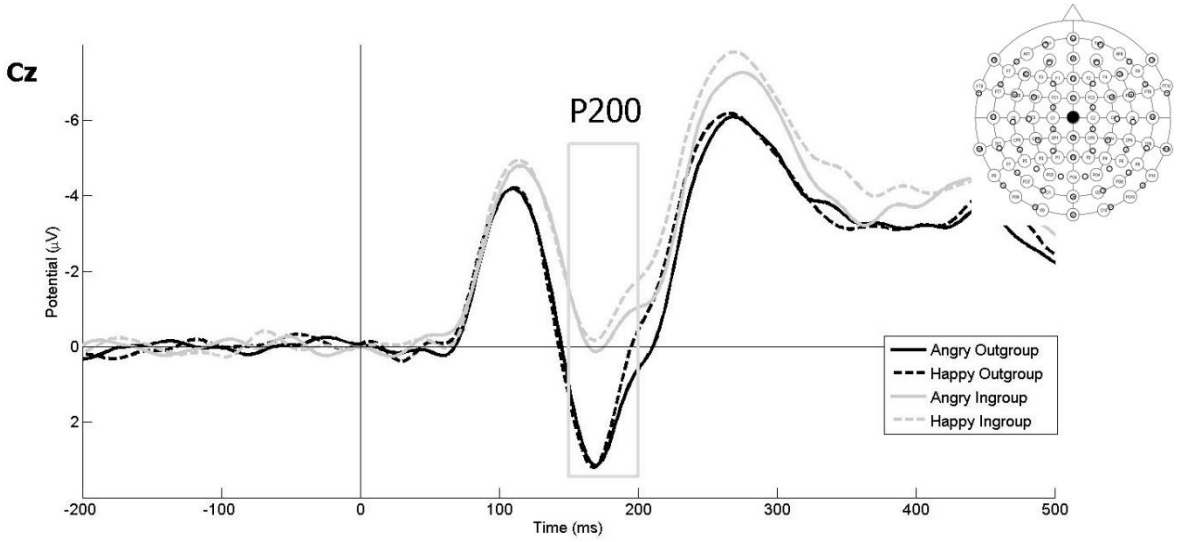

Figure 4: Grand average ERPs of the P200 component at Cz electrode site, depicting angry and happy face conditions as well as outgroup and ingroup face conditions. Negative is drawn upward by convention and stimulus presentation started at 0 ms.

3.3. EEG results

3.3.1. P100

A 2 x 2 x 2 repeated measures analysis with the within-subject factors *group* (outgroup/ingroup), *emotion* (angry/happy) and *hemisphere* (right/left) was applied and revealed significant main effects of *group* ($F(1,27) = 8.47$, $p = .007$, $\eta_p^2 = 0.24$) and *hemisphere* ($F(1,27) = 19.14$, $p < .001$, $\eta_p^2 = 0.42$). P1 mean amplitudes were more positive at right electrode sites ($M = 5.33$, $SE = 0.74$) than left electrode sites ($M = 2.82$, $SE = 0.55$). Additionally, P1 mean amplitudes were more pronounced for outgroup stimuli ($M = 4.37$, $SE = 0.61$) than ingroup stimuli ($M = 3.78$, $SE = 0.58$). The main effect of *emotion* did not reach significance ($F(1,27) = 0.91$, $p = .348$). Whereas the interaction between *emotion* and *hemisphere* did not reach significance ($F(1,27) = 3.26$, $p = .082$), the interaction between all three factors (*hemisphere* x *group* x *emotion*) was significant ($F(1,27) = 4.66$, $p = .040$, $\eta_p^2 = 0.15$). Bonferroni-corrected post-hoc tests revealed that right electrodes showed significantly more positive mean amplitudes than left electrodes for all factor combinations (*all p-values* $\leq .001$). Happy outgroup faces elicited a more pronounced P1 mean amplitude than angry outgroup faces at left electrode sites ($p = .004$). P100 mean amplitudes were more positive for outgroup than ingroup faces for right electrode sites in angry conditions ($p = .039$) and for left electrode sites in happy conditions ($p = .001$).

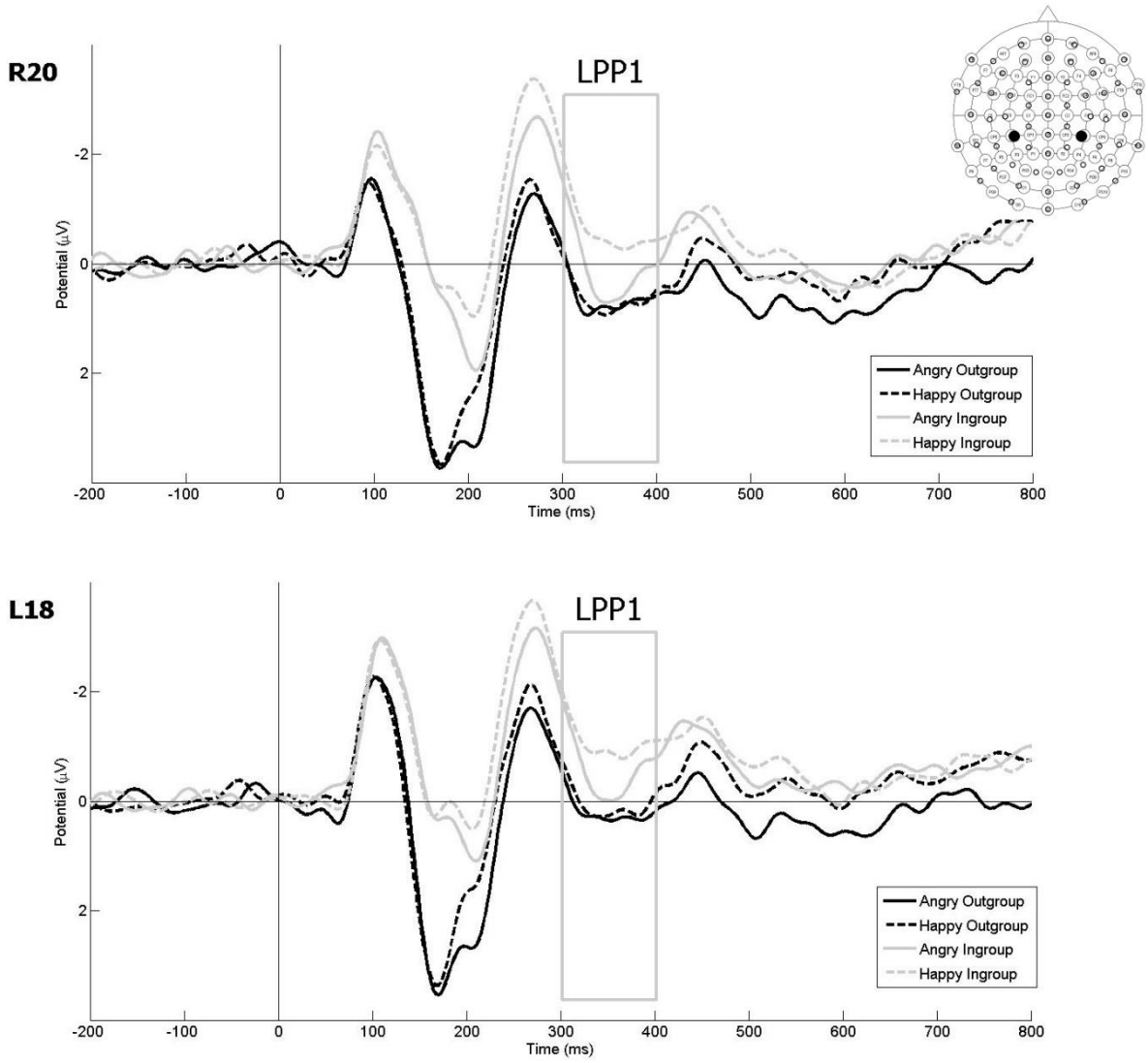

Figure 5: Grand average ERPs of the LPP1 component at right (R20) and left (L18) electrode site, depicting angry and happy face conditions as well as outgroup and ingroup face conditions. Negative is drawn upward by convention and stimulus presentation started at 0 ms.

3.3.2. P200

P2 mean amplitudes were analyzed using a 2 x 2 (*group x emotion*) repeated-measure ANOVA at electrode site Cz, revealing a significant main effect of *group* ($F(1,27) = 55.97$, $p < .001$, $\eta_p^2 = 0.68$). P2 mean amplitudes were more positive for outgroup ($M = 2.31$, $SE = 0.89$) than ingroup ($M = -0.56$, $SE = 0.76$) face stimuli. Neither the factor *emotion* ($F(1,27) = 0.28$, $p = .598$) nor the interaction effect ($F(1,27) = 0.20$, $p = .655$) reached significance.

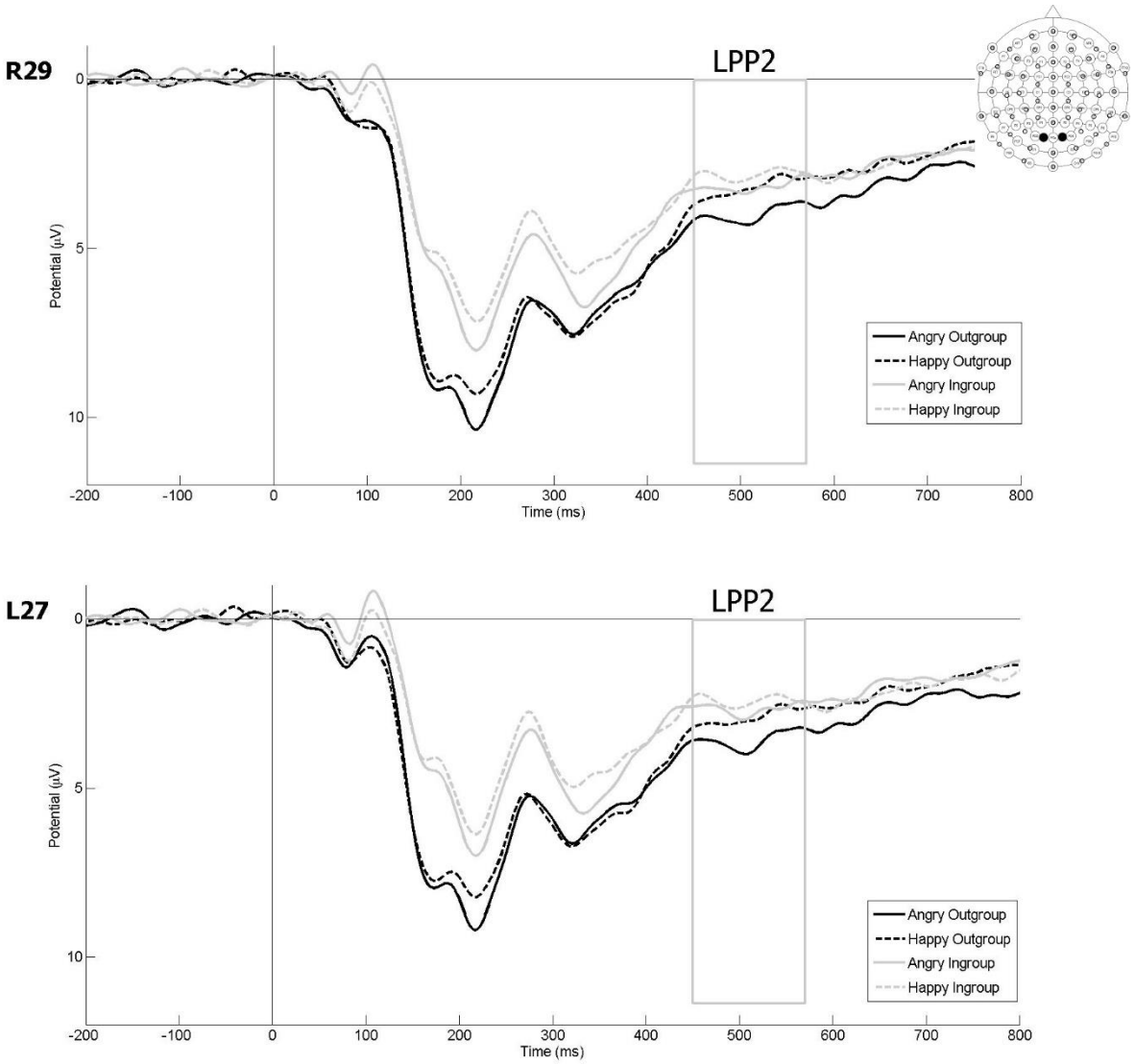

Figure 6: Grand average ERPs of the LPP2 component at right (R29) and left (L27) electrode site, depicting angry and happy face conditions as well as outgroup and ingroup face conditions. Negative is drawn upward by convention and stimulus presentation started at 0 ms.

3.3.3. LPP1

For the early LPP component (LPP1), data was analyzed using a 2 x 2 x 3 repeated-measure ANOVA with the within-subject factors *group* (outgroup/ingroup), *emotion* (angry/happy) and *electrode* (midline/right/left). All three main effects of the ANOVA, the factors *group* ($F(1,27) = 26.60$, $p < .001$, $\eta_p^2 = 0.50$), *emotion* ($F(1,27) = 5.05$, $p = .033$, $\eta_p^2 = 0.16$) and *electrode* ($F(2,27) = 9.97$, $p < .001$, $\eta_p^2 = 0.27$), reached significance. Outgroup face stimuli ($M = 0.00$, $SE = 0.63$) elicited more positive LPP1 amplitudes than ingroup faces ($M = -1.00$, $SE = 0.62$). Moreover, angry stimuli ($M = -0.33$, $SE = 0.63$) triggered a more pronounced LPP1 than happy stimuli ($M = -0.68$, $SE = 0.62$). LPP1 mean amplitudes were more positive at right ($p < .001$) and left electrode ($p =$

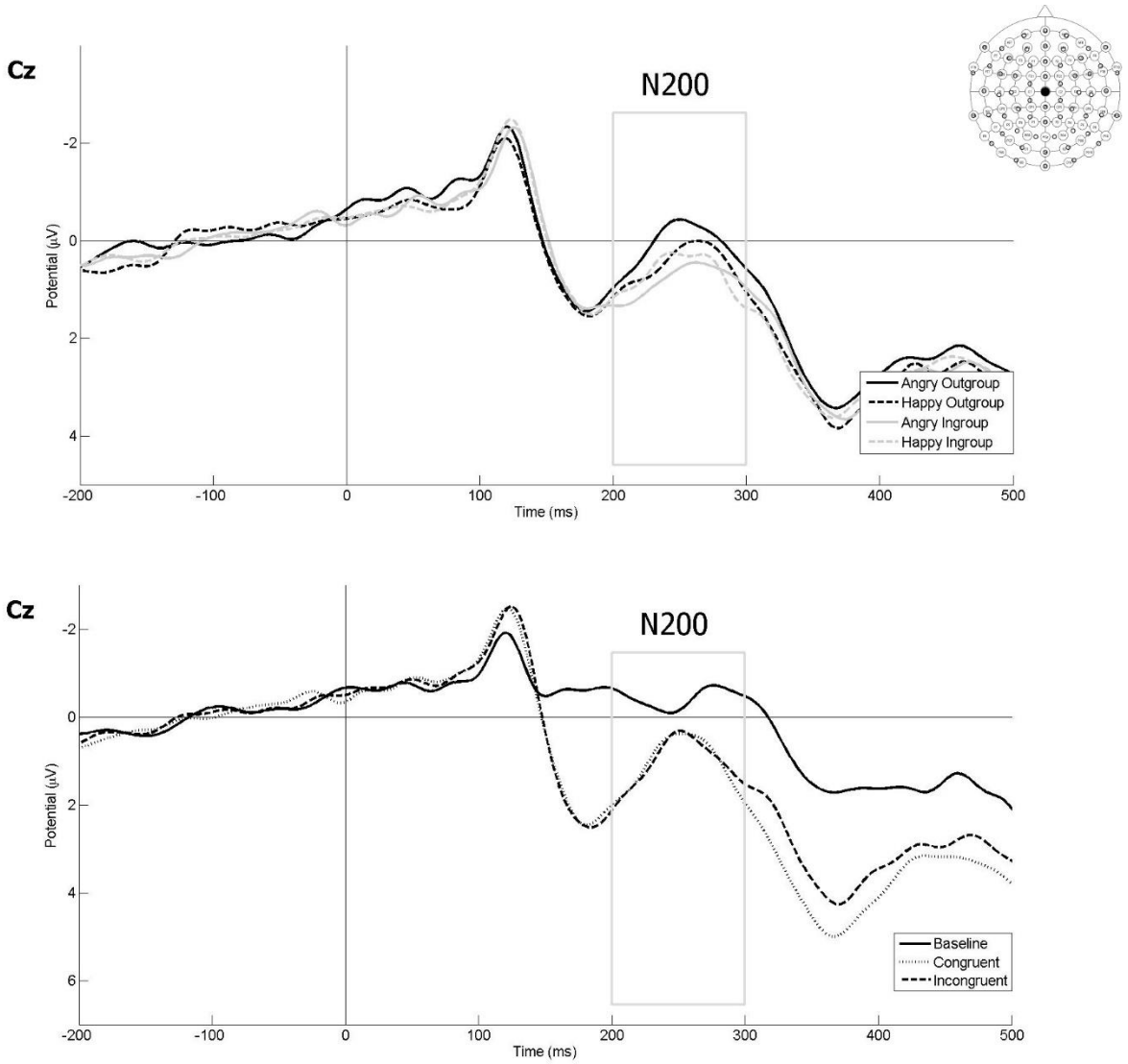

Figure 7: Grand average ERPs of the N200 component at Cz electrode site, subdivided into face stimuli condition and congruency condition, depicting angry and happy, outgroup and ingroup face conditions as well as baseline, congruent and incongruent conditions. Negative is drawn upward by convention and stimulus presentation started at 0 ms.

.004) than at midline electrode, but did not differ between left and right electrodes (p = .336). No two-way interaction effect reached significance (*all p-values* ≥ .148), nor did the three-way interaction effect (F(2,54) = 2.46, p = .095).

3.3.4. LPP2

LPP2 mean amplitudes were analyzed using a 2 x 2 x 2 (*group x emotion x hemisphere*) repeated measures ANOVA. The main effects for the factors *group* (F(1,27) = 3.32, p = .079), *emotion* (F(1,27) = 3.02, p = .094) and *hemisphere* (F(1,27) = 2.76, p = .108), as well as the interaction effects (*all p-values* ≥ .087) did not reach significance.

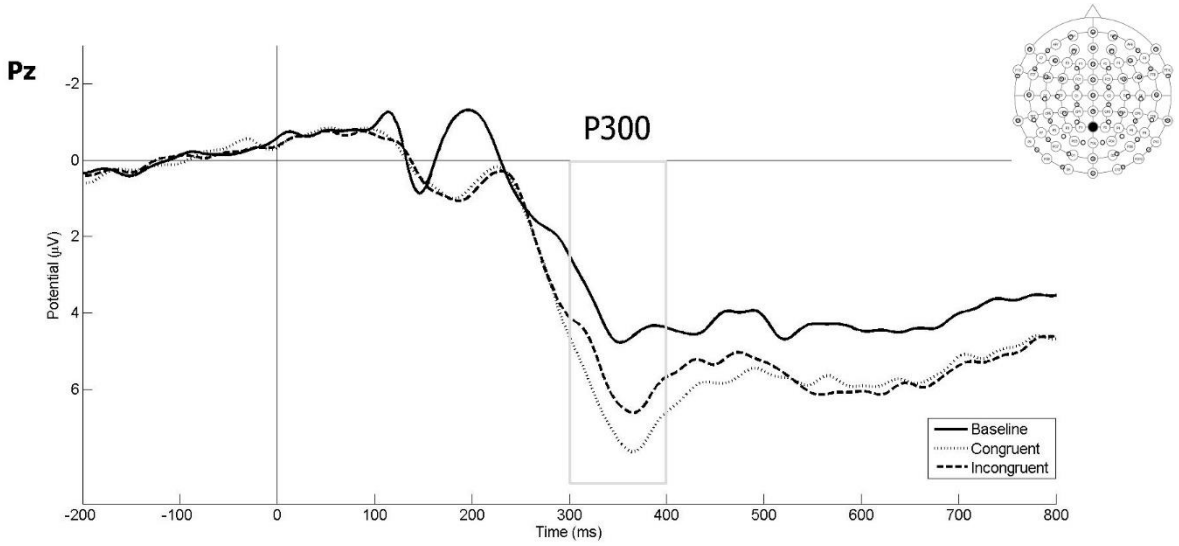

Figure 8: Grand average ERPs of the P3b component at Pz electrode site, depicting baseline, congruent and incongruent conditions – merged for the factors group and emotion. Negative is drawn upward by convention and stimulus presentation started at 0 ms.

3.3.5. N200

A 2 x 2 x 3 (*group x emotion x congruency*) repeated-measure ANOVA for N200 mean amplitudes showed significant main effects of *group* ($F(1,27) = 12.21$, $p = .029$, $\eta_p^2 = 0.16$) and *congruency* ($F(1.57,42.36) = 5.05$, $p(GG) < .001$, $\eta_p^2 = 0.31$). The main effect of *emotion* did not reach significance ($F(1,27) = 1.23$, $p = .278$). Outgroup face stimuli ($M = 0.38$, $SE = 0.56$) elicited more negative N200 mean amplitudes than ingroup face stimuli ($M = 0.74$, $SE = 0.55$). Post-hoc tests (Bonferroni corrected) revealed that, while congruent and incongruent trials did not differ from each other concerning N200 mean amplitudes ($p > 0.999$), mean amplitudes of baseline trials were more negative than of congruent ($p = .004$) and incongruent ($p = .001$) trials. Furthermore the interaction effect between *group* and *emotion* ($F(1,27) = 5.23$, $p = .030$, $\eta_p^2 = 0.16$) was significant. Post-hoc tests (Bonferroni corrected) revealed that outgroup face stimuli elicited a more pronounced negativity than ingroup faces for angry conditions ($p = .001$). Furthermore, angry outgroup faces were followed by more negative N200 mean amplitudes than happy outgroup faces ($p = .048$).

3.3.6. P3b

For P3b mean amplitudes, a 2 x 2 x 3 (*group x emotion x congruency*) repeated-measures ANOVA revealed a highly significant main effect of *congruency* ($F(1.51,40.84) = 16.82$, $p(GG) < .001$, $\eta_p^2 = 0.38$). Post-hoc tests (Bonferroni corrected) revealed that congruent trials elicited a more

pronounced positivity than incongruent ($p = .010$) and baseline trials ($p < .001$). Furthermore, mean amplitudes of incongruent trials were more positive than those of baseline trials ($p = .007$). The main effects of *group* ($F(1,27) = 0.23$, $p = .636$) and *emotion* ($F(1,27) = 2.61$, $p = .117$) did not reach significance. Also the interaction between *emotion* and *congruency* did not reach significance ($F(2,54) = 2.35$, $p = .105$), as well as all other interaction effects (*all p-values* $\geq .117$).

4. Discussion

4.1. Main purpose and main findings

The objective of the current thesis was to investigate the temporal neural dynamics of mimicry under the influence of facial stimuli varying in their emotional state and ethnical group membership. Previous studies have assumed the mimicry effect to be modulated by affiliative goals, like affiliation and appeasement (Rauchbauer et al., 2015a). While behavioral measurements, like reaction times, do not provide information about the background processes of mimicry, we hypothesized distinct ERP components to reveal the neural time course of mimicry under different affiliation goals, triggered through social-affective context cues. One main aim was to investigate, whether the mimicry effect might be modulated through social-affective cues by a differential attentional shift towards specific cue properties, as the emotional state and ethnical group membership of a person. This would strengthen the hypothesis of an input modulation of mimicry in response to social-affective cues. On the other side, we wanted to investigate how the interference effect is depicted in ERP's known to reflect conflicting stimuli. We adhered with our hypothesis to findings of other tasks which produce interference effects, based on the assumption that specific stimulus features of the present task, as in incongruent trials, might also be perceived as conflicting.

The behavioral results show increased mimicry for happy ingroup faces and angry outgroup faces, replicating previous findings (Rauchbauer et al., 2015a). The fact that the behavioral results are about a trend significant interaction effect is negligible, considering that this pattern has been replicated frequently in studies relying on more numerous populations ($N < 180$).

The early attentional components P1 and P2 were both sensitive to the ethnical group membership of face stimuli. Thereby, outgroup faces triggered more positive deflections than ingroup faces. While P2 component showed no sensitivity for emotional displays, P1 component showed at least a hemispheric pattern of emotion processing. Thereby, right electrode sides seem to be especially sensitive for group differences in angry conditions and left electrode sites for happy conditions.

Emotion processing was reflected in LPP1 amplitude variations. Here, LPP1 amplitudes were more pronounced for angry than happy faces and additionally, for outgroup compared to ingroup faces. LPP2 component in contrast showed only trend significant results, indicating a preferential processing of angry outgroup faces

N200 amplitudes, against our hypothesis, did not differentiate between congruent and incongruent trials. Moreover, N200 was sensitive to ethnical group differences and especially, N200 amplitudes were more pronounced for angry outgroup faces compared to angry ingroup or happy outgroup faces.

P3b component differentiated between congruent and incongruent trials, but not in the hypothesized direction. P3b amplitudes were more pronounced following congruent compared to incongruent stimuli.

In the following sections, we will interpret the reported findings and discuss their meaning for the processes behind the regulation of mimicry in response to social-affective context stimuli.

4.2. P100

Together with the early onset of the P1 component, the finding that P1 amplitudes vary regardless of task-relevance of a given stimulus (Heinze, Luck, Mangun, & Hillyard, 1990), gives rise to the suggestion that P1 component depicts attentional processes, even before perceptual processing has been completed (Luck, & Ford, 1998). These properties of the P1 component make it a favorable tool to investigate the input modulation theory of mimicry, which suggest mimicry to be influenced by social context through attention allocation towards specific stimulus features. Thus, the social stimuli used in the current thesis could have influenced the initial visual processing, by unintentionally directing attention towards specific stimuli. But while we hypothesized, that attention should be allocated towards those stimulus feature-combinations eliciting the most pronounced mimicry effect (thus angry outgroup and/or happy ingroup faces), P1 amplitudes were only sensitive for group membership differences. P100 amplitudes were more pronounced for outgroup than for ingroup faces which provide room for several explanations. Because of the association between P1 amplitudes and visual attention deployment, it could be suggested that facial features indicating ethnical outgroup members capturing attention as displayed by P1 amplitude variation, leading to differential subsequent processing for these stimuli. But while He, Johnson, Dovidio, & McCarthy (2009) also found more pronounced P1 amplitudes following Black outgroup faces, P1 amplitudes following Asian outgroup faces were less positive than those following White ingroup faces. Therefore the assumption of a general attentional shift towards outgroup members could not be maintained. In addition, P1 amplitude variation could also be found in studies investigating the so-called negativity bias (Ito et al., 1998; Smith, Cacioppo, Larsen, & Chartrand, 2003). The negativity bias argues that negative events and information are processed

preferentially and therefore elicit a faster or more pronounced reaction than in neutral or positive situations. In this sense, outgroup faces could be perceived as more negative, due to their association with threat as revealed by the IAT, as He et al. (2009) also observed in their study, that African-American, as well as Asian outgroup faces were more associated with threat and ingroup faces with security. However, P1 amplitude ordering (Black > White > Asian) did not fit the assumption of P1 component reflecting attention allocation towards negative, or threatening stimuli respectively. Moreover, He et al. (2009) conclude, that although pronounced P1 amplitudes have been repeatedly associated with stimuli features capturing attention, the P1 amplitude variations related to ethnical group membership could be due to physical differences (e.g. skin tone and lower-level physical properties). This assumption has been reinforced by the fact that P1 component arises even before full processing of faces took place, as indicated by the face-specific N170 component (He et al., 2009). Even though we matched the in- and outgroup faces for luminance differences in the current thesis, there are still low-level physical features differentiating between Black and White faces. Therefore, P1 amplitude variations with respect to ethnical group membership most likely reflect preliminary stimulus feature processing. While P1 component has been shown sensitive to emotional content of faces (Achaibou et al., 2008; Batty, & Taylor, 2003), we could not find a difference in P1 amplitudes regarding happy and angry faces. The main difference to the studies showing P1 component to be sensitive to emotions and the current thesis is that we did not focus on emotional displays only, but combined it with the social cue of ethnical group membership, leading to a more complex social-affective stimuli combination. Moreover, Eimer et al. (2003) revealed in their study, that emotions are only processed, when focal attention is directed towards emotion displays. Interestingly, the hemispheric pattern, as indicated by the interaction effect between hemisphere, group and emotion, somehow showed a subliminal differentiation between the emotion displays. While in- and outgroup faces were differentiated from one another only for angry emotional displays at right electrode site, outgroup faces elicited more pronounced P1 amplitudes than ingroup faces only for happy faces at left electrode site. This hemispheric pattern is comparable with the findings of Pizzagalli et al. (2002), showing that disliked faces depicted a more pronounced P1 component at right electrode sites only, whereas left electrode sites revealed more pronounced P1 amplitudes for liked faces. Therefore, it could be stated, that emotional display processing was concealed by the processing of group membership differences. The actual findings suggest, that angry faces elicit the same P1 amplitudes pattern as disliked faces and happy faces as liked faces. Nevertheless, this interpretation remains speculative. At last, P1

component was generally more positive at right hemisphere, comparable to past findings (Achaibou et al., 2008; Batty, & Taylor, 2003; Pizzagalli et al, 2002).

4.3. P2/LPP

The P2 component like the P1 component, is known for its function to reflect attention allocation and stimulus feature detection (O'Donnell et al., 1997).Therefore, P2 component was implemented into the actual thesis, to investigate input modulation theory further. Besides its role in attention allocation, the P2 component reflects the preferential processing of negative, or threatening cues respectively (Carretié et al., 2001; Correll et al., 2006; Eimer et al., 2003). Our findings of pronounced P2 amplitudes following outgroup faces, compared to those following ingroup faces replicate the findings of previous studies (Correll et al., 2006; He et al., 2009; Ito, & Urland, 2003, 2005), consistent with the idea, that African-American faces are perceived as more threatening than White faces by Caucasian participants. This interpretation seems to be fortified by the result of the IAT, with participants intrinsically associating White faces with security and Black faces with threat. Once again, variations in emotional expressions do not seem to be reflected in P2 amplitudes. As already stated in the explanation of the results concerning the P1 component, emotional displays are assumed to need focal attention to be processed and reflected in ERP amplitude variation (Eimer et al., 2003), for example through task instructions directly pointing out emotion differences. Nevertheless, out initial assumption, that especially angry outgroup faces might elicit pronounced P2 amplitudes, could not be strengthened. Even though angry outgroup faces seem to elicit an enlarged tendency to mimic arbitrary fingerlifting movements for appeasement reasons, P2 component results showed no significant interaction effect between the factors group and emotion.

The LPP component depicts a later picture processing stage than the one of the P1 component. LPP component is thereby associated with the processing of arousing stimuli features and could hence have a part in the input modulation of mimicry. Based on the study of Bublatzky and Schupp (2012), we separated the LPP component into two subcomponents, namely the centro-parietal LPP1 and the parieto-occipital LPP2. Regardless of the chosen time windows, LPP amplitudes increase especially in response to biological relevant information, like pictures showing mutilation, or erotic and threatening contents (Bublatzky, & Schupp, 2012; Hajcak, & Olvet, 2008; Schupp et al., 2004; Weinberg, & Hajcak, 2010). Bublatzky and Schupp (2012) suggested to discriminate between two functions of the LPP component. While the earlier LPP seems sensitive

to the original threat information of shown pictures (picture category), the later one could depict the processing of the threat cue added to the positive, neutral or negative pictures through task instruction (threat imminence). Visual inspection of the LPP1 time window in the present study suggests that happy ingroup faces were ignored compared to the other face stimuli conditions and show less positive amplitudes. This assumption would reflect the picture categorization function of the LPP1, with happy ingroup faces being received as rather "neutral" compared to the other pleasant or unpleasant conditions. However, there was no significant interaction effect supporting this claim. In the current thesis, LPP1 amplitudes were sensitive to group and emotion of facial stimuli, being more pronounced after outgroup and angry faces. As it seems, the early LPP1 component could reflect the general function of the LPP component, of increasing for biologically relevant information, as when being confronted with angry facial expressions or with faces of an outgroup. Likewise, the visual inspection of the LPP2 component suggests, that angry outgroup faces elicited more positive amplitudes, consistent with the theory that LPP2 component reflects threat imminence (Bublatzky, & Schupp, 2012). In this case, angry outgroup faces would be seen as more threatening than all other conditions, possibly paving the way for an increased mimicry effect for these stimuli. But similar to the results of the LPP1, the interaction effect between group and emotion, as well as their main effects did not reach significance for the LPP2 component, even though all trends were in the hypothesized direction. The difficulty of the LPP component analysis is the length of its amplitudes, lasting for the full duration of stimulus presentation (Weinberg, & Hajcak, 2010) and even beyond (Hajcak, & Olvet, 2008; Weinberg, & Hajcak, 2010). Many researchers therefore split LPP amplitudes into two (Bublatzky, & Schupp, 2012; Weinberg, & Hajcak, 2010) or more time windows (Hajcak, & Olvet, 2008) to analyze LPP amplitude variations. For the actual thesis, we chose the time windows on the basis of the findings of Bublatzky and Schupp (2012) and visual inspection, but a more explorative analysis of the LPP amplitudes would possibly lead to a more precise picture of the LPP component revealed by the SAMT.

4.4. N2/P3b

The N2-P3 complex is a common tool for the investigation of inhibitory processes, therefore these components were used to investigate inhibition in the mimicry effect of the actual thesis. For the N2 component, recent studies seem to challenge the long held interpretation of N2 amplitudes depicting a response inhibition process only (e.g. Eimer, 1993). Even more the N2 component seems to reflect general cognitive control processes. Similarly, N2 amplitudes could

be localized to the anterior cingulate cortex (ACC) using high-density EEG recordings (Nieuwenhuis, Yeung, Van den Wildenberg, & Ridderinkhof, 2003), a brain area known to have an important role in monitoring for conflicts to occur while action selection (Botvinick, Braver, Barch, Carter, & Cohen, 2001). Moreover, Donkers and Van Boxtel (2004) showed in their study that pronounced N2 amplitudes are likewise present for go and no-go signals, whereas following the inhibition-hypothesis for N2 component no-go signals should elicit more pronounced negative amplitude deflections than go signals. Because the SAMT is a measure for mimicry in a social-affective context, the findings concerning N2 component function in a go/no-go task could be transferred to the actual results. While we initially hypothesized incongruent trials to elicit more pronounced N2 amplitudes than congruent trials due to inhibition processes, the actual findings support the alternative interpretations of the N2 component. As pronounced N2 amplitudes were observed for go and no-go trials (Donkers, & Van Boxtel, 2004), N2 amplitudes were similar for congruent and incongruent trials in the current thesis. Nevertheless, N2 amplitudes are suggested to reflect general cognitive control processes. In the actual thesis, cognitive control seems to be allocated towards the face stimuli, instead of reflecting the processing of the arbitrary fingerlifting movements. Even though N2 amplitude variation for face stimuli was not implemented in our initial hypotheses, N2 component was more pronounced for outgroup faces, and a significant interaction effect between group and emotion revealed more pronounced N2 components especially for angry outgroup faces. Indeed, N2 amplitude variations have also been found for other manipulations not related to interfering response activations like no-go and go signals (e.g. cue frequency; Bartholow et al., 2005; Nieuwenhuis et al., 2003). Thereby conflicting (e.g., infrequent) stimuli were detected by N2 component irrespective of whether the response was intended to be executed or suppressed. As Dickter, & Bartholow (2010) assume: "Such findings suggest that conflict can occur whenever the response requirement for a given trial is inconsistent with a current response strategy, irrespective of whether stimuli activate opposing responses." (p. 596). Accordingly, enhanced N2 amplitudes for angry outgroup stimuli could be interpreted as reflecting a conflict detection process or rather depict the fact that these stimuli had to be encountered with a deviant response strategy.

The dominant view on P3b component was that it represents working memory updating for task-relevant and subjectively unexpected events (Donchin, 1981; Duncan-Johnson, & Donchin, 1977, 1982; Johnson, & Donchin, 1980). However, Verleger et al. (2005) argue in their study that P3b reflects a process, mediating between perceptual analysis and response initiation. Moreover,

they assume P3b component to depict the "monitoring whether decision to classify a stimulus is transformed into action" (Verleger et al., 2005, p. 165). With regard to our findings, revealing more pronounced positive deflections in response to congruent than incongruent trials, P3b could possibly reflect the process of response facilitation. Likewise, Rauchbauer et al. (2015a) reported "[…] that the regulation of mimicry seems to specifically affect response facilitation […]" (p.41) in congruent trials. Thereby, "[…] on a process-level, they [we] consider response facilitation to represent a social feedback signal of enhanced congruency with an interaction partner." (p. 41f.). Altogether, enhanced P3b amplitudes in response to congruent trials could reflect the decision to replicate the perceived action unrestrictedly, which can further be perceived as response facilitation.

4.5. Input/output modulation hypothesis

Several studies revealed, that motor mimicry can be influenced through attentional shifts and feature selection, thus input modulation. For example Longo, Kosobud and Bertenthal (2008) could show that while the mimicry effect initially stays the same for possible and impossible finger tapping movements, the mere mentioning that some movements could seem impossible let participants automatically react with a reduced mimicry effect for these trials. This means, because attention was allocated to another stimuli feature due to task instruction, the tendency which finger tapping movements to mimic had changed. While intuitively these findings would somehow contradict the automaticity of the mimicry effect, dual-route models used to explain the interference effect of SRC tasks acknowledge that automaticity can be facilitated through attentional shifts towards objects of interest (Heyes, 2011; Kornblum, Hasbroucq, & Osman, 1990). For the actual thesis this would mean, that if the automatic mimicry effect is influenced or caused by input modulation, the attentional shift towards angry outgroup and/or happy ingroup faces should somehow be reflected in ERPs known to be sensitive to stimulus features and attention allocation. However, the actual findings concerning early attentional ERPs show a different pattern. These early ERP amplitude variations as reactions to the face stimuli seem to depict general categorization processes, like attentional shifts towards arousing, threatening and/or evolutionary significant stimulus features.

Except for input modulation hypothesis, a potential other modulation of interference effects has been proposed. Output modulation theory suggests higher social cognitive processes to be involved in the control of response preparation (Brass, Ruby, & Spengler, 2009). The finding of an

increased N2 component for angry outgroup faces appropriate to increased mimicry for these stimuli supports the idea of an output modulation of mimicry. Thereby the N2 component would serve as a conflict detecting instance. Brass et al. (2005) found a frontally located overlap of active brain areas for the imitation-inhibition task and the Stroop task. This one was located in the right inferior frontal gyrus (rIFG), which has been assumed to be involved in the no-go condition of go/no-go tasks (Konishi, Donaldson, & Buckner, 2001; Rubia et al., 2001), and in stop-signals (Aron, Fletcher, Bullmore, Sahakian, & Robbins, 2003). In an electrocorticography (ECoG) study, the rIFG response to stop signals began in N2 time window (100-250 ms after signal onset; Swann et al., 2009). Accordingly, N2 component has been linked to conflict monitoring. As it seems, N2 component (and P3b component as we will see further) take part in the social cognitive processes modulating preceding action execution.

4.6. Inhibitory mechanisms of the SAMT

Interference effects triggered through tasks like the Stroop or no-go/go tasks has commonly been associated with a modulation of the N2-P3 complex (e.g. Donkers, & Van Boxtel, 2004; Folstein, & Van Petten, 2008; Huster et al., 2011; Van Boxtel et al., 2001). While we hypothesized comparable processes between the interference effect of cognitive conflict tasks and the SAMT, the mimicry effect might be distinguishable in its process from other interference effects. It has been suggested that incongruent trials are responsible for the interference effect and therefore should somehow elicit a more pronounced amplitude variation in ERPs reflecting inhibitory control (N2; e.g. Van Boxtel et al., 2001) and response processing (P3b; Verleger et al., 2005). Furthermore, N2 amplitudes did not differ between incongruent and congruent stimuli and P3b amplitudes showed a reversed pattern as suggested by investigation of no-go signals for example (Enriquez-Geppert et al., 2010), with greater more pronounced positive deflections after congruent than incongruent stimuli. Baseline trials were used for behavioral analysis only, as they are not comparable to trials in which movements have actually been performed, and thus results concerning baseline trials were not interpreted further. While our findings let assume that P3b amplitude variation could be related to the response facilitation process for congruent trials, the process underlying the interference effect in incongruent trials still has to be investigated further.

4.7. General discussion and limitations

The main hypothesis of the actual thesis was to investigate the neural time course of the modulation of mimicry by social-affective cues, with specific focus on input modulation hypothesis

(Heyes, 2011). As we already stated, the ERP components following the onset of the facial stimuli most likely reflect lower-level physical properties differentiating between Black and White faces. Nevertheless, beginning with the first time window of the LPP (from 450 ms), stimuli-combinations could become evident in the modulation of the mimicry effect. Unfortunately, LPP component results were only statistical trends and can only vaguely support an input modulation hypothesis. Because of the long time range of the LPP component, one alternative for LPP component analysis could be a partition in smaller time windows, covering the full duration of LPP amplitude variations. Moreover, the implication of another ethnical group differing physically less from White faces (e.g. Asian faces) would clarify, whether group differences in the first ERP's following cue onset are only due to physical attributes or not.

Concerning the exploration of the interference effect of the SAMT, results suggest that different processes underlie the motor interference effect as investigated by the SAMT and the imitation-inhibition task, as for example findings of stop or no-go signals would let assume. While our findings suggests output modulation of the mimicry effect due to N2 amplitude variations, P3b amplitudes rather represent response facilitation for congruent than imitation inhibition for incongruent trials. A higher number of participants would be reasonable at least for the reaction time measurements, as preceding studies included about 60 participants (Rauchbauer et al., 2015a) and the current behavioral results did not reach significance. Furthermore, the stimuli used in the actual thesis were very complex (e.g. faces) and diverse (hands vs. faces; Black vs. White). To understand the ERP's elicited by the SAMT further, another study, for example separating the hand and face stimuli into two discrete tasks (mimicry task and social-affective task) to compare the results with the actual thesis, would be of great interest. Especially the ERP's following the onset of the hand cue could be analyzed independently from the social-affective context.

4.8. Conclusion

In summary, we analyzed the neural time course of the modulation of mimicry by complex social signals, like ethnical group membership and emotional state of an interaction partner. One main finding of the current thesis is that the mimicry effect does not seem to be modulated through stimulus input, as stimulus-dependent ERPs did not replicate the pattern of the mimicry effect of behavioral measurements. Early attentional ERPs seem rather to depict general categorization processes, foregrounding cues signaling threat. However, N2 component indicated a possible output modulation of mimicry, as amplitudes were enhanced for angry outgroup faces, the one stimulus feature combination which revealed a more pronounced mimicry effect. While P3b component findings suggested the component to depict response facilitation processes, the neural processes underlying the interference effect for incongruent trials have to be further analyzed.

In sum this study gives a first overview on the neural time course of social-affective modulation of mimicry, aiming to trigger further investigations, potentially concerning the role of output modulation in the course of mimicry regulation in response to social-affective cues.

Overall, the present thesis gives an insight into the temporal neural dynamics of mimicry. Even though mimicry is automatic and ubiquitous, it represents a complex social-cognitive process, occurring at later processing stages, after general stimulus categorization processes have been completed. For this reason, mimicry can be supposed to be modulated not only by simple stimulus characteristics, but by complex social-affective integrations.

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7. Figures and tables

Figures

Tables

Abstract

Differential affiliative and regulatory functions have been accredited to mimicry. Since naturalistic and behavioral measurements are incapable to reveal processes underlying the modulation of mimicry by social-affective cues, an event-related potential (ERP) study was conducted. The social-affective mimicry task (SAMT) was used to investigate the neural temporal course of mimicry under the modulation of face stimuli, differing in their emotional display (happy/angry) and ethnical group membership (White ingroup/Black outgroup).

Thirty participants participated in the study and carried out the SAMT while electroencephalogram (EEG) was recorded. Behavioral result revealed enhanced mimicry towards happy ingroup and angry outgroup faces. Early attentional ERP variations (P1 and P2 components) revealed sensitivity for group membership, which has been linked to basic categorization processes due to physical differences between Black and White faces. The earlier LPP component (LPP1) of the two analyzed time windows reflected besides group membership also emotion processing. Further, trend significant results of the LPP components reflected picture categorization and threat-related processes. Against our initial hypothesis, N2 component was not reflective of the processing of the interference effect due to incongruent trials. In contrast, it rather reflected the modulation of mimicry through threatening stimuli. Finally, P3b amplitudes were more positive after congruent than incongruent trials, which could reflect response facilitation.

The present results suggest that modulation of mimicry through social-affective cues is not mainly driven by effects of heightened attention (input modulation), but potentially starts at a later processing stage associated with higher social cognitive processes (output modulation), but this has to be investigated further. While response facilitation through congruent trials could be linked to P3b amplitude variations, the processes behind the interference effect of the SAMT have to be further investigated.

Keywords: mimicry, automatic imitation, SAMT, P1, P2, LPP, N2, P3b, input modulation, output modulation, interference effect

Zusammenfassung

Mimikry werden verschiedene regulatorische und affiliative Funktionen zugesprochen. Um Prozesse der Regulierung von Mimikry durch sozial-affektive Reize aufzudecken, wurde eine Elektroenzephalographie (EEG) Studie durchgeführt. Um den zeitlich neuralen Ablauf von Mimikry unter dem Einfluss von im emotionalen Ausdruck (fröhlich/ärgerlich) und ethnischer Gruppenzugehörigkeit (Afro-Amerikanische Outgroup/Kaukasische Ingroup) variierender Gesichts-Stimuli weiter zu beleuchten, wurde der *social-affective mimicry task* (*SAMT*) vorgegeben.

Dreißig Versuchspersonen nahmen an der Studie teil und führten den *SAMT* durch, während ihr EEG aufgezeichnet wurde. Die Verhaltensdaten zeigten vermehrt Mimikry gegenüber ärgerlichen Outgroup und fröhlichen Ingroup Gesichtern. Frühe Amplitudenvariationen (der P1 und P2 Komponenten) mit Bezug zu Aufmerksamkeitsprozessen zeigten Sensitivität bezüglich der Gruppenzugehörigkeit der Stimuli, dies wurde auf grundlegende Kategorisierungsprozesse aufgrund von physischen Unterschieden zwischen schwarzen und weißen Gesichtern zurückgeführt. Die frühere der beiden untersuchten LPP Komponenten (LPP1) wies neben Variationen aufgrund von Gruppenzugehörigkeit der Gesichter auch Variation in Hinblick auf die Emotionsausdrücke der Stimuli auf. Des Weiteren wiesen statistische Trends der LPP Komponenten auf das Reflektieren von Bildkategorie und Bedrohung hin. Entgegen unserer ursprünglichen Hypothese war die N2 Komponente nicht an der Verarbeitung des Interferenzeffekts aufgrund von inkongruenten Trials beteiligt. Im Gegenteil, sie zeigte sich sensibel gegenüber der Modulation von Mimikry durch bedrohliche Stimuli. Schließlich waren P3b Amplituden positiver für kongruente im Vergleich zu inkongruenten Trials, was sich auf die Erleichterung von motorischen Antworttendenzen bei kongruenten Trials zurückführen lässt.

Die Ergebnisse dieser Thesis suggerieren, dass die Modulation von Mimikry durch sozial-affektive Hinweisreize nicht hauptsächlich durch verstärkte Aufmerksamkeitsprozesse (Input Modulation), sondern eher in einem späteren Verarbeitungsschritt höherer sozial-kognitiver Prozesse (Output Modulation) erfolgt, doch diese Vermutung erfordert weitere Forschungsarbeit. Während die Erleichterung von Antworten durch kongruente Trials mit der P3b Komponente in Verbindung gebracht werden konnte, bedarf es bezüglich der zugrundeliegenden Prozesse des Interferenzeffekts weiterer Forschung.

Stichworte: Mimikry, Automatische Imitation, ERP, SAMT, P1, P2, LPP, N2, P3, Input Modulation, Output Modulation, Interferenzeffekt

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