THE IMPACT OF BLOCKING THE ACTIVATION OF FACIAL MUSCLES IN THE PROCESSING OF SUBSEQUENT EMOTIONAL INFROMATION, AND ITS MECHANISM

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ABSTRACT

In this thesis we focus on how previous activation of the representation of an emotional state impacts the processing of subsequent emotional information (within a priming paradigm). Our approach is guided by an embodied perspective on cognition. According to embodied cognition theories, affective representations are partial simulations of emotional experience (Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005). Among other simulations, re-enacting an emotion may involve the activation of correspondent facial motor activation. In the present work, we directly approach the hypothesis that facial muscle activation has a role in emotional category priming effects within a blocking paradigm. However, because blocking may still allow partial muscle activity, we first address muscular specificities of a facial muscular blocking procedure.

Our first experimental approaches aimed to establish the proper methodology used to test our hypothesis. Experiment 1 addresses our hypothesis within an emotional category priming paradigm similar to the one used by Carroll and Young (2005) and, establishes the proper temporal window to observe the effect. Resutls show a general emotional priming effect, such that all emotional faces impacted all, and only, emotional targets judgment (both congruent and incongruent). This indicates that perceiving emotional primes facilitates emotional judgments of emotional stimuli in general.

Our second Experiment aimed to define the muscular specificities of a blocking procedure (Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001) necessary to address the role of muscle activation in the observed priming effects. Assuming that the blocking procedure may exert different influences on different muscle's activation, we characterized this procedure in terms of promotion of muscle activation over *zygomaticus major*, *orbicularis oris* and *corrugator supercilii*. Results corroborate that blocking exerts different effect for different muscles, suggesting that its effect on emotion priming effects may be moderated by the type of emotion primed.

Experiment 3, replicated the procedure of Experiment 1, including an additional blocking condition, in order to test the embodiment hypothesis. In this experiment, as well as a general emotion priming effect, we also found some evidence of category emotional priming effects qualified by type of emotion. There was a clear congruency effect for happiness, and a generalized effect for sadness (both for congruent and incongruent trials). As expected, these effects suffered an interference from the facial muscle blocking manipulation (Niedenthal et al., 2001). This supports the hypothesis that muscle facial activation plays a role in the mechanism through which emotional category priming effect occurs. However, under blocking conditions, priming effects only disappeared for happy prime-target pairs. Priming effects became stronger for sadness and anger. These differences seem to be explained by the fact that the blocking procedure (Experiment 2, 4 and 5) has a preponderant blocking impact over the *zygomaticus major* (the muscle of smiling), and a different impact over muscles associated with other emotions. As it becomes more clear in Experiment 4 and 5, blocking manipulation increased the variability observed in the *orbicularis oris*, activation. We, thus argue that these different effects of blocking explain why negative emotions may have had a stronger priming effect in Experiment 3, under blocking.

Results are discussed in terms of implications for embodiment theories and in terms of methodological implications for futher research making use of blocking procedures.

Keywords: Embodiment; priming; facial expression; blocking

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Overview

Processing emotional information is a task we perform more or less automatically in our daily lives. In looking people's faces we are able to perceive their emotional experiences seemingly effortlessly and this is shown in an impressive number of studies (Buck, 1988; Darwin, 1872; Ekman, 1982; Ellison & Massaro, 1997; Fridlund, 1992; Frijda, 1969; Izard, 1980; Russell & Bullock, 1986; Wallbott & Ricci-Bitti, 1993; Young, Rowland, Calder, & Etcoff, 1997). In this thesis we focus one of the factors that is related with how we perform this kind of task, and how we do it more or less easily: previous activation of the emotional state in ourselves (Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001; Niedenthal, Halberstadt, Margolin, & Innes-Ker, 2000). On studying this issue we focus on what an emotion is and how we are able to perceive it in others.

Several lines of research focus on the processing of emotional stimuli from different perspectives on the cognitive representation of emotions. According to a number of authors (see Bower, 1981; Ingram, 1984; see Niedenthal, 2008 for a review; Teasdale, 1983), the representation of emotion is similar to the representation of any other concept (e.g. as semantic associative networks). However, as other authors (e.g. Lang, 1984; Niedenthal, Setterlund, & Jones, 1994), early noticed, there are some limitations of those semantic network models in explaining the complexity of emotional information. The components of emotion knowledge such as bodily aspects or physiologic activation seem to be well accounted by modern *embodied theories* (Barsalou, 1999; Clore & Schnall, 2008; Damasio, 1999; Decety & Jackson, 2004; Gallese, 2003; Glenberg, 1997; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Semin & Cacioppo, 2008). Because of this, in the present thesis, we endorse this perspective. This perspective holds that representations in general and representations of emotion in particular involve the process of re-enacting and integrating modality-specific states (in motor, somatosensory, affective and reward systems that stands for the meaning of the emotion) generated during the original experience of the concept or emotion (Niedenthal, Mermillod, Maringer, & Hess, 2010), rather than re-describing them into abstract symbols that represent referents.

Embodied approaches to emotion perception have suggested that it may involve a motor simulation of the observed facial expression in the percipient's face (motor simulation). Here we focus on this as a possible mechanism that explains why previous

activation of an emotion in the perceiver may facilitate perception of others' emotional expressions. In fact, a number of reported findings suggest that mimicry plays an important role in the perception of other's facial expression (Niedenthal et al., 2001; Oberman, Winkielman, & Ramachandran, 2007; Stel & van Knippenberg, 2008) although several recent studies suggest that mimicry is not a necessary condition for emotion perception (Adolphs, 2002; Calder, Keane, Cole, Campbell, & Young, 2000; Keillor, Barrett, Crucian, Kortenkamp, & Heilman, 2002; McIntosh, 2006) because contextual effects of previous knowledge or expectancies may play a role when simulation is not able to occur (Niedenthal et al., 2010).

By focusing on previous activation of emotional components (the emotional concept or muscles' activation) in emotional perception we helped to clarify the assumptions made by the embodied perspective (Winkielman, Niedenthal, & Oberman, 2008, for a review) and take a critical view of one of its most relevant methodological procedures: the blocking mimicry procedure (Niedenthal et al., 2001).

In order to motivate the present research, in Chapter I we explore the notion of affective representation and how it is conceived within an embodied perspective. Chapter II focuses on the effect known as *emotional category based priming*, which shows how the previous activation of an emotion feature interferes with the perception of subsequent emotional stimuli. We give special attention to the previous activation of facial muscles (one of such features), and develop the idea that prior activation of muscles relevant to an emotion can be a mechanism that explains affective priming phenomena. Chapter III aims to introduce the reader to one of the most popular methodological procedures to study facial muscle activation role on concept's perception: the blocking of facial expressions.

In Section II, we then present a set of empirical studies, designed to establish whether embodied approach engaging facial muscle activation can account for emotional priming phenomena. The first experiment establishes a temporal window in which a category based emotional priming effect can be found, allowing the test of our hypothesis by the use of a muscle blocking paradigm. We expected that by blocking muscle activity we would change the pattern of the observed priming effects. Before running an experiment providing evidence that mimicry has a role on that effect we wanted to understand the muscular specificities of a blocking procedure (Niedenthal et al., 2001). A pre-test was therefore conducted on the consequences of the blocking manipulation for muscular activation as assessed by EMG. This study characterize the blocking procedure in terms of promotion of

muscle activation over *zygomaticus major*, *orbicularis oris* and *corrugator supercilii* (hyper or hipoactivation). Experiment 3 replciates Experiment 1 adding to it a blocking condition and the two subsequent studies explored other blocking effects on muscle activity in order to better understand the mechanism through which the manipulation produced different results across different emotions in the priming task.

The dissertation then ends with a discussion of the theoretical and empirical issues related to our studies, integrating them in the knowledge already established and in questions to be explored in the future.

Section I

Chapter I: Emotion representations and emotion perception

Perceiving is a process that involves the activation of previous knowledge (Postman, Bruner, & McGinnies, 1948). Perception of an emotion is not an exception. Our knowledge of what an emotion is and what constitutes as specific category of emotions guides our perceptions. But how is that knowledge accessed when we perceive an emotion on another's face?

The answer to this question is not straightforward. It is dependent upon how we conceive knowledge representation. In the present chapter we discuss the notion of affective representation and how it is conceived from an embodied perspective. Within this framework we introduce the emotional category based priming effect, giving special attention to the prior activation of facial muscles.

The representation of emotions

Pure cognitive approaches to emotional information processing have argued that emotion information is no different from other cognitive information. One such approach is represented by the semantic information models. In this group of models: semantic network models of emotion (see Bower, 1981; Ingram, 1984; see Niedenthal, 2008 for a review; Teasdale, 1983), assumes units of representation - concepts (also called nodes) that transduce information in propositional form. Each emotion is represented by a set of nodes. Nodes are linked by pathways that reflect the strength of their semantic association (Collins & Quillian, 1969). When an emotion is experienced, a relevant node is activated and this activation spreads to associated nodes, which can be bodily features of the emotion, its antecedents or other related features.

Cognitive theories have in common the idea that representations are amodal, not preserving analogical features of the perceptual experience. Representations result from the process of redescribing the modality-specific states, generated during the original experience, into abstract symbols that represent referents (Barsalou, 1999). Emotional representation contents, in these pure cognitive models, such as eliciting stimulus, meaning, and emotional responses are stored in a propositional form, which means that an internal symbol stands for a referent which is an internal or external experience previously occurred (Breckler & Wiggins, 1989; Zajonc & Markus, 1984). Even physiological response patterns

that are known to occur in emotional experiences are assumed to be stored in a proposition-based network.

Pure cognitive models of emotion representations have been criticized (e.g. Isen, 1984; see Leventhal & Tomarken, 1986 for discussion) for their poor account of the richness of emotional experience with the assumption that it is plausible that codes other than propositional may preserve somatosensory aspects of experience. Cognitive models lose their power by assuming this somatosensory experience rising from a bidirectional link (Bower, 1981), which signal a potential activation of physiological patterns and subjective state through emotional thoughts and vice versa. This would mean that words and ideas about emotions should activate emotions themselves (Lang, 1984). Emotions are not always primed by words or propositions referring to them (Niedenthal et al., 1994).

An alternative view is offered by embodied theories of cognition**.** The general idea of these models is that representations of knowledge are grounded in modality-specific systems (Barsalou, 1999; Clore & Schnall, 2008; Damasio, 1999; Decety & Jackson, 2004; Gallese, 2003; Glenberg, 1997; Niedenthal et al., 2005; Semin & Cacioppo, 2008). When the concept is activated, this would involve a partial simulation of the original state generated during the experience with the object (those could be introspective states, perceptual states or motor states). In this approach, processing emotionally charged information involves reactivating part of neural states that occurred when one experienced that emotion or processed a particular emotional cue (Niedenthal, 2007). As an example, activating the concept of happiness, would involve simulating happiness itself, including its somatosensory manifestations such as its specific mimicry, postural features (upright position), and so forth.

Evidence supporting an embodiment approach relative to a pure cognitive one, rises from different fields focusing somatosensory: a) impact on emotions; b) activation in perception of emotions and c) activation by emotional constructs.

Somatosensory impact on emotion. Various studies have shown that embodied simulation can have an impact on the emotional state of the inidvidual. One modality of simulation specifically relevant in the case of emotions is facial mimicry. Two facial muscles are frequently manipulated, in this respect. The *zygomaticus* (which pushes up lip corners to create a smile) and the *corrugator supercilii* (which knits the eyebrows to form a frown) which are involved in, respectively, a positive and a negative reaction (Cacioppo, Petty, Losch, & Kim, 1986; Dimberg, 1990). Several studies have suggested that the

contraction of facial muscles is able to initiate/ modulate the subjective experience of the individual. This *facial feedback hypothesis* (for a review see Adelmann & Zajonc, 1989; McIntosh, 1996) was tested by experiments that induced participants to pose or suppress a facial expression. These studies have shown that different facial expressions influence both the reports of what emotions are felt and their physiological responses. In one of such studies Lanzetta, Cartwright-Smith and Kleck (1976) submitted the participants to series of electrical shocks that varied in terms of intensity, and which aversiveness was announced before its administration. Half of them were asked to suppress or to exaggerate the facial expression during the announcement period. Both self-reports of shock painfulness and skin conductance were measured. Findings showed that the concealing of expressive responses decreased the magnitude of skin conductance changes and subjective reports of painfulness relative to the free expression or exaggeration conditions (see also, Kopel & Arkowitz, 1974). In another study, (Laird, 1974) participants were instructed to adopt facial displays (of happiness and anger) while they watched positive and negative slides. The instructions that induced facial expression did not mention the term *facial expression* or any association with emotions, leading participants to believe the experiment concerned “the activity of facial muscles under various conditions” during perception. The participants were attached to electrodes allegedly measuring muscular activity. For anger expressions the participants were requested to “touch lightly the electrodes between the eyebrows”, then to contract these muscles. After this, they were asked to “touch lightly the electrodes at the corners of the jaw and then contract these”. For inducing the happy pose, the participants were instructed to “touch lightly the electrodes near the corners of the mouth and contract these muscles”. Findings showed that *smiling participants* felt happier when viewing positive slides (children playing) and *frowning participants* felt more anger when viewing negative slides (members of the Ku Klux Klan). However mismatching pairs of expressions and slides produced an attenuation of participants’ feelings.

Another study that provides evidence in favour of the feedback hypothesis is the already classic of Strack’s team (Strack, Martin, & Stepper, 1988). It was this work that introduced the procedure of inducing facial expression, by asking participants to put a pen in the mouth, with its top out, while holding it with the teeth (inducing a smile) or with the lips (preventing the smile). While performing this task, individuals were exposed to a humorous cartoon. Participants reported increased amusement while covertly induced to smile (teeth

condition) than in the lip condition. A comparable procedure was also tried with negative emotions by Larsen, Kasimatis, and Frey (1992), who attached two golf tees to participant's brow region, specifically above the inner corner of the eye. In order to produce a sad facial expression, the participants were instructed to try to bring the ends of the tees together. When an inhibition of sad expression was required, the instruction involved keeping the ends of the golf tees apart from each other. This task was performed while participants were exposed to unpleasant slides, which caused the participants to feel sadder when accompanied by the instruction to bring the tees together, that is, the production of a sad expression.

Another set of experiments extended the type of emotions that can be induced by facial feedback. Duclos, Laird, Schneider, Sexter, Stern, and Van Lighten (1989) gave participants instructions that covertly induced facial expressions of fear, anger, disgust, and sadness while they were exposed to neutral tones. In all cases, the expressions were generated by a muscle-by-muscle contraction induction. Subsequently participants rated their feelings on emotion scales. As predicted by a facial feedback account, each expression increased the self report of feelings of its particular emotion compared to the remaining.

The impact of muscle activation in reported emotions has a ecological version in Zajonc, Murphy and Inglehart (1989) study. In this study participants had to pronounce among other control sounds, the vowel *ü*, which should inhibit smile or *e* than should result in a muscle configuration similar to a smile. The authors found that participants who had the task to pronounce the sound *ü* reported worse mood, compared to those in the control condition (who pronounced *o*) and in the *e* condition. Those who pronounced *e* as well as reported better moods than *ü*, also differed from controls.

Taken together, these studies demonstrate that the activation of a somatosensory state is able to trigger by itself an emotional experience or bias it. This is consistent with the general idea of the embodied perspective that holds that emotional experience could be grounded in a previous partial re-enaction of a modality-specific state (such as facial motor behaviour in this case).

Somatosensory activation role on the perception of emotions. Evidence that somatosensory activation exerts a role in perception of emotions comes from the studies that suggest mimicry has a role in our ability to perceive other's emotions (Niedenthal et al., 2001; Oberman et al., 2007; Stel & van Knippenberg, 2008). Strong evidence of this is presented by, Dimberg (Dimberg, 1982, 1990, 1997; Lundqvist & Dimberg, 1995), whose

studies have demonstrated that perception of an emotional face activates muscular activity in the perceiver. In an initial experiment (Dimberg, 1982) participants were exposed supraliminarly to series of happy and angry emotional facial expressions. The results revealed an increased zygomatic region's (associated to smile) activity to happy stimuli and increased *corrugator* region's (associated to frown) activity to angry stimuli. The experiment was replicated with subliminal exposures of the emotional expressions (Dimberg & Thunberg, 1998; Dimberg, Thunberg, & Elmehed, 2000; Dimberg, Thunberg, & Grunedal, 2002) suggesting that the effect has the characteristics of an automatic process. This automaticity received further support in Dimberg and colleagues' (2002) study. In this study participants were presented with pictures of facial expressions (that could be of anger or happiness) and asked either to react or not to them immediately. The reactions consisted in wrinkling eyebrows (promoting a frown) or elevating the cheeks (promoting a smile). Faster responding to the stimuli occurred when the facial instruction matched the facial expression in the picture. Relevant to the argument of automaticity, even when subjects were told not to react, electromyographic activity was differentiated over the *corrugator* and *zygomaticus* as a function of the emotion that was being perceived.

Along with these correlational data pointing to the involvement of mimicry in the perception of facial expressions, there is also causal evidence that this activation facilitates perception of emotional facial expressions (Niedenthal et al., 2001; Oberman et al., 2007; Stel & van Knippenberg, 2008). Niedenthal and colleagues (2001) reported evidence of the role of mimicry in the perception of facial expression in a study in which participants were requested to identify the transition point of a face in a morph video moving from one facial expression (happy) to a different one (sad) and vice versa. During this task, one group of participants was prevented from mimicking with a procedure that involved *holding a pen sideways with teeth and lips slightly*. The other half was free to mimic. Participants whose mimicry was blocked by the pen procedure were less efficient in *detecting the transition* of the facial expression, such that this change was detected later than the group of participants who was free to mimic. This result supports the claim that mimicry has a role in the recognition of facial expressions. Oberman and colleagues (2007) also found supportive evidence for the role of muscle activity in perception of another's smile. These researchers exposed participants to a set of pictures conveying happiness, sadness, fear and disgust at different levels of intensity, each one for a duration of 500ms. Participants performed a

forced-choice identification task. Results showed that participants were more accurate at *recognizing* smiling but not other facial expressions when mimicry was free than for mimicry was blocked. Also using a mimicry constraining paradigm, Stel and Knippenberg, (2008) presented participants with photos of individuals expressing positive and negative emotions for 67ms each. Subjects judged the valence of the expression by pushing a button corresponding to positive emotion vs. negative emotion. Participants who were instructed to clench their teeth were slower in making a response, than those who were free to mimic.

Together these studies add support to the claim that mimicry has a role in processing, this time not in the triggering of emotion itself but in its perception.

However this role does not seems to be one of a "necessary condition". In fact some evidence shows that mimicry is not a necessary condition to emotion recognition. Blairy, Herrera and Hess (1999) developed an experiment in which participants rated a series of videos of persons expressing anger, sadness, disgust, and happiness. EMG activity was recorded over muscles relevant for each emotion. Although this measurement revealed that participants mimicked all types of expressions, a mediational analyses did not reveal a relationship between mimicry and emotion recognition. Consistent with this claim is the behaviour observed in autistic individuals. Whereas McIntosh and colleagues (McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2006) showed that autistic individuals, when confronted with happy and angry photos, do not spontaneously mimic them, Spezio and colleagues (Spezio, Adolphs, Hurley, & Piven, 2007) observed that they are able as normal individuals to categorize facial expressions. The fact that this individuals do not spontaneously mimic, but are able to recognize emotions casts doubt in the role of mimicry for the process, reinforcing the idea that mimic does not seem to be a pre-requisite to perceive other's emotions.

Further support for this doubt is offered by studies with participants with facial paralysis (e.g. Calder et al., 2000a; Calder, Keane, Manes, Antoun, & Young, 2000; Keillor et al., 2002). For example, Calder and his team (2000) worked with subjects with Moebius Syndrome. These individuals did not reveal increased level of errors in recognizing static photographs (in a forced choice task) or vocal expressions of six basic emotions (happiness, sadness, anger, fear, disgust, and surprise) compared to controls.

Because they imply that mimicry is not a necessary condition to emotion recognition, these studies raised the question of when individuals use facial simulation and when they use other cues (perceptual cues, experiential cues, and conceptual knowledge) to interpret facial

expressions. This question is in the root of the emergence of SIMS model (Niedenthal et al., 2010) which focuses on the particular case of the interpretation of smiles. The SIMS model states that the perception of a smile activates the amygdala, which in turn increases the probability of eye contact, which will be responsible for triggering the embodied simulation. However, there are many situations in which eye contact is not achieved, or mimicry is inhibited, for experimental or social reasons. In those cases, processing focus on perceptive features of the smile is in charge, and the individuals perform a match between the perceived smile and stored perceptual representation of previous experienced smiles. In cases, such as in socially inhibited mimicry, it may be that simulation is not completely impaired, so that conceptual knowledge may influence judgment via embodied simulation.

Somatosensory activation by emotional constructs. The emotional lexicon is also able to preserve something about the actual experience of emotion. This is suggested by work of Mendolia and Kleck (1993) who observed that the manner in which a person describes an event shapes the reaction to the same event in a later point in time. Also Halberstadt and Niedenthal (2001) demonstrated that perceptual memory for ambiguous facial expressions was influenced by the presence of a word label accompanying the previous exposure to the face (Halberstadt & Niedenthal, 2001). These studies seen from the embodiment sight, point out the possibility of words being simulators of emotional states.

Concerning specifically the motor reenaction of an emotion, Larsen, Norris and Cacioppo (2003) showed that lexical stimuli are able to elicit motor resonance exposing participants to series of positive and negative words (6 seconds each) where no other task was requested during the exposure, except that EMG activity over the *zygomaticus* and *corrugator* was recorded. The experiment supported the conclusion that positive valenced words were able to exert inhibition over the *corrugator* and negative words over the zygomaticus. In addition to this also Foroni and Semin (2009) tested the supraliminal exposure, to words, this time, focusing on positive and negative representing the facial expressions of two specific emotions (i.e., to smile, to frown) or states associated with these expressions (e.g. happy, angry). For the purpose, EMG activity was also recorded for *zygomaticus* and *corrugator*. The measurement revealed a correspondence between greater activation of the *zygomaticus* for the positive words and greater activation of *corrugator* for

negative words. The pattern holds both for action words of emotion or emotions states, being less clear in the case of the emotional states (adjectives).

Words are not only able to elicit motor responses in the face but also are shown to be impacted by external motor simulations of emotion. Havas, Glenberg, and Rinck (2007) conducted a study in which they manipulated facial expression using Strack and colleagues' (1988) procedures in order to covertly induce a smile or inhibit smile facial expressions. They found that the facial pose had an impact in the understanding of language. Participants had to rate the pleasantness of valenced sentences. Reading times were the measure of text comprehension, and *smiling subjects* were faster reading positive sentences valence while *inhibited participants* were faster reading negative sentences. A second experiment produced the same results in a different variable: the perception of difficulty in understanding the sentences. In the area of language comphension but using an novel way of experimentally blocking mimicry through muscle paralyzing, Havas, Glenberg, Gutowski, Lucarelli and Davidson (2009) studied people who voluntarily were subjected to *botulinum toxin-A* injections over the *corrugator*, with the cosmetic purpose to treat *gabellar lines* (frowning lines). As expected, individuals who were injected with *botox*, were faster in reading sentences of other emotions (happy and sad) than anger sentences processing information. This again strengthened the idea that peripheral feedback in language has a role in the processing of language.

Another interesting study reports that even at the response level muscular compatibility between the response and the form of the response facilitates the performance. In Neumann and colleagues' experiment (Neumann, Hess, Schulz, & Alpers, 2005), the response was not made on a computer keyboard but with the contraction of specific muscles (the *zygomaticus* and the *corrugator*). No reference was made to the muscles. Instead, they were instructed to "pull eyebrows together" in the case of *corrugator*, and to "raise the corners of your mouth", for *zygomaticus*. The authors found that contractions were faster when there was congruence between the valence of the facial pose and the valence of the word compared to the cases where incongruence occurred.

It seems clear at this point that emotional words can stimulate emotion facial muscle activation. However and according to embodied view, whether the individual engages in deep simulation of the concept or makes a superficial analysis of it, may be dependent on the characteristics of task at hand (time, exposure, motivation or even the instruction driving selective attention for relevant features of the concept to be simulated). And the extent of

this simulation determines the quality of the response output. For example the detection of a congruence effect may be easier when the extent of simulation is wider (Niedenthal, Rohmann, & Dalle, 2003).

Illustrating this idea Niedenthal, Winkielman, Mondillon, and Vermeullen (2009) asked participants to judge words according to two different criterions: indicating whether a word was emotional or not (conceptual task), or indicating if it was written in lower or upper case (perceptual task). In one case, the emotional processing was relevant for the task, on the other, was irrelevant. Only in the case of an emotional goal (indicating whether the word was emotional or not) was there evidence of recruitment of muscular activity (measured by EMG resonance in the check, eye, brow and nose region). Adding causal evidence to this interpretation, the authors ran a follow-up study, inviting participants to decide whether the words were associated to an emotion or not, this time, contrasting a group of individuals whose mimicry was free, and another whose mimicry was blocked through Niedenthal and colleagues' (2001) procedure. The participants made more errors when judging the words when individuals were prevented to mimic than when their mimicry was free. However, this inhibitory effect of the pen manipulation was restricted to specific emotions. The authors hypothesised that holding a pen could only influence the activity in the lower part of the face, by decreasing the ability to raise the lip in smile, lower it in sadness, in contrast to the brow and other muscles in the upper face which should not suffer the impact of the manipulation. This could explain how, as sadness and happy concepts were impaired by the pen manipulation, but processing of anger or neutral was unaffected, suggesting that the blocking effects were limited to emotions that engage relevant muscles.

In this chapter we have been focusing on *emotion representation* in order to answer to the question: "How is knowledge accessed when we perceived an emotion on others face?" The evidence reviewed here suggests that not only concpetual knowledge is activated when we perceive emotions in others, our body may also react to it by simulating the usual bodily activity associated with that emotion. The muscles of our face may be one important aspect of that reaction.

The literature reviewed suggests that somatosensory activation is present both when we perceive an emotional face or an emotional word. The congruence of these activations may be a source of facilitation os processing one after the other. If this is so, we would argue that the presence of an emotional face can prime emotional processing through an embodied

mechanism. In Chapter II we addressed this hypothesis reviewing the concept of *priming* and the evidence that can suggest as likely this hypothesis.

Chapter II: Somatosensory activation role in subsequent processing

In Chapter I we provided evidence and theory to suggest that emotion representation involve somatosensory processes, particularly in face muscle activity.

We postulated that this muscle activation occurs when the perception of an emotional face primes the emotion and impacts subsequent processing of congruent or incongruent emotional stimuli. In order to understand this as a hypothesis that is worth being addressed, in the present chapter we defined priming as a general phenomenon that translates into a memory activation that interferes (in terms of latency and accuracy) with subsequent stimulus processing and focused on the impact of priming specific emotions (Carroll & Young, 2005; Kemp-Wheeler & Hill, 1992; Matthews & Southall, 1991; Niedenthal, Halberstadt, & Setterlund, 1997; Rossell & Nobre, 2004). These priming effects were explored here not only at the valence level but also at the emotional level. That is to say that an emotion was expected to affect, differently, the processing of related and unrelated emotional stimuli. This revision focused on anchors for our assumption that embodiment is a route for emotional priming. If the perception of emotions involves reactivation of the emotional experience, including its muscular correlates, then those may be involved in priming.

Priming emotions

Priming occurs when a presentation of a stimulus influences either positively or negatively the efficiency of subsequent processing of a related or unrelated stimulus. In some way, the temporary activation of the mental representation of those stimuli seems to affect subsequent perception, evaluation, motivation and even behaviour (e.g. Bargh & Chartrand, 2000). Such priming effects seem to be automatic in the sense that it is fast and short-lived (Hermans, De Houwer, & Eelen, 2001; Klauer, Rossnagel, & Musch, 1997), depending neither upon explicit evaluative goals (e.g. Bargh, Chaiken, Raymond, & Hymes, 1996; Hermans, De Houwer, & Eelen, 1994), nor on the presence of deep processing resources (Hermans, Crombez, & Eelen, 2000). Furthermore, priming is not dependent on subject’s awareness, which means it can be observed if subliminal primes are presented (e.g. Draine & Greenwald, 1998; Greenwald, Klinger, & Liu, 1989; Greenwald, Klinger, & Schuh, 1995).

Methodologically, we refer to the context stimulus that is previously presented as a *prime*. Primes can have different natures and influence processing in different dimensions as for example, attitudes (e.g. Fazio, Sanbonmatsu, Powell, & Kardes, 1986), stereotypes (for an overview see Brauer, Wasel, & Niedenthal, 2000; Devine, 1989), and behaviours (e.g. Bargh, Chen, & Burrows, 1996). Different stimuli features can act as primes in a specific context (such as its function, taxonomic category, affective colour, perceptive colour, status, gender, race). When the stimuli feature is affect/valence, and it seems to impact subsequent affective reactions (e.g. evaluations) it has been referred as *affective priming*.

Affective priming. Affective priming has been defined as an unintended influence of a first evaluative response to a stimulus (prime) on a subsequent *target* stimulus (see reviews Fazio, 2001; Klauer, 1998; for related results on influence paradigm Murphy, Monahan, & Zajonc, 1995; Murphy & Zajonc, 1993; Rotteveel, de Groot, Geutskens, & Phaf, 2001). Fazio and collegues (1986) defined this phenomenon, demonstrating that presenting a word towards which an individual has an accessible attitude facilitates the processing of a subsequent one that is charged with a congruent affective valence. Fazio and colleagues presented to participants, as primes, negative and positive attitude objects (nouns) that were previously evalutated as having a strong versus a weak evaluative association (strongly good/ bad or weakly good/ bad). There was also a baseline condition, in which primes were neutral strings of letters (e.g. BBB). These primes were presented for 200 ms (SOA 300ms or 1000 ms) in task that involved saying whether other subsequent target words were good or bad, as fast as possible. Targets were 10 clearly positive and 10 clearly negative adjectives. Greater facilitation was observed on trials that had a relation of congruence between primes and targets than on trials involving incongruent valences for primes involving a strong evaluative association but not for primes involving a weak association.

The effect identified by Fazio and colleagues was highly replicable (e.g. Bargh et al., 1996; Hermans et al., 1996; Klauer et al., 1997; Wentura, 1999). But affective priming can also be seen in the influence that the prime exerts on the valence of the judgment itself. Niedenthal (1990) offers us some examples of this. The author primed participants with happy, disgusted or neutral facial expressions for 2 seconds, having them to subsequently form an impression about a cartoon character. Participants who were exposed to the happy primes formed more positive impressions of the character than those who were primed with

disgust. Also Murphy and Zajonc (1993) reported a similar finding. They used happy and angry facial expressions as primes, which were found to influence evaluations of neutral Chinese characters in an affect-congruent manner. When preceded by a happy prime, the neutral Chinese ideographs received higher ratings of likeability than when preceded by an angry one. And both types of primes were significantly different from the no prime and neutral control conditions.

A categorical perspective: Emotional priming. Fazio's approach focused on valence of the prime as the affective feature able to prime subsequent evaluations. Fazio's view is thus an unidimensional model which attributes to valence (the level of positivity) of the emotional experience the greatest part of the variance encountered in the predicting valence congruent results. Other authors (Osgood & Suci, 1955) pointed that such a valence model is limited because ultimately all information in memory carries some information about valence. For this reason, "an activated emotion unit would spread minimal activation to any given item to which was linked by valence" (e.g. Anderson & Bower, 1973; see also Isen, 1984). An emotion should be stronger prime to information that is highly associated with that emotion (e.g. Gernsbacher, Goldsmith, & Robertson, 1992; Halberstadt, Niedenthal, & Kushner, 1995; Hansen & Shantz, 1995; Laird, Wagener, Halal, & Szegda, 1982).

Some evidence suggests this to be the case. That is, specific emotions have been shown to influence subsequent processing of emotional stimuli (Niedenthal et al., 1997, 1999). In an attempt to test specific priming with emotions, Niedenthal, and colleagues (1994) induced participants to feel happy or sad, by exposing them to music (allegros vs. adagios, respectively). In Experiments 1 and 2, participants were asked to perform a lexical decision task where they had to verify whether a string of letters was a word or not. In the pool of stimuli, they included positive words, (e.g. charm, insight, grace), words directly associated to happiness (e.g. joy, cheer, delight), negative words (e.g. blame, decay, crime) and words closely associated to sadness (e.g. hurt, despair, regret). Happy participants were more efficient (faster) in processing happy words than sad words, while there was a decrease in reaction times for sad participants when processing sad words relative to happy words. An additional exploration in terms of valence did not reveal significant differences. These results are suggestive of categorical congruence in perception. Additional analysis provided

evidence that the categorical account fit more elegantly for sad words than for happy. This is because sad subjects made lexical decisions about sad words faster than happy subjects, but not for negative words. On the other hand, happy subjects were no faster in processing happy words than positive words compared to sad participants. In Experiment 3, participants performed gender discriminations over happy and sad photos of males and females, after being induced to feel happy or sad. The results revealed that happy facial expressions were better discriminated in terms of gender when happy subjects performed the task compared to sad ones. The reverse was true for sad words. Although this does not provide evidence contrasting a categorical model to a valence model, it already provided support for emotion congruence in perception.

Other studies brought more clarity to the claim of an emotion priming effect. One of such studies was carried by Niedenthal and collaborators (1997) who tried to reveal in a more powerful way this specific effect by contrasting different emotions that shared or did not share the same affective charge. They did this by first inducing participants to be happy, sad or neutral through the same procedure described above. After the induction participants completed a lexical decision task in which word stimuli were related to the following emotions: happiness, love, sadness and anger. The emotional state of the perceiver produced facilitation in the recognition of words that matched in emotional meaning. That is to say, happy participants were faster in recognizing happy words compared to neutral sad words. And conversely sad individuals were faster in recognizing sad words than happy words and controls. No facilitation effect was observed for love or anger words. The study clearly supports categorical priming (emotion priming). The same effect was achieved in a third experiment where instead of a performing a lexical decision, the participants pronounced a word as soon as it become visible on the screen.

This same categorical effect of emotion has also been observed in studies in which specific emotions are primed with words, demonstrating that the effect is not only limited to the inducing of a particular emotional state in the subject as in the previous case, but can occur when subjects are primed with emotional words. Rossell and Nobre (2004) illustrated this idea, calling attention to the fact that the impact of priming specific emotions can differ across emotion category. In happy prime–target pairs the authors demonstrated the existence of priming effects, similar to the effect found for neutral pairs. This corroborates a previous study of Matthews and Southall (1991) who besides this, demonstrated that negative emotion word pairs produced the same pattern of facilitation. Rossell and Nobre (2004), on their side,

observed that in fearful pairs there was an absence of a priming effect or slight priming facilitation. Sad pairs displayed an inhibition effect that slowed responses to sad word targets. The authors speculated that this is due to a compensatory mechanism that leads to the inhibition in the spread of sad affect. Alternatively, the spread of sad affect may have reduced the capacities of the word-processing system, requiring additional effort to process the targets, suggesting the operation of a controlled process. The authors proposed that this asymmetry verified in negative categories is due to an increased vigilance necessary in adverse contexts (controlled processing), or it may reflect that the associative mechanisms that links words of negative valence has a different nature. According to Rossell and Nobre (2004), the incongruent results on the patterns of priming using emotional categories, shown by different studies reflects a reality that emotional relatedness can be a less powerful form of semantic relatedness.

The authors (Rossell and Nobre, 2004) also suggested that the focus on deeper levels of semantic or affective analysis of words, such as the affective judgment task and may yield different results, more approximate to the facilitation patterns encountered for happy pairs (De Houwer, Hermans, & Eelen, 1998; Fazio et al., 1986; Hermans et al., 1994). This idea was empirically confirmed in the experiment by Carroll and Young (2005) in which participants were primed supraliminarly with facial expressions displaying, anger, happiness, sadness, fear, disgust and also a neutral facial display. Immediately after the exposure, participants were confronted with words belonging to the above emotion categories, which they verbally categorized in terms of the emotion with which it was related, in a force choice task. The authors observed that when prime (facial expression) and target (word) where strictly related in terms of the emotion they expressed, the reaction times were faster compared to the condition in which words were preceeded by neutral faces or to incongruent faces. Although there was a facilitation of the congruent responses over the responses of the neutral condition, no inhibition of incongruent pairs was observed. That is to say, incongruent trials did not differ significantly from the neutral condition. This finding suggests that categorical emotional priming is not a simple variant of semantic category priming, because it does not follow a typical semantic priming pattern of inhibition of the incongruent trials.

In the next section we discuss how priming effects have been framed and how embodiment can be a plausible alternative in their expalanation, specifically in the case of emotional category based priming effects.

Mechanisms accounting for priming effects

Several mechanisms have been proposed to account for priming effects. Most of the explanations account for the findings of a single experimental task, but fail to account for priming observed in other tasks. All accounts fail to explain why muscular feedback would interfere in priming effects (Foroni & Semin, 2009).

The most popular explanations of the mechanisms assumed to underlie affective/ emotional priming effect is the mechanism of *spreading activation* similar to the one that explains semantic priming (Neely, 1991). A *compound cue mechanism* (Dosher & Rosedale, 1989; Ratcliff & McKoon, 1988) is also offered as an explanation of semantic priming effects and at the same time is able to account for affective priming. Differing form those two hypothesis because turns the effect independent of memory representations, the *response competition mechanism* (Klauer, 1998; Klauer et al., 1997), which makes an analogy of affective priming tasks with the *Stroop paradigm* (MacLeod, 1991). Finally we describe the *affective-matching hypothesis* developed by Klauer (1998; Klauer & Stern, 1992), which views this priming as a result of responses bias.

Spread of Activation Account. When one is perceiving the prime it is activated its corresponding node in a semantic network (Bower, 1981; Fazio et. al, 1986), and this activation then spreads to other nodes of evaluatively related targets, but not to inconsistent targets, this way facilitating processing of the target when there is a congruence between prime and target.

Although this mechanism seems to be very straight forward in explaining the affective priming effects, there are many findings that are difficult to reconcile with it.

This view does not predict context dependency effects, and facilitation of prime-target congruent trials processing is expected, meaning that it is a context-independent effect, that occurs no matter the processing goal or task required. However there is a literature demonstrating that affective priming is task-dependent (e.g. De Houwer, Hermans, Rothermund, & Wentura, 2002; Klauer & Musch, 2002; Klinger, Burton, & Pitts, 2000). Several studies have challenge the idea that affective priming holds for tasks that do not require an explicit evaluation of the target, as for example the naming task, where participants have to pronounce words as soon as they are displayed (Klauer & Musch, 2003). In a relevant study, De Houwer, and collaborators (2002; Exp. 2) compared a group of

participants that had to categorize targets as persons versus animals (semantic classification) to a group in which the participants were told to make evaluative decisions on these same targets. An affective priming congruence pattern only emerged for the evaluative decision task, contrary to the semantic-classification task condition where no affective priming effects were significant (e.g., for similar results Klinger et al., 2000; Wentura & Rothermund, 2003).

This task dependence should be difficult to explain for those who propose a spreading activation mechanism as explanation, once it defeats one of its assumptions (Fazio, 2001; Ferguson & Bargh, 2003; Klauer & Musch, 2003; Niedenthal et al., 2003; Wentura & Rothermund, 2003). The automatic spread of activation that occurs during priming is, as its name suggests, automatic. These models do not consider a priori that task type influences the automatic spread of activation, they rather establish that efficiency in priming is defined by strength of association.

Spread of activation also does not do a good job of explaining findings related to tasks in which affirmative and negative responses are required. In those cases the results indicate less pronounced effects as well as a tendency to verify reversed effects when negative responses are requested (Klauer & Musch, 2002; Klauer & Stern, 1992; Wentura, 2000).

Similarly, a spreading activation model has trouble accouting for list-context effects such as sequential effects found by Wentura (1999) and Greenwald and his team (Greenwald, Draine, & Abrams, 1996). This gap in accounting contextual effects is fulfilled by more recent theories as those described above.

Compound Cue Theory. Ratcliff and McKoon (1988) and Dosher and Rosedale (1989) proposed that information is retrieved in memory through a process that combine various cues present in the context into a compound cue.

Instead of considering temporary associations in long term memory, as in a spreading activation account, compound cue models presuppose that prime and target are processed as a composite cue in the short term memory. When a comparison process, between composites and long term memory associations is triggered, a *level of familiarity* is experienced by the individual. And it is this level of familiarity of the composite prime-target resulting from this matching that determines the facilitation of congruent primes-target pairs both in terms of accuracy and response latency.

McKoon and Ratcliff (1992), and Seidenberg, Waters, Sanders, and Langer (1984) observed priming effects for pairs lexical stimuli which were not associated in terms of free-association production measures. Even in cases in which free association does produce connections between words, "the production probabilities do not correctly predict priming effects" (Ratcliff & McKoon, 1994). For this reason, these authors believe free association as it is conceived by spreading activation, it is not a "veridical measure of distance in memory, and thus priming effects should be explained using other measures such as co-occurrence statistics" (McKoon & Ratcliff, 1992).

The fact that this approach takes into account the context and relies on short term memory associations makes it a powerful approach to explain order effects (Ratcliff & McKoon, 1994). For example, a nonword preceeding a target should slow the responses to this target, as well as a prime related to a target should have an impact even if there is another item in between.

Critics of compound-cue theories highlight its failure to explain results from tasks such that do not deal with recognition memory such as the naming task and lexical decision task McNamara (1992). According to Ratcliff and McKoon (1994) to produce semantic priming effects, it would be necessary to add a semantic component to the assumed priming effects.

As we can see this theory is a powerful explanation to affective priming effects if we assume that evaluation or emotional judgment tasks make use of recognition processes. If not, the model fails in understanding the phenomena. As with the spreading of activation assumption this mechanism does not deal fully with the context effects found to be associated with affective priming, since cues should activate the same memory representation independent upon the goal with which this is done.

Response Competition. Assuming independence of priming effects of simple memory representation, the response competition hypothesis views priming as a Stroop-like effect (Logan & Zbrodoff, 1979), a mechanism also capable of explaining context effects. The Response Competition Model (e.g. Bargh et al., 1996; Hermans et al., 1996; Klauer et al., 1997; Wentura, 1999) puts the focus on the response instead of in memory representation. Prime and target develop simultaneously motor response tendencies on the keyboard. The response towards the prime can be compatible or incompatible with the response that is activated by the target. However, this tendency to respond to the prime is

irrelevant, because the task requires the individual just to respond the target. The latency to respond to the target is the time to eliminate this irrelevant tendency to respond to the prime. When prime and target are congruent there's no need to eliminate this tendency, so the response to the target is faster than in the case of incongruency.

The model hypothesizes the existence of two response thresholds when a response is delivered. First, there is an *automatic component* of the prime weight which is positive. This is no more than an automatic influence of irrelevant prime evaluations. Besides this, the prime weight has a *strategic component* related to attention allocation, requiring conscious processing, occurring when the prime information is generally useful (Cheesman & Merikle, 1986). A response is given as soon as the gathered evidence falls outside the interval defined by the two thresholds. The available evidence is given by a weighted sum of the accumulated prime information and the accumulated target information.

Because this Stroop-like mechanism integrates the impact of irrelevant information, is specially successful explaining visible and masked affective priming in evaluative decisions (MacLeod, 1991), consistency proportion effects and sequential effects (Greenwald et al., 1996). Negative priming effects as demonstrated by Wentura (1999) for affective priming are generally found in Stroop-like tasks, as well as effects of prime strength (Musch, 2000) where prime and target evaluations are integrated in the form of a weighted sum. This mechanism also explains the absence of affective priming in tasks that require nonevaluative responses to target stimuli. This weighting mechanism allows that only response-relevant prime information is integrated. This strength ends up being also a limitation. This model cannot explain priming in nonevaluative tasks that require both affirmative and negative responses such as the lexical decision task. It also fails to explain the complex results in the pronunciation task. Summarizing, the Stroop mechanism well integrates the task dependency issue, but isn't able to explain why in some nonevaluative tasks there's still priming effects.

The Affective-Matching Mechanism. The affective-matching mechanism is a postlexical mechanism and was originally proposed to explain evaluative consistency in social judgments (e.g. Abelson & Rosenberg, 1958; Cooper, 1981; Klauer & Stern, 1992; Nisbett & Wilson, 1977). The model has three basic assumptions: a) evaluations of both prime and target are activated automatically and compared in terms of evaluative consistency independently of the individual's processing goal/task; b) evaluative consistency

of the prime-target pairs creates a *feeling of plausibility* and evaluative inconsistency produces a feeling of implausibility; c) the feeling of plausibility facilitates the delivery of affirmative responses, while the feeling of implausibility inhibits them. On the other hand, a feeling of implausibility facilitates the emergence of negative responses, whereas a feeling of plausibility inhibits such responses.

The advantage of this mechanism lies in the fact that it can explain priming effects whenever affirmative or negative responses are required by the task at hand (e.g. lexical decisions), integrating both congruent and incongruent pairs, as the case of lexical decision task. In this case, an affective priming effect is predicted for word targets although the evaluations of prime and target are irrelevant (contrary with what would be predicted by the response competition mechanism). In summary, the explanation power of the affective-matching model overcomes processing goal effects, and accounts for affective priming in wide contexts, integrating effects in non-evaluative tasks and negative response patterns, at least in binary response tasks.

Priming in an embodied perspective. Embodied cognition offers a suitable famework for explaining priming that although anchored in concept representation, goes far away from the assumptions made by the two models described above. In addition, the framework accounts for evidence that the four previously-described cannot elegantly explain. Studies such as the ones (referred to in Chapter I) were developed by Foroni and Semin, (2009, 2011) and reveal that disrupting facial mimicry eliminates priming effect of valenced words on ratings of an evaluative judgment. These authors primed positive and negative words, and showed that the primes had a congruence effect on the funniness ratings of a cartoon. When the participants performed the task when their facial mimicry had been blocked , no differences were detected in the funniness ratings of positively primed and negatively primed individuals.

In addition, findings revealing that pre-motor cortex is involved when facial expressions are primed suggest that embodied cognition may be a relevant approach in explaining the priming phenomenon. Hsu, Hetrick, & Pessoa (2008) primed participants with facial expressions of anger, happiness and neutral in high (90ms) and low (33ms) visibility conditions over target words pertaining to happy and fear categories. Then, subjects were asked to press a button to indicate whether the word was happy or fearful. Results suggested a priming effect, in that reaction times in response to the targets were

faster when congruent trials were presented compared to incongruents, in high visibility conditions, contrary to low visibility, where no difference was found. Important to our claim that embodied simulation is in charge in priming effects, was that lateralized readiness potentials (LRP's) were measured over the motor cortex. The analysis of these electrophysiological results provides data on the initiation of a preparation process on motor cortex towards the stimuli. The authors were able to detect, in high visibility, but not in low visibility conditions a difference between congruent and incongruent trials, respecting the values of LRP's. This is considered a marker of an initiation process on the motor cortex. [1]

Studies such as the ones described above provide initial evidence that amodal theories do not have enough power to account for priming phenomena, and that embodiment theories can be a suitable explanation. One of the criticisms of spreading activation models is their inability to explain task dependency effects. As well as the other models, this is a limitation that embodied theories of cognition are prepared to overcome. In an experiment demonstrating that embodiment is not a simple case of spread of activation, of memory features together with other physiological features, and embodiment effects rely on processing goals, Niedenthal and colleagues (2009) asked participants to respond whether presented words were written in upper or lower case. If that was the case, an automatic spread of activation from the concept to the facial expression facial expression of the participant that was being measured should have occurred. However, no specific activation of the muscles occurred even though the exposure time to the words was relatively long, sufficient for somatic responses to be primed automatically (Stroop, 1935). The activation of facial muscles only occurred when the task requested the activation of relevant simulations, that is emotional task that involved deciding whether the word was emotional or not. In fact "the more priming is shown to be dependent of the task requirements, stimuli and other procedural factors, the more likely that the effect is not caused by the production of an automatic affective response" (Niedenthal et al., 2003). This evidence of task dependence raises the possibility that, although affective priming can occur across dimensions of stimuli, it may be that the process also anchors in more specific features of stimuli representation. Thus, across generality of priming effects, bodily correlates can also have a role in priming

[1] We should be alert to the idea that, high that supraliminal exposure should be more prone in revealing behavioural responses as well as neural responses which is completely in line with the embodied perspective that states that exposure time is able to influence the extent of simulation.

effects. These theories are able to fully account for task dependency, suggesting that affective responses only are triggered when evaluative tasks are requested because the embodied simulation is partial. In other words, the evaluative task mobilizes attention to relevant features of the stimuli in the current situation (Barsalou, 1999), in this case, the affective ones.

Althought other models can support task dependency effects, those same accounts weren't shaped to make precise a priori predictions about what type of embodied simulation should support what type of task. It should be remembered that none of the four non-embodied alternatives can account for the absence of affective priming effects when mimicry is impaired in a priming task (Foroni & Semin, 2009, 2011). Similarly to Niedenthal and colleagues (Niedenthal, Krauth-Gruber, & Ric, 2004) we also assume that embodiment can provide a parsimonious explanation for congruency effects in affective/ emotion category priming.

In addition to this, according to Niedenthal and colleagues (Niedenthal et al., 2004), in embodied cognition the target affectively congruent word completes a simulation pattern already triggered by the prime. Priming makes a concept more accessible because it potentiates its simulation. A higher accessibility is expected with representation of a more perceptual grounding of the concept. Thus, even if at a conceptual level semantic priming occurs, embodiment may have a relevant role in enhancing the probability of re-enacting affective properties of the concept. The extent of simulation of a concept is a determinant of the impact of that concept on subsequent processing and behavioural responses. If we enhance simulation by priming it, a greater priming effect will emerge (NIedenthal et al., 2003).

As we can see from above, spread of activation isn't able to account for contextual effects, something that all the remaining models are able to do. However, copound cue models cannot manage to explain outside the spectrum of tasks that do not rely on memory, as well as response competition models cannot explain priming effects in binary response tasks as lexical decision tasks. In turn none of those models are able to integrate a priori, bodily effects.

As a conclusion, it should be mentioned that these explanations are accounted for mechanisms that are not necessarily mutually exclusive (Fazio, 2001; Klauer, 1998). All of them may contribute to affective priming in different conditions and shifts in the mechanism can occur as a function of the task that is performed. And especially when emotional

information is involved, and simulation of emotional components is triggered, embodied priming mechanism should be the more adapted response to task requirements.

Summarizing…

Priming occurs in an affective dimension. Although the valence can be the relevant dimension in the influence of the processing of one stimulus on another, several studies suggest that the category of the affect is also relevant. This categorical approach is here named emotion category based priming, and assumes that priming a particular emotion facilitates the response to a target of the same emotion more than any other emotion.

From several explanations that literature offers for the priming phenomenon, embodiment perspective presents us one of the best to fit emotional priming since its able to naturally predict emotional specificity as well as giving a satisfactory explanation for the long lasting debate on the task dependency of priming effects. Assuming emotions are represented by their physiological correlates and simulation of these correlates when an emotion is perceived, it is expected that these embodiment features exert a role on emotion priming effects. This is because facilitation in priming occurs as a consequence of congruent targets completing a simulation pattern already triggered by the prime. Thus, disturbing simulation would at least have a detrimental effect in priming, showing this way that mimicry has an impact on it.

Chapter III: Facial muscles' activity as embodiment of emotion constructs. Some methodological issues

In order to understand the facial muscles' role in emotional priming effects, as assumed by an embodied perspective, several methodological issues must be addressed. In this chapter we discuss: a) how face musculature maps onto to different emotions; b) how can we measure muscle activity, c) how to prevent face musculature from being activated by an emotion, and d) how to adapt the priming paradigm to this measurement.

Human facial muscles and emotion

Human facial expression has been widely recognized as a powerful means of communicating emotions and allowing the observer to ascribe mental states to the others. Many researchers accept the idea that basic emotions are expressed as both distinct facial expressions (Ekman, 1992; Izard, 1994) and different autonomic patterns (Levenson, Ekman, & Friesen, 1990). In this section we summarize our knowledge about which muscles are involved in the expression of each emotion (happiness, anger and sadness), and the physical characteristics of those muscles as well as the activities they perform, and the association of those actions to particular emotions.

Happiness is known to produce changes in various parts of the face recruiting more muscle activity over all the face compared to other type of emotions. Evidence for this is found in one experiment conducted by Oberman and colleagues (2007) that measured the activity of several muscles (i.e. *zygomaticus major*, *levator*, *orbicularis oris*, and *buccinator*). When participants smiled, researchers observed higher levels of activity than when the participants expressed any other emotion. However, in a very consistent way, across studies, the *zygomaticus* has been demonstrated to be the muscle responsible for happy facial displays (Ekman & Friesen, 1978; Ekman, Friesen, & Tomkins, 1971; Hjortsjö, 1970; Izard, 1971). This muscle (see Gray, 1918/2000) the "*zygomaticus* (*zygomaticus major*), is a muscle that arises from the *zygomatic bone*, in front of the *zygomaticotemporal suture*, and descending obliquely with a medial inclination, is inserted into the angle of the mouth, where it blends with the fibers of the *caninus*, *orbicularis oris*, and *triangularis*". It's action involves pushing lip corners up and back (Fridlund, 1994; Hjortsjö, 1970).

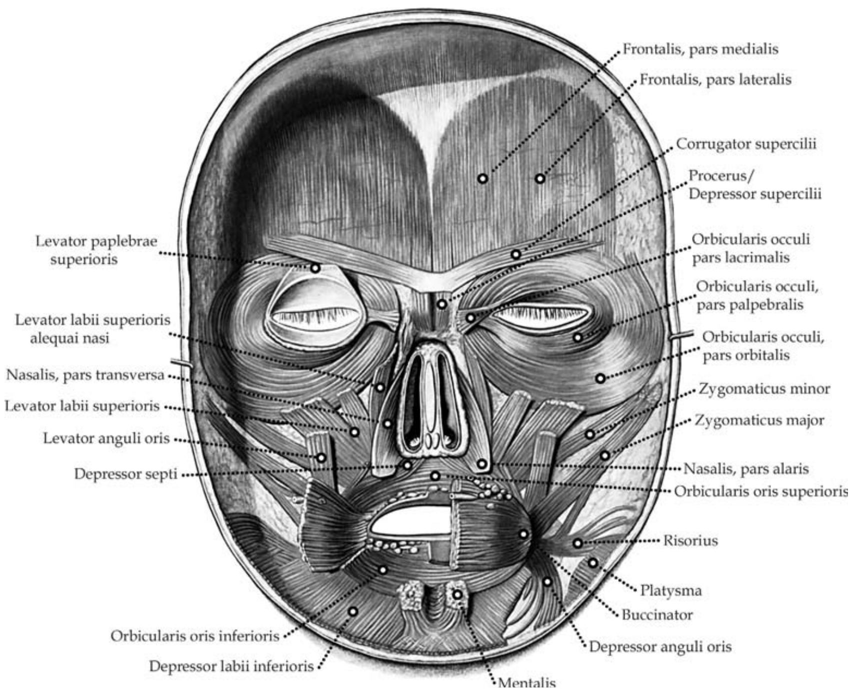


Figure1. Facial Muscles, image from (Tassinary, Cacioppo, & Vanman, 2007).

There is also consistent report of the activity of another muscle, the *corrugator*, as responsible for the creation of the frown as in anger (Ekman & Friesen, 1978; Ekman et al., 1971; Hjortsjö, 1970; Izard, 1971). Anatomically (Gray, 1918/2000) the *corrugator supercilii* is a "small, narrow, pyramidal muscle, placed at the medial end of the eyebrow, beneath the *frontalis* and *orbicularis oculi*. It arises from the medial end of the *superciliary arch*; and its fibers pass upward and lateralward, between the palpebral and orbital portions of the *orbicularis occuli*, and are inserted into the deep surface of the skin, above the middle of the *orbital arch*". The action of *corrugator* is drawing the eyebrows together and downward, producing vertical furrows between brows, forming a frown (Ekman & Friesen, 1978; Ekman et al., 1971; Hjortsjö, 1970).

Sadness is an emotion that seems to show most clearly in the eye area (Ekman et al., 1971). However, several muscles are contracted in the face of individuals feeling sadness. *Orbicularis oris*, among other muscles (*corrugator, frontalis, elevators, orbicularis oculi, pyramidal*) is involved in the expression of sadness (Waynbaum, 1907). The activity of *orbicularis oris* is, according to Perotto (2005), also associated with more extreme expressions of sadness such as grief and despair. But notice it is also involved in the expression of anger (Ekman & Friesen, 1975; Ekman, Friesen, & O'Sullivan, 1988).

Anatomically (Gray, 1918/2000) the *orbicularis oris* “consists of numerous strata of muscular fibers surrounding the orifice of the mouth but having different direction. It consists partly of fibers derived from the other facial muscles which are inserted into the lips, and partly of fibers proper to the lips. Of the former, a considerable number are derived from the buccinator and form the deeper stratum of the *orbicularis*”. The *orbicularis oris* allows the inversion of lips, tightening, pouting, compressing, protruding; (Daniels & Worthingham, 1986; Ekman & Friesen, 1978; Ekman et al., 1971; Gray, 1918/2000; Hjortsjö, 1970; Izard, 1971; Kendall & McCreary, 1980; Weaver, 1977) .

Although there is wide consensus about the interpretation of the *zygomaticus* as a positive reaction to a stimuli and the activity of the *corrugator*, as a negative reaction, there is less consensus about the interpretation of *orbicularis oris*. Bush and Tassinary (1992) point out that in experiments that used mildly pleasant or unpleasant eliciting stimuli, *orbicularis oris* failed to differentiate between them (compaire Bush, Barr, McHugo, & Lanzetta, 1989; Cacioppo, Petty, & Marshall-Goodell, 1984; Dimberg 1986, 1988; Englis, Vaughan, & Lanzetta, 1982; Greenwald, Cook, & Lang, 1989), suggesting that this muscle is not as responsive as *zygomaticus* and *corrugator*. Even though, considering other muscles in the perioral area, this one is known to be the most reactive one. Tassinary, Cacioppo, Geen & Vanman (1987) ran an experiment in which they recorded the activity of the following perioral muscles mentalis, *orbicularis oris superior*, *orbicularis oris inferior*, and *depressor anguli inferioris* while asking the participants to adopt facial actions described by FACS involving perioral movements. Only the site over the *orbicularis oris inferior* muscle region displayed higher activation when the individuals posed, compared to the referred proximal muscles, suggesting this muscle to be the most reactive eletromyographically in that specific area.

As we can see in the schema depicting the facial muscles, these muscles are richly interconnected. And, although there are muscles most associated with a certain emotion, a component of general muscle activity is also present in most emotions, as Oberman and colleagues (2007) suggest. As specific effects of muscles arise, also general effects of muscular activity, may be expected.

Another point of interest concerning the characteristics of muscles is their contraction times. This is especially relevant when we are dealing with tasks that involve short-lived effects (such as priming), where we have to be precise in choosing the time window of the muscle activity measurement. All facial muscles exhibit fast contraction times (Linquist,

1973). Haggard and Isaacs (1966) verified that is possible to observe muscular changes as early as 125-200ms. Although the reaction itself may start within that range, the time where the muscle activation is able to show discriminative responses to different kinds of stimuli is slightly higher. In a series of experiments employing the same paradigm, in which participants were passively exposed to photos of facial expressions of happy and angry facial expressions, (Dimberg, 1991, 1994, 1997b) the *zygomaticus*, as expected, revealed increased activity towards happy stimuli compared to angry faces. And the reverse was true for *corrugator*. This differentiation between the two types of stimuli occurred for both muscles, consistently across studies, around 300 ms for *corrugator* and 400 ms for *zygomaticus*.

Responsiveness of the muscles is also a feature of muscles that could enhance the difficulty of observing the activity of certain muscles using statistical techniques. Not only is the *corrugator* quicker in its onset, but the literature also suggests a superiority of *corrugator* over *zygomaticus* in terms of responsiveness. In an experiment Lang and colleagues (Lang, Greenwald, Bradley, & Hamm, 1993) used pictures that varied across a dimension of pleasantness and unpleasantness. Each stimulus was viewed for a 6-sec period while *zygomaticus* and *corrugator* activity were measured. There was a stronger linear effect of valence on activity of *corrugator* than of the zygomaticus. This was interpreted as a certain insensitiveness of the *zygomaticus* to substantial portions of the valence dimension, which defined a quadratic component in the relationship. The magnitude of the quadratic relationship between valence and activity over *zygomaticus* was stronger, and so, the increasing or decreasing of values of valence produced nonmonotonic changes in the *zygomaticus*. These results were replicated by Larsen and colleagues (2003). Their participants were instructed to pay attention to three groups of stimuli: pictures, words, and sounds. The group of stimuli appeared in a random order. While pictures and words were projected, sounds were delivered by speakers. The stimuli were presented for a 6 second period. Following the recovery period, participants rated their positive and negative reactions to each stimulus separately, on two dimensional instead of an unidimensional scale of valence. Valence had a visibly stronger effect on activity over *corrugator supercilii* and this was true for all three tasks. In a similar fashion it was found an equally strong quadratic effect of the *zygomaticus*.

In general, the literature suggests some consensus around the idea that *zygomaticus* major, the *orbicularis oris*, and the *corrugator supercilii* are involved in the expressions of happiness, sadness, and anger respectively. Morever, it suggests that although muscle

contraction is very quick. It is more or less after 400ms after the presentation of an emotional stimulus that the activation of the muscle (which is related to the emotion of the stimulus) assumes a significant more active pattern than other muscles.

Measurement of muscle activity. Measurement of muscle activity has to have uniform criteria across studies so that they can be comparable. The most popular guidelines, widely used for EMG measurement are those of Fridlund and Cacioppo (1986).

In EMG studies surface electromyography rather than needle or fine-wire electrodes are typically used (Tassinary & Cacioppo, 2000). Although electrodes are less sensitive measuring muscular sites more than specific single motor units (Lawrence & De Luca, 1983; Lippold, 1967) they are less invasive. For this purpose, silver – silver chloride electrodes are used in surface EMG, which chemical stability makes it less sensitive to artifacts, and thus, less susceptible to noise (Cooper, Osselton, & Shaw, 1980).

Electrodes are usually attached with double-sided adhesive tape and filled with a highly conductive substance to stabilize the interface between skin and the electrode. This reduces movement artifacts because gel establishes an elastic connection between the two surfaces (Tassinary & Cacioppo, 2000), which will reduce interelectrode impedance. Site preparation should involve the rubbing of skin surface with alcohol, in order to clean it from dirt and oily substances.

The most typical method of electrode attachment to the skin is the bipolar configuration, which involves affixed electrode pairs parallel to the course of muscle fibers, which was shown to produce sensitive and selective recording of activity (Basmajian & De Luca, 1985; Cooper et al., 1980). This is because the bipolar configuration is more sensitive to fluctuations in the electrical activity within the pairs of electrodes than between other pairs of electrodes (cross-talk). Electrodes should be placed proximal and orientated parallel to the muscle (this is to say, parallel to voltage gradients) and distal and perpendicular to extraneous signal sources (other muscles).

O'Dweyr et al. (1981) argued that is not possible to specify standard sites using landmarks unless with palpation of the muscle specifically for each subject, due to a great variability between individuals. However according to other authors, it should be possible to identify sites (e.g. Fridlund & Cacioppo, 1986). Establishing guidelines for the electrode placement should take into account factors just as proximity to the muscle (with minimal interference of other muscles); position of the electrode in reference to the direction of

muscle fiber; locations of ease attachment (avoiding skin folds for example); choosing anatomical landmarks that show uniformity across participants.

Tassinary and colleagues (Tassinary et al., 1987,1989) report relevant data for the isolation of the *corrugator* and *zygomaticus* major muscle regions and for the position of electrodes for muscles in the perioral area. In an experiment (Tassinary et al., 1989) subjects were instructed to pose different facial actions so that they activated certain muscles. Facial action was coded according to Facial Action Coding System (Ekman & Friesen, 1978) and EMG activity was measured in series of different sessions so that could be elaborated a measure of reliability. The authors recorded activity over *zygomaticus major* and *corrugator supercilii* and adjacent muscle sites (*depressor supercilii/procerus*, *zygomaticus minor*, *risorius/ buccinator*) so that the specificity of the measurement could be assessed. The chosen sites were selected on the basis of anatomical studies (Duchenne, 1867/1959; Kennedy & Abbs, 1979; Lightholder, 1925; Martone & Edwards, 1962; Weaver, 1977).

For *corrugator*, the first electrode is placed "directly above the *endocanthion* just superior to the eyebrow; the second electrode placed lateral from the first along an imaginary line extending from the gabella to the *ipsilateral superciliary arch* of the frontal bone. This line forms a 60º angle (SD=11º) with the facial midline". For the *zygomaticus major*, the "first electrode is placed 2.5cm from the *cheilion* (i.e. the lip corner at rest) along an imaginary line connecting the cheilion to the *ipsilateral condylion* (palpable when the jaw is moved) and the second electrode was placed posterior and lateral to the frst along this imaginary line. This second electrode was also the first electrode for the upper channel, and the second electrode for this upper channel is placed further back continuing along this imaginary line". The authors verified the present configuration of electrodes exhibited greater activity for facial actions that were associated by authors as Ekman and Friesen (1978) to *corrugator* as for example knitting brows, than the remaining poses. The same was true for the configuration of *zygomaticus* comparing facial actions of tightening the cheeks and drawing lips down, for example. In a second experiment the authors compared different sites along the extension of the *zygomaticus*, in order to identify the most discriminating one. The most effective sites for measuring are situated in a small region in the infraorbital triangle between 2.5 and 4.5 cm back from the corner of the mouth along an imaginary line extending between the cheilion and the preauricular depression. In sum, the optimal placement for electrodes over the *zygomaticus major* was between cheilion and the midpoint of an imaginary line extending from the cheilion and the *preauricular depression*.

For *corrugator*, although the optimal place was not tested systematically along its extension, the recording over the site, superior and lateral to the endocanthion along the *brow line*, proven to give sufficiently discriminatory results in the first experiment.

According to Fridlund and Cacioppo's (1986) guidelines, the *orbicularis oris* leads should be placed in the following configuration: "the first electrode is affixed 1cm bellow the cheilion, and second electrode is placed 1cm medial to, and slightly inferior to, the first, so that the electrode pair runs parallel to the *lower lip border*.

The ground electrode should be used in the *mid-forehead* (approximately 3-4cm) superior to the *upper borders of the inner brows*, near the hairline.

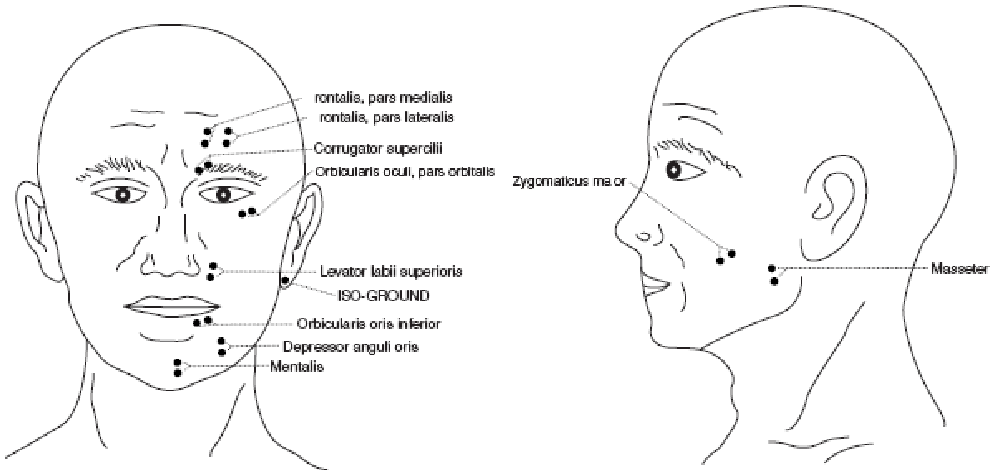


Figure 2. Tassinary and Cacioppo (2007) Suggested electrode placements for surface EMG recording of the facial muscles, based on Fridlund and Cacioppo (1986). (Modified and redrawn from Figure 6 of Cacioppo et al., 1990).

Having already defined the muscles involved in the expressions of happiness, sadness and anger, it is also important to assess the literature that shows those muscles can be manipulated, and if the already existing manipulations are able to impact those muscles in the same way or not. For this reason, we next focus our attention in the procedural and electromyographic characteristics of manipulations of facial expressions. Specially we discuss those that were shaped to impair muscle's activity and thus able to show the impact of the absence of this activity in other dimensions as behavioural measures.

Manipulations of facial activity: expression and blocking. The literature proposes various ways of manipulating muscle activity either by exaggerating/suppressing facial

expressions, by offering muscle by muscle instruction, and by using other more subtle manipulations such as the pen-in-the-mouth manipulation.

Exaggeration and dissimulation paradigms involve exaggerating/suppressing facial expressions that should occur in response to a wide range of emotional stimuli as for instance, electric shocks or pleasant/unpleasant videos (Colby, Lanzetta, & Kleck, 1977; Kleck et al., 1976; Kraut, 1982; Lanzetta et al., 1976; McCanne & Anderson, 1987; Zuckerman, Klorman, Larrance, & Spiegel, 1981). For instance, Zuckerman and colleagues (1981) requested participants not to reveal their reaction to videos. Although these procedures have shown that voluntary facial efference/dissimulation has an impact on emotional experience and autonomic patterns (for a review see Adelmann & Zajonc, 1989; Laird, 1984; Manstead & Wagner, 1988; Matsumoto, 1987; McIntosh, 1996; Winton, 1986), Strack and colleagues (Strack et al., 1988) warned that these kind of procedures do not eliminate ambiguities and experimental artefacts. These authors interpreted some past findings in terms of cognitive mediation and not due to physiological mechanisms. They argued that it may be the case that participants in past experiments have used cognitive strategies to support the required facial expression or directed away their attention from the emotional stimulus instead of the the results being the consequence of suppressing the facial expression that would occur in the sequence of the exposure.

An alternative procedure that would eliminate the above problem, was facial posing introduced by (Laird, 1974) or muscle-by-muscle instructions with or without emotional stimuli (Duclos et al., 1989; Hess, Kappas, McHugo, & Lanzetta, 1992; Laird, 1974; Rutledge & Hupka, 1985; Tourangeau & Ellsworth, 1979), in which participants were requested to exhibit a certain facial display. In the latter case, participants were requested to activate specific muscles involved in certain facial expressions never mentioning that they should modify their own expression.

Refining the way in which the intents of the experiment are disguised, Strack and colleagues (1988) created a procedure that covertly induced facial expressions without directing attention to this objective or inducing participants to associate their facial response to a particular emotion. This procedure was associated with a cover story which said that the study concerned psychomotor coordination, and people’s ability to perform different motoric tasks with parts of their body not normally used for those tasks, as handicapped person have to do. A slight adaptation of the cover story was used by Havas and colleagues (2007). They

told participants the study concerned language processing and the manipulations were specifically designed to prevent the articulation of words.

Consistent with the cover story of Strack and colleagues (1988), participants were told to perform various tasks with a pen, involving holding it in different positions. That would cause to activate certain muscles associated to specific facial expressions. The tasks were: holding a pen with the lips (with its tip out of the mouth), with the teeth or with their nondominant hand (being this the control condition). The lips instructions emphasized that subjects should not touch the pen with the teeth, and in this way inhibiting smile (or as it is referred in more recent literature, "impairing muscles associated with the smile"). The smile was facilitated for participants who held a pen with the teeth, preventing their lips from touching it. No difference regarding the difficulty of performing the task was observed (Strack et al., 1988) between conditions, thus eliminating alternative explanations of the results based on the difficulty. Also, Soussignan (2002) ruled out any difference of pleasantness of the two pen-holding techniques, which may have produced the differences in the dependent measure of interest (funniness of a cartoon). In addition to this, the authors manipulated the intensity of the manipulation by asking participants to prevent their lips from touching in different degrees, was shown not to have a differential impact on the dependent measure.

Blocking: Inhibition of muscle activity. Although the pen-teeth task clearly induces *zygomaticus* activation, there is not clear understanding of the pen lip task. The pen lip task could be more an inhibition of smile manipulation than a promotion of any type of activation. However its status of "blocking of emotion" is put into question (Soussignan, 2002). The manipulation seems to activate the *orbicularis oris* (Ekman & Friesen, 1975; Ekman et al., 1988). For this reason, this manipulation should not be thought to block, because it is in fact inducing a particular expression.

However, blocking is a necessary strategy to study the role of a particular muscle. Understanding this, Niedenthal and colleagues study (2001) created a new manipulation inspired by Strack and colleague's methodology (1988). This blocking procedure did not produce any facial configuration associated with any emotion in particular. The manipulation involved asking participants to hold a pen sideways in the mouth pressing

slightly with lips and teeth. This manipulation proved to be effective in interfering with the perception of facial expression (see Niedenthal et al. 2001, Experiment 2).

We should, however, notice that the blocking is not general. That is, this procedure does not block all the face muscles. According to Niedenthal and colleagues (2001) this manipulation effectively prevents mimicry in the lower face. However in the upper face, mimicry can still occur, allowing some aspects of the perceived facial expressions to be mimicked. Still, the pen manipulation will not allow the same level of match between the perceived face and the perceiver's muscular activity. This manipulation has been used in several studies (Foroni & Semin, 2009; Niedenthal et al., 2009; Stel & van Knippenberg, 2008).

Stel and van Knipenberg (2008) offer an alternative blocking procedure, that is a slight modification of Nidenthal and colleagues' (2001) manipulation. They asked participants to simply clench their teeth without any pen. Unfortunately, there are some disvantages of this technique. First, it is likely to cause the participant to allocate attention to his own facial expression. In addition, it may induce the embodiment of anger, because if an exaggerated pressure is exerted, clenching the teeth may be involved. Finally, it may be the case that the pressure exerted on the pen is not constant during the task because of fatigue caused by the effort and because the participant is engaged in a concurrent task.

The advantage of using the pen is thus clear. In addition if participants are permanently holding something in the mouth that may fall, this would signal that the subject is not accomplishing the task correctly, allowing one to correct for it.

Unfortunately, blocking procedures are not clearly understood in how and in what muscle they activate. It is not clearly specified which muscles were involved when the participants were required to hold the pen in the mouth, and to what degree this happened, and how this involvement was related specifically to the impairment of the recognition of each emotions in particular. The advantage of being aware of what specific muscles are engaged when a muscular manipulation is performed is allowing the experimenter to formulate more specific hypothesis, of the effects of the manipulation on the responses to the emotion specific stimuli.

Oberman and colleagues (2007) were the first to test the muscular involvement of a blocking procedure. They asked whether muscle activity was promoted by a blocking procedure, assuming that impairing simulation was not associated with specific muscle activity but is not also associated with an absence of activity. On the contrary, all muscles

should be activated, creating kind of an unspecific global activation that they would name as muscular noise. However this concept of noisy activation is still unclear in literature, leaving room to pose several hypothesis of what it may be. According to Glenberg and Colleagues (2008) a peripheral muscular blockade should generate increased muscular output but loss of specificity similarly to what happens in muscle fatigue (Gandevia, 2001).

Other ways of interfering with muscle activity besides mechanical action as the pen procedure are also available. Botox paralyzes the muscle through mechanism that blocks the release of acetylcholine in the terminal bouton of the motor neuron (at the neuromuscular junction.) Nerve signals remain unaffected when travelling from the brain to the muscle but no acetylcholine is released at the muscle synapse. Thus, no feedback reaches the muscle and consequently no movement is performed (Dolly & Aoki, 2006). So, no information is sent back to the central nervous system, reducing this way the afferent feedback from the muscles to the brain (Hennenlotter et al., 2009). On the other hand, inducing an increase of skin resistance with a dermal filler (Restylane), does not impair muscle function, allowing facial feedback to occur (Brandt & Cazzaniga, 2007). Neal and Chartrand (2011) have gone even further showing this substance increases the effort the individual has to make in order to counteract the skin resistence, resulting in increased feedback when compared to participants who were injected with botox. They verified this result in a task that involved selecting the emotion that best matched a certain facial expression, among three different emotional labels. From these few examples we can conclude that each manipulation is a different case and involves completely different mechanisms. This highlights the need of a careful pretest whenever a blocking manipulation is required.

Although chemical alternatives are the most selective and precise in the way of impairing muscles, such a methodology has the disvantage of being invasive and expensive. Certainly factors that still constrain its use.

Methodological Adaptation of the priming procedure in an EMG study

Priming effects are studied with a specific paradigm: a stimulus (the prime) presentation is followed by a target stimulus (the probe) to which subjects should react. In order to study the role of muscle activation in this process, muscle measurement has to be developed between the prime presentation and the target. As previously referred muscles have their own timing for developing their activity. So, exposure time of primes should be higher than 400 ms, in order to be sufficient for the development of EMG activity. However,

it should be noted that affective priming effects tend to be short lived in time, and so we should use short interstimulus intervals (<100ms), in order to obtain reliable affective priming effects (Hermans et al., 2001, 2003) replicating Winkielman and Cacioppo (2001) in this respect.

In the following section we used these features in defining our experimental approach to the question of what is the role of muscle activity in emotion priming effects.

Section II:

Empirical Section

Our empirical approach to the question of the role of an embodiment such as face muscle activity in emotional category priming was investigated in two studies: one that examined the emotional category priming effect and other that addressed blocking impact on that effect. Between these two experiments, we addressed the implications of Niedenthal and colleagues' (2001) blocking procedure, to muscle activity, in order to understand its impact on emotional category priming effects.

The studies relied on an experimental priming paradigm inspired by Carroll and Young (2005). We expected to replicate emotion category priming effects with the emotional task used by (Niedenthal et al., 2009). Our targets were words that represented three categories of emotions (happy, sad, and angry) and words not related to any emotion. These words were preceded by related or unrelated emotional facial expressions, or were not primed at all. Participants were asked to categorize target words as emotional vs. non-emotional. We expected to find evidence of emotional category priming across nonverbal (facial expressions) and verbal (words) stimuli, simply because they share emotional semantic features associated with face's muscular activation. Therefore, and consistent with prior research (Carroll & Young, 2005), we expected the results of our two experiments to show that emotional specific category words could be primed by congruent facial expression (i.e., anger would prime anger more than sadness, even though they are both negative emotions).

Because Hsu, Hetrick, and Pessoa (2008) showed emotion priming effects to be dependent upon depth of processing of face expressions (high-visibility conditions) primes were presented for 500 ms (see Li, Zinbarg, Boehm, & Paller, 2008 for a contra-argument). Note that although the extent of facial expression processing without awareness remains a matter of debate (Kouider & Dehaene, 2008; Pessoa, 2005), as well as the likelihood of embodied simulation in these conditions (Niedenthal et al., 2003) we wanted to be sure priming to be effective in our studies. By presenting primes supraliminaly we expected to increase the likelihood that simulation would be triggered. Also, as discussed in the previous chapter, by establishing prime exposure in 500ms there should have been enough time for differential EMG activity on the muscles of interest (Dimberg, 1997; Dimberg & Thunberg, 1998) which would allow us to test if muscle activation played a role in the process. Short interstimulus intervals (<100ms) were used so that affective priming effects could emerge (Hermans et al., 2003).

In our study and similarly to Winkielman and Cacioppo (2001) the prime was immediately followed by the target. Intertrial intervals were set to 6ms, so that the EMG activation that followed the presentation of each trial returned to baseline levels (Winkielman & Cacioppo, 2001).

Experiment 1 was designed to clearly test the experimental paradigm and defined the category emotional priming effects just described.

Our second aim was to directly test the hypothesis that muscle activity plays a role in emotional priming effects. For this purpose, we planned to add a blocking condition (see Section I Chapter 3) to the design defined in Experiment 1 using the procedure of Niedenthal and colleagues (2001). The goal was to show that this blocking of muscle activity impairs emotional priming, which would illuminate the role of embodiment in emotional priming effects. However, based on the literature reviewed in Chapter 3 of Section I, on the implication of blocking procedures on muscle activity, we realized that blocking may still allow partial muscle activity and for that reason, a blocking manipulation may be differently effective in blocking different muscles. If that is the case it would be logical not to expect priming effect to disappear equally in the happiness, sadness and anger prime-target pairs. In order to turn all this assumption clear, we developed a preliminary study (Experiment 2), addressing blocking procedure's impact on muscle activity.

If Experiment 2 corroborates the predictions that were enlightened by the literature of face muscle activity and blocking procedures, we would expect, blocking effects in priming, approach in experiment 3, to be qualified by emotion, suggesting a clear role of muscle activity in the process.

Experiment 1: Priming emotion category effect

Method

Participants and Design

A total of 36 ISPA – Instituto Universitário's undergraduates (89% Women), with ages ranging between 19 and 48 years (*M*=23.97; *SD*=7.36) were randomly assigned to the conditions of the mixed experimental design: 2 (Prime: present; absent) x 3 (Emotion of the prime: happy; sad; angry) x 3 (Relation prime-target: congruence prime-target;

incongruence prime-target; emotional prime-neutral target), being the emotion of the prime a between factor.

Material

Primes. Forty-eight faces expressing one of the three target emotions were randomly selected from The Karolinska Institute's data base (Lundqvist, Flykt, & Öhman, 1998) - 16 for each emotion for each emotion. All pictures were converted into gray scale, and in 5 x 5 cm format. They were pre-tested for their emotional intensity and level of familiarity. All pictures were correctly associated with their emotion category. No differences were found in the intensity of their expression concerning the three groups of facial expression (M_{happy}=4.58; *SD*=.20; M_{sad}=4.41; *SD*=.20; M_{angry}=4.77; *SD*=.20; $F(2,45)<1$). There were no differences between the three sets of emotional primes in terms of familiarity (M_{happy}=2.35; *SD*=.14.; M_{sad}=2.17; *SD*=.14; M_{angry}=2.02; *SD*=.14; $F(1,45)=1.39$; $p=.259$; $\eta^2=.06$).

Targets. Four sets of eight words (see Appendix A) that were demonstrated in a pilot test to be related to a specific emotion: happiness, sadness, anger (more than 80% of pre-test subjects reported that association and less than 50% of participants associated it with other emotions) were defined as targets. A set of eight neutral words (words that fewer than 2% of the subjects associated with an emotion) were used as controls.

Words were matched for length in order to avoid differences in reading times associated to this variable. The four sets of words did not differ in their number of letters (M_{happy}=7.75; *SD*=.77; M_{sad}=7.50; *SD*=.77; M_{angry}=6.75; *SD*=.77; $M_{neutral}$=7.38; *SD*=.77; $F(1,28)=.305$; $p=.821$; $\eta^2=.03$). Although we tried to equate words on level of familiarity, this was not possible regarding words related to happy emotion (M_{happy}=5.89; *SD*=.24; M_{sad}=4.98; *SD*=.24; M_{angry}=5.085; *SD*=.24; $M_{neutral}$=4.73; *SD*=.24; $F(1,28)$=.4.34; $p=.012$; $\eta^2=.32$). Post-hoc tests revealed that only happy words were more familiar than neutral words, sad and angry (see Table 15, Appendix C).

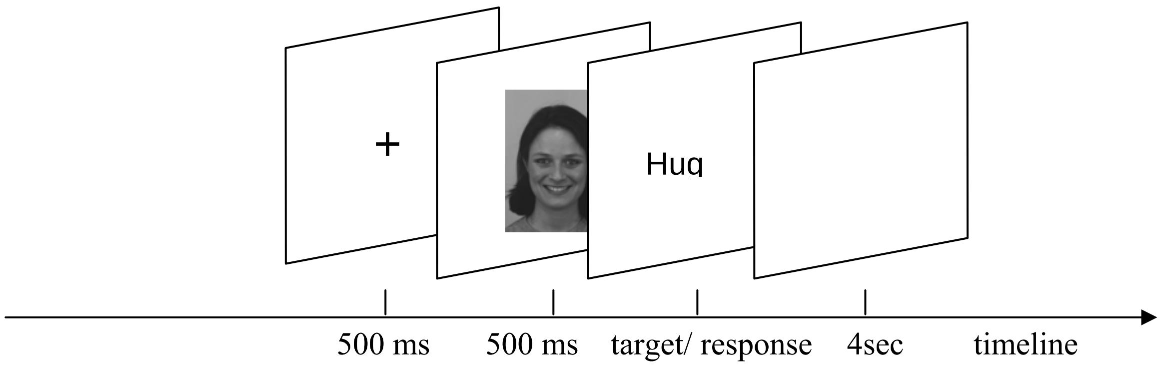
In each eight-word set, four were primed with a congruent facial expression, the remaining four were unprimed.

A total of 32 filler targets were also presented. Fillers were words that established less clear associations to a specific emotion than those which were reserved to critical trials. This was reflected in the association to other emotions being higher than 50%. Fillers were also primed with facial expressions. As the emotion of the prime was a between-subjects

factor, when one emotional prime was presented to the participant, the other remaining emotions served as fillers to match filler ambiguous targets. The inclusion of those emotions was done to disguise the objective of studying the impact of particular emotions.

Procedure

The experiment was presented as a study of psycholinguistics, designed to test the speed of processing words in a computer task using E-prime v1.9 (Psychology Software Tools Inc., PA, USA). The participants were asked to evaluate words in a computer screen, according to a certain criterion. They were warned that each word could be preceded or not by a human face (presented supraliminally). The participants were told that these faces would be subject of a questionnaire, to be completed later. This procedure was included to justify the presence of the faces. Participant's task was to decide if the words presented in the screen were or not emotional, by pressing the S or L key (counterbalanced between subjects). Each trial began, with a fixation point of 500 ms, followed by the facial expression presented for 500 ms (prime) and the target word which stayed on the screen until a response was given. There were a total of 64 trials (32 relevant and 32 fillers) being the inter-trial interval 4 seconds. Target trials were defined by strong emotionally associated words. These were associated with one specific emotion (happy vs. sad vs. anger) dependent upon the experimental condition participant was distributed to. Filler trials were defined by weaker emotional words and those were associated with a non relevant to condition facial expression.



SOA 500ms

Figure 3. Procedure of Experiment 1.

All participants responded to a post experimental questionnaire that had the aim to reinforce the coverstory. In this questionnaire, they were presented with a group of faces,

and they had to report which ones were presented previously during the experimental task. After this, they were asked about the intents of the experiment. After responding to this questionnaire they were thanked and debriefed.

Results and Discussion

All participants reported seeing the faces. None reported an experimental intent close to the real purpose of the experiment.

Reaction times

Our first aim was to test for the presence of priming effects. Priming would imply that presenting an emotional face which emotion was congruent with the emotion of subsequent presented word. This congruence would elicit faster responses than for trials in which no congruent face was presented. Although we presented mean values in milliseconds, in order to test our hypothesis we first log transformed all RT's. The logRT's were entered into a three-way ANOVA, defined by the emotion primed as a between subject factor and both congruence vs. incongruence vs. neutral and primed vs. non-primed trials as within factors.

The analysis yielded a main effect of prime ($F(1,32)=5.91$; $p=.021$; $\eta^2=.16$). Responses were faster on primed trials ($M=1197.59$; $SD=67.03$) than on non prime primed trials ($M=1352.94$; $SD=83.71$) suggesting that the mere presence of an emotional face facilitated emotional judgments in general.

As expected, the prime main effect was qualified (with marginal significance) by the relation that the prime and the target established - congruence, incongruence or neutral - ($F(2,64)=2.63$; $p=.079$; $\eta^2=.08$). However this effect was due to a match between emotional prime and emotion judgment, and not the match between categories of emotions and targets. So, whereas emotional primed faces did not facilitate judgments of nonemotional neutral words ($M_{primed\text{-}neutral}=1264.29$; $SD=83.63$; $M_{no\ prime\text{-}neutral}=1209.30$; $SD=81.45$; $t(32)<1$) priming was clearly present in other conditions. Again consistent with a general effect, priming impact was present regardless of the level of congruence of the primed emotion and the emotional target to be judged. Thus, the difference between priming ($M=1133.56$; $SD=81.05$) and no priming condition ($M=1475.00$; $SD=153.04$) was greater for congruent

than the neutral words, suggesting the existence of a facilitation effect associated with congruence ($t(32)=2.11$; $p=.042$). But we also observed priming effects in incongruent trials, ($M_{no\ prime\text{-}incongruent}=1194.91$; $SD=92.71$; $M_{no\ prime\text{-}incongruent}=1374.53$; $SD=97.70$; ($t(32)=1.97$; $p=.057$). The magnitude of priming did not differ between congruent and incongruent trials ($t(32)<1$).

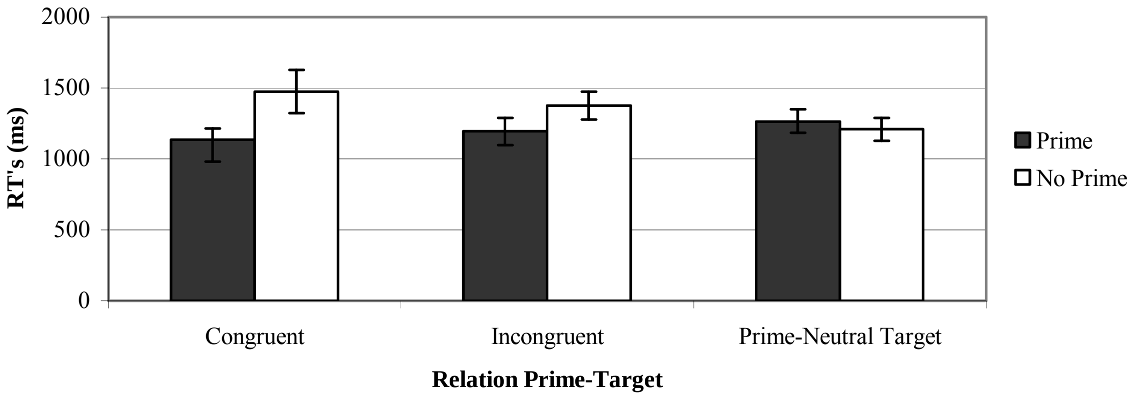


Figure 4. Interaction: Presence of the prime X Relation Prime – Target.

The facilitation in incongruent trials could be interpreted as an emotional leakage effect, which was also found by Carroll and Young (2005). So whereas emotional faces independently of its emotion, were capable of facilitating a response regarding the emotional feature of an emotional target, no effect was found for judgments of the neutral targets.

No other main effects or interactions were found (Appendix D), suggesting that the three sets of emotional primes promoted similar results ($F(4,64)<1$).

Accuracy of responses

Accuracy (percentage of correct responses) scores were subjected to an ARCSin transformation according to recommendations by Winer (1962). This transformation normalizes skewed distributions. Accuracy scores were analyzed within a mixed ANOVA design defined by the three levels emotional prime (happy, sad and angry) as a between subject factor and the two within factors: prime vs. no-prime and congruent vs. incongruent and neutral targets. No effects were found. Not even the main effect of the prime $F(1,32)=1.37$; $p=.250$; $\eta^2=.04$ or the Prime x Congruence interaction ($F(2,66)<1$). This pattern of results clearly suggests the existence of a trade-off between response times and accuracy.

Although there is a role of emotion in priming effects in this study, the restults do not support a specific category emotional priming effect. Perceiving a specific emotion did not clearly facilitate the judgment of a word that matched that same emotion in comparison to words that did not match the emotion. Contrary to our expectation, incongruent emotions facilitated the emotional judgment, in the same way facilitation was promoted by the congruent primes.

Before accepting the present findings as evidence inconsistent with an emotion category priming hypothesis, we should think carefully what may be happening in these data. One possibility is that the difference is there, but that the low power of our analysis or other confounding does not allow its detection. Semantic characteristics of emotions may have caused a leakeage effect (Carroll & Young, 2005) becoming more difficult to detect the presence of a category priming effect. As we discussed in Chapter 3 of Section I, emotions share muscle activation. This muscle activity may be the reason for this apparent general emotion priming phenomena. If there is, in fact, an overlap in terms of muscle activity, this may lead to a general emotion priming effect, not being necessary to assume an overlap between semantic characteristics of emotions. To test this possibility we should block the muscular feedback and see general impact over all emotion judgments. In this experiment, several methodological flaws should be overcome in order to ensure that these results really suggest no evidence of an emotion category priming effect. We should, thus, increase power in our analysis. This, because one possibility of having observed these resutls is that our statistical analysis lacks enough power to detect the effect. If the power of the analysis was the responsible for our data, increasing the power with more subjects would lead to an emergence of the categorical emotional priming in the free condition, and consequently a differential impact of the blocking manipulation for each emotion, as stated before.

We addressed this methodological issue in an experiment that directly tested embodiment (Barsalou, 1999) as a suitable account for explaining emotional category priming effects, using the muscular blocking paradigm. This procedure is assumed to prevent any facial configuration associated with any emotion in particular. From the procedures reviewed in Chapter 3 Niedenthal and colleagues (2001) manipulation seems to be more effective in preventing mimicry of the lower face, and was thus selected for our purposes. However, it is unclear which facial muscles this manipulation act on. Without such knowledge we are not able to interpret the findings of studies using this manipulation. Thus

Experiment 2, was developed as a pilot study to clarify the impact of the procedure on muscle activity.

Experiment 2: Pilot study of the Niedenthal et al's (2001) blocking procedure

Here we tested muscle activity associated with Niedenthal and colleagues' (2001) blocking procedure, by associating it with EMG measures of three muscle regions.

The advantage of learning which specific muscles are engaged when a muscular manipulation is performed would be enormous as was suggested by Oberman and colleagues' (2007) work, who tested the muscular involvement of a specific blocking procedure. Their blocking procedure required participants to actively hold a pen in the mouth sideways, without touching it with their lips. The manipulation was shown to create a hyperactivation of a variety of muscles (*zygomaticus*, *levator, buccinator* and *orbicularis oris*). In their paper Oberman and colleagues argued that Niedenthal's and colleagues' (2001) procedure was not associated with that type of hyperactivation. Oberman and her team (2007), assumed it as a passive procedure that *prevents the participants from generating muscular signal*. Although this seemed to be a best blocking procedure, because of that characteristic, the truth is that we have no data that suggests that to be so. Moreover, we have not evidence on which muscles are the target of this manipulation.

In order to assess the specific effects of the Niedenthal and colleagues (2001) blocking manipulation on facial musculature, we instructed subjects to perform the manipulation and used EMG to recorde concurrent activation of their facial muscles. If the procedure impaired the generation of muscular signal (as assumed by Oberman and colleagues), activity of muscles should decrease. If blocking means creating noise (as in the case of the Oberman procedure), then the prediction should be that blocking increased muscle activity.

Method

Participants and Design

Eleven ISPA's undergraduates students (91% women), were randomly assigned to the conditions defined by the following within subject design: 3 (Muscle: *zygomaticus major*; *corrugator supercilii*; *orbicularis oris*) x 2 (Mimicry: blocked; free).

Procedure

Upon the arrival to the laboratory participants were informed the experiment would involve the collection of physiological measures, and for that reason electrodes should be attached to the skin. The experimenter explained that the procedures would constitute no harm for the participant. And the participant was also invited to pose any questions related to the equipment.

Then, the experimenter rubbed their skin with alcohol in order clean the participant's skin, so that the electrodes could be efficiently attached to *zygomaticus*, *corrugator* and *orbicularis oris*,

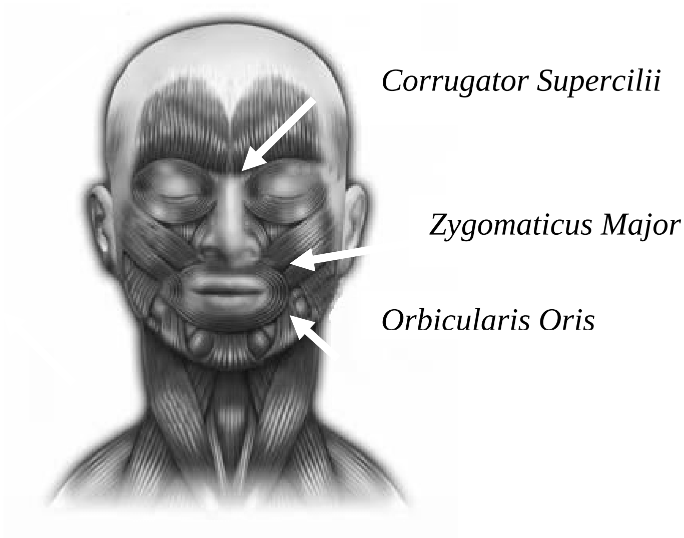


Figure 5. Measured muscles

Then, our study was presented to the participants as a pre-test of a manipulation that interfered with sub vocal activity.

The participants were asked, in random order, to adopt the Niedenthal's and colleagues' (2001) blocking procedure or to stay in a free mimicry condition. In the blocking

mimicry condition, participants were asked to "hold a pen sideways with the teeth and lips with a slight pressure", while the computer showed a photo exemplifying how the pen should be held.

Figure 6. Niedenthal and colleagues' (2001) blocking procedure (Winkielman, Niedenthal, & Oberman, 2008).

Participants were told that they would keep the pen after the experiment so that they could be sure that the same pen had not been used by other participants. Even so, alcohol was available in case the participant felt the necessity to disinfect the pen.

After being in the correct position, participants were asked to maintain it during 6 seconds, just looking at a fixation point. After this, participants were debriefed, thanked and dismissed.

EMG measurement. EMG was used to assess activity of muscles. We monitored the activity in the cheek region by recording the activity of *zygomaticus major* (the muscle that raises de lip corner), *orbicularis oris* (responsible for protruding lips and inverting them) and *corrugator* (which approximates eye brows.

Muscle activity was measured with pairs of adjacent silver/silver-chloride electrodes placed on the left side of the participant's face. An additional ground electrode was placed in the upper portion of the forehead. The impedance was reduced to less than 10 kΩ. The attachment of the electrodes was performed according Fridlund and Cacioppo (1986). The acquisition of the signal was through MP150 Amplifiers and Acknowledge 3.1 by BIOPAC (BIOPAC Systems, Inc., Goleta, CA). The gain was 5000, and data was filtered online with a lowpass filter of 100Hz and a highpass filter of 1.0Hz and sampled at 1000 times per second.

Results and Discussion

In order to understand the pattern of activation of the 3 muscles during the blocking manipulation, EMG measures were first integrated (root mean square) and rectified as well as screened for movement artefacts. Data were standardized within subjects and muscle sites, attenuating the impact highly reactive participants. The data used refers, , to the average EMG activity of the period between the 2^{nd} second and the 6^{th} second after the presentation of the instructions, as in Oberman and colleagues' (2007).

These data were submitted to a two-way ANOVA according to the design (3 muscle x 2 mimicry). Against the idea was that blocking procedure prevents muscle activity no main effect of the free vs. blocking mimicry manipulation was found ($F(1,10)=1.55$; $p=.241$; $\eta^2=.13$). The absence of a main effect seems to indicate that the general activity of the face was no different from the free mimicry condition compared to the blocked mimicry. However, and most relevant, the analysis yielded an interaction between those two factors ($F(2,20)=6.30$; $p=.008$; $\eta^2=.39$) suggesting that blocking was related differently to specific muscle activity. Exploring this interaction, we found that blocking produced more activation of the *zygomaticus* ($M=.81$; $SD=.29$) than the free condition ($M=-.23$; $SD= .18$; $t(10)=2.52$; $p=.031$). In the case of *orbicularis* this difference was not enough to reach common levels of significance ($M_{blocked}=.41$; $SD=.30$; $M_{free}=-.30$; $SD=.15$; $t(10)=1.74$; $p=.112$,). And in the case of *corrugator* its activity was less when the participant was holding the pen than when no manipulation was required. ($M_{blocked}=-.40$; $SD=.25$; $M_{free}=.63$; $SD=.22$; $t(10)= 2.51$; $p=.031$).

In general, this pattern of results corroborate the idea of Oberman and collegues (2007) that blocking promotes muscle activation, but that this procedure is more effective in blocking lower facial muscle than the upper ones (e.g. *corrugator*) as Nidenthal suggested.

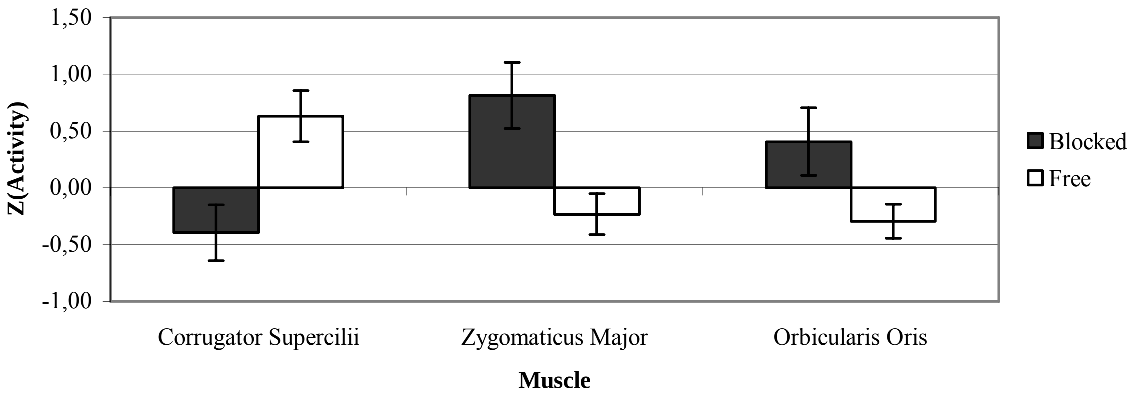


Figure 7. Interaction: Muscle x Mimicry.

Our analysis initially examined average muscle activity. However, because muscle activity is an over-time phenomenon, differences may be found not only in the means of the mean of the particular distribution for each subject, but also on the means of the standard deviations that characterize that distribution. Thus, it may be the case that the manipulation not only impacted its mean activation, but it also reduced the natural activity of the muscle, freezing its natural changes of activity. In order to investigate this possible effect of blocking, that is, the impact on the variability of muscle activity, we analyzed the standard deviations of the activity, which had been submitted to an Arcsin transformation.

Blocking did not differ from free mimicry with regard to the variability observed in general muscle activity ($F(2,9)=1.38$; $p=.269$; $\eta^2=.13$), or specific muscle activity (no interaction $F(2,18)<1$). These null effects seems to discard the idea that block is synonym of a hyperactivation that freezes the muscle in one level of activity, promoting less variability in degree, if muscle activity states than free mimic.

Concluding, we verified that Nidenthal and colleagues' (2001) procedure was operating through a process of activating *zygomaticus*. *Orbicularis oris* also seemed but not in an effective way.

We suspect that the high activity of *corrugator* reported in free mimicry was promoted by participants' attention mobilization to the fixation point during the task while waiting for instructions. Blocking seems in some way to prevent this activation, either because of the procedure itself or because of interfering with this attention mobilization.

In the discussion of Experiment 1, we posed the hypothesis that emotion priming is driven by embodiment features. In Experiment 3 we introduced a blocking procedure with

the prediction that it would influence priming. If priming is general as suggested by experiment 1 (and not a question of power in analysis) blocking should interfere with the general effect. However, priming has a category component we expected the interference on priming by the blocking procedure to be qualified by type of emotion that was primed. Anger may provide a less stronger evidence of blocking, since the brow movement seems to be less disturbed by the procedure itself as observed in Experiment 2 (Niedenthal et al., 2009). Blocking may provide the stronger disruption of the priming effect associated with happiness, since this emotion recruits more muscular resources that should be occupied with this effortful pose (Oberman et al., 2007). A third pattern of results may be that the priming effect, whatever its form (category based or general) persists in blocking conditions. This would suggest that embodiment does not have a role in explaing emotion priming effects.

Experiment 3: Blocking the priming emotion category effect

This study replicated Experiment 1 in a free mimicry condition and added to it a blocked mimicry condition. The addition of such condition would be helpful in explaining the general priming effect of emotions we observed in the previous experiment. If no embodied component was involved in the priming effect there is no parsimonious reason for the blocking of the muscular feedback to interfere in the performance of the above-described emotional priming. By increasing the number of participants we expected to clarify the results obtained regarding emotion congruence and incongruence effects, in the free mimicry condition.

Method

Participants and design

Sixty-four ISPA’s undergraduate students (84.33% women), between 17 and 42 years (M=22.13; SD=6.49) were randomly assigned to the conditions of the experimental design: 2 (Prime: present; absent) x 3 (Emotion of the prime: happy; sad; angry) x 3 (Relation prime-target: congruence prime-target; incongruence prime-target; emotional prime-neutral target) x 2 (Mimicry: free; blocked), being the emotion of the prime and mimicry between factors.

Material

For the present experiment, the set of material used was the same as in Experiment 1. Forty-eight primes of facial expressions (happy, sad, and angry) were selected from Karolinska Database. In each between emotion prime condition, 16 were critical primes of a specific emotion, and 32 were fillers of the remaining emotions.

In addition, a pool of 32 words critical targets was selected. Eight critical words were associated with each emotion (above 75% of association to a specific emotion, and bellow 50% of association to other emotions) and eight were neutral stimuli (never associated more than 2% to any emotion). Those words were controlled both for familiarity and length. There were also 32 filler ambiguous words pairing with the filler primes. The fillers were words that were more weakly associated with the emotion (less than 50%) and linked to a face expression not related to the emotion to be primed in that experimental condition.

Procedure

The participants followed the same procedure as in Experiment 1. In brief, participants were supraliminally exposed to facial expressions, which were then followed by a target word. All participants learned that some words would be preceded by a face and others would not. They were further instructed that their task was to judge whether the word was an emotion word or not.

However, this time, half of the participants were assigned to a mimicry-blocked condition in which the procedure followed that used by (Niedenthal et al., 2001), was employed.

Participants were told that we gave the used pens as gifts to its correspondent users, guaranteeing the same pen was never used by two different participants. In spite of this, we additionally let the participants rub the pen with alcohol, in case this made them feel more confident about the hygienic conditions of the experiment. When participants indicated that they were comfortable and adopted in the required position, the experimenter gave the signal to the participant initiate the task. Free mimicry participants were told to begin right after they read the instructions of the decision task. After they concluded all emotional decision trials, they were thanked and debriefed.

Results

The data were analyzed in order to a) understand if we replicated the pattern obtained in experiment 1; b) see if mimicry condition moderated that pattern and c) better understand how blocking impacted the effects on priming on of word emotional judgment process.

Reaction Times

Analysis of the pattern of results obtained in Experiment 1. Along with what was observed in Experiment 1, a main effect of priming was found ($F(1,31)=6.13$; $p=.019$) $\eta^2=.17$ Primed targets were more quickly judged as emotional ($M=688.43$; $SD=52.02$) than no primed targets ($M=772.05$; $SD=70.37$). This replicated general priming effect observed in Experiment 1.

In addition to what was found in Experiment 1, we also found evidence of categorical emotional priming. The main effect of the level of congruence ($F(2,62)=3.89$; $p=.026$; $\eta^2=.11$) was significant. As expected, congruent trials were associated with quicker reactions ($M=723.82$; $SD=69.20$) than incongruent trials ($M=794.46$; $SD=74.83$). Non emotional words ($M=672.42$; $SD=42.87$) were faster to be judged as non emotional than were positive identifications of emotional words as emotional. The interaction between presence vs absence of a prime and the level of congruence between the prime and the target ($F(2,62)=3.16$; $p=.050$; $\eta^2=.09$), reveal that whereas primed congruent pairs were processed faster prime did not affect incongruent and neutrals targets. This indicates that each category of emotion is mostly facilitated by stimulus of the same emotional category rather than from different emotional category, contrary to what happened in the previous experiment. Leanding to the conclusion there is specificity when we are priming emotions and that effects of Experiment 1 may be just a case of power in analysis.

These effects were moderated by the category of emotion that was primed ($F(4,62)=2.46$; $p=.054$; $\eta^2=.14$). As this moderation does not involve the factor that defines if the prime is present or absence means that when we refer to happy prime condition, for example means that there were not only happy prime trials but also non-primed trials that were presented in a happy priming context.

For the angry context, we found no effect of levels of congruence (t<1). The effect is both present in a happy prime context, (t(31)=2.67; p=.012) and in the sad context (t(31)=2.41; p=.022).

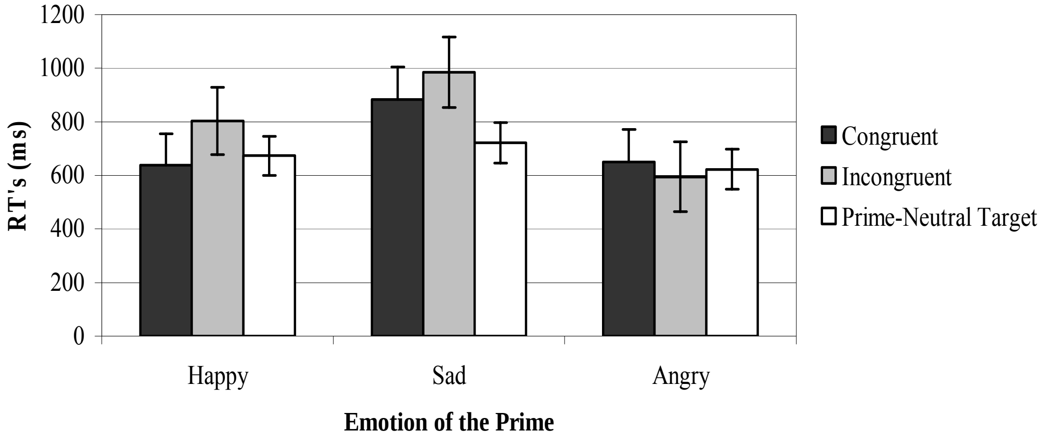


Figure 8. Interaction: Relation Prime-Target x Primed Emotion

Relevant for a better understanding of these pattern of results, they were found to be moderated by the priming factor (F=(4,62)=2.22; p=.077; η^2=.13). The pattern of results previously described was mainly associated with the priming conditions (see Fig. 9).

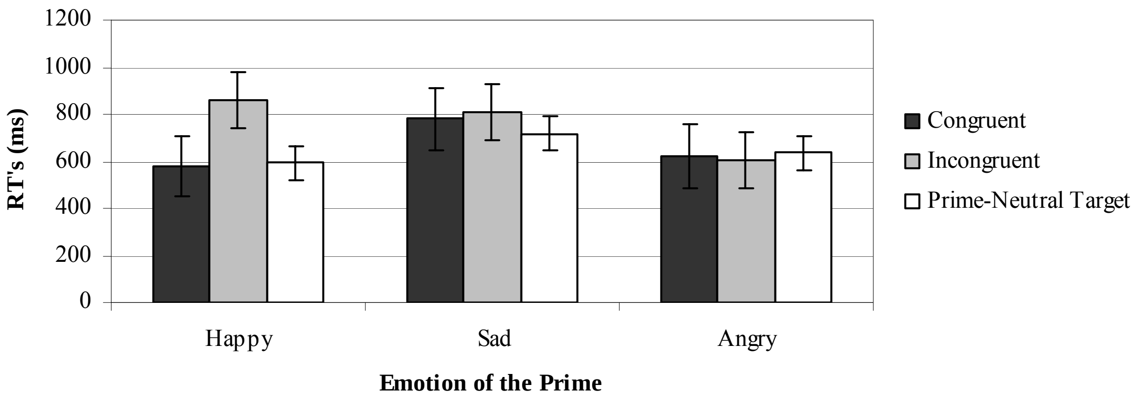


Figure 9. Interaction: Relation Prime-Target x Primed Emotion, for primed trials

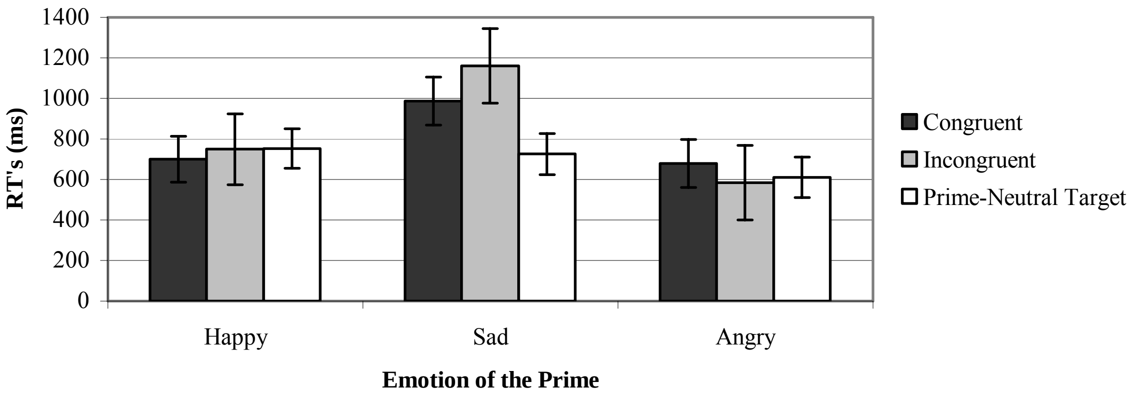


Figure 10. Interaction: Relation Prime-Target x Primed Emotion, for non-primed trials

There was an unexpected effect of word category in the no-prime trials in the sad condition. Notice that targets are only congruent or incongruent with regard to that particular prime. Non-primed words should not be affected by target manipulations (since they were simply not present). This data seems to suggest that an overall context of sadness was primed in that set of subjects. That is, although we have included several fillers with other emotions, in order to prevent that the prime was still activated across primed and non primed trials, it seems that the prevalent occurrence of sad primes turn it more likely to be activated. However we found no reason why the effects of this higher relative frequency of one type of prime over the others, that would spilled over to the non-prime conditions, is only found in the sad condition.

Blocking effect. We expected that the pattern of effects obtained in the free mimicry condition would change with blocked mimicry, as a function of each emotion. As Experiment 2 has shown anger should be less affected by the manipulation, *corrugator* is still free to mimic this emotion. In the case of *orbicularis* impairment in the priming effect should be observed since this manipulation involves an effort in the lower face. Happiness is the emotion that should be most affected by this blocking manipulation.

In order to test this hypothesis, we added the blocking condition to the design. A mixed ANOVA comprising mimicry conditions (blocking vs. free), the type of prime as a between factor and prime vs. no-prime and congruent, incongruent vs. neutral targets as within factors was performed.

Blocking didn't have the impact on reaction times that we would expect if it clearly moderated priming. First, because there was no blocking main effect (*F*<1). Second, because a clear main effect of priming was identified ($F(1,58)=20.99$; $p<.000$; $\eta^2=.27$), such that prime trials (*M*=682.70; *SD*=49.91) produced faster responses than non-primed trials (*M*=785.31; *SD*=55.14). Third, because the highly marginal qualification of this effect by blocking $F(1,58)=2,87$; $p=.095$; $\eta^2=.05$) revealed exactly the opposite effect we would expect if blocking was expected to prevent the effect. The free mimicry condition promoted a difference in RT associated with prime and non primed trials smaller (Difference M_{prime} - $M_{\text{no prime}}$=83.62) than the one verified in the blocking conditions (Difference M_{prime} - $M_{\text{no prime}}$=121.61).

Blocking effects (as preventing the muscle representation of a construct) should be found in the moderation of two interaction effects: the Priming x Congruence interaction and the three-way interaction. However, neither the first moderation, reflected in the three-way interaction defined by Mimicry x Priming x Level of congruence of targets, reached levels of significance ($F(4,116)<1$), nor the second moderation reflected in the four-way interaction Mimicry x Priming x Level of congruence of Taget x Emotion did achieve significance (F<1).

It should be concluded from this analysis that blocking mimicry did not impact in any way the judgmental task participants were engaged into?

That does not seem to be the case since blocking moderated some relevant interactions. The interaction between level of congruence and the emotion that was primed ($F(4,58)=3,54$ $p<.009$; $\eta^2=.11$) was moderated by blocking (three-way interaction $F(4,58)=2,54$ $p<.043$; $\eta^2=.08$). Since there is no interpretation of the effect of prime manipulation (reflecting level of congruence) without this factor, we further explore priming effects isolated by condition free vs. block, directly testing our predictions as planned comparisons. Notice that our predictions, being derived from our pilot study are more precise than the general main effects or interactions previously presented.

Enlightened by Experiment 2 we expected that blocking would have an effect that is specific to particular emotions (see Figs. 11 and 12, below). This specificity is corroborated by the interaction found between prime and type of emotion primed ($F(2,58)=4,41$ $p=.016$; $\eta^2=.13$) which was moderated by mimicry condition ($F(2,58)=5,34$ $p=.007$; $\eta^2=.16$). Priming effects obtained in free conditions were changed by blocking with regard to happiness (eliminating it) and anger (accentuating it). The facilitating effect of happy primes

in the free condition (M_{prime}=675.49; *SD*=115.00; $M_{no\text{-}prime}$=734.28; *SD*=127.04; *t*(58)=1.88; *p*=.065) totally disappeared when mimicry was blocked (*t*(58)<1). On the contrary, the facilitation effect of sad primes in free mimicry (M_{prime}=769.48; *SD*=120.11; $M_{no\text{-}prime}$=957.33; *SD*=132.69; (*t*(58)=1.73; *p*=.090), was made clear in blocking condition (M_{prime}=547.89; *SD*=125.98; $M_{no\text{-}prime}$=828.18; *SD*=139.17; *t*(58)=5.15; *p*<.000). Interestingly, non-exiting effect of angry primes in free mimicry (*t*(58)<1) became visible when the blocking procedure was applied (M_{prime}=527.04; *SD*=125.98; $M_{no\text{-}prime}$=738.02; *SD*=139.17; *t*(58)=2.87; *p*=.006).

Figure 11. Interaction: Presence of the prime x Primed Emotion, for free individuals

Figure 12. Interaction: Presence of the prime x Primed Emotion, for blocked individuals

Accuracy

Due to very low variance, no analysis could be performed on the proportion of correct responses.

Discussion

Experiment 3, together with the first experiment, revealed a reliable general emotional priming effect. Priming emotional words with emotional faces facilitated judgments of emotionality of those words independently of the specific emotion. Suggesting that the effect could be priming the concept of emotion itself since incongruent trials were also facilitated when compaired to neutral ones, in Experiment 1. The increased statistical power of Experiment 3 suggests that the difference observed in Experiment 1 between congruent and incongruent trials is reliable. Thus, the findings of Experiment 3 indicate the presence of an emotion congruence effect. In fact, the congruence effect was clearly present at least on a happiness and sadness context. Anger contexts are not so clear in its effects.

We assume that facial muscle activity and its superimposed activation in different emotions, could explain the pattern of effects observed. Thus, preventing participants from mimicking should be expected to increase RT's and destroy any facilitation effects of priming at least in some emotions, such as happiness. The pattern of data associated with happiness is congruent with our predictions. Priming effects disappeared in the blocking condition. The same did not happen with the other two emotions. Notice however that we hypothesised that the blocking manipulation could be inoperative on muscles associated to sadness or anger. By having these muscles in activity, they may be supporting the superimposed activation of all emotions, and thus make clear the general emotional priming effects found in Experiment 1. Not only was category priming present for sadness and anger in the block-mimicry conditions, but also the blocking increased priming effects on judgments of word emotionality under the sad and anger conditions.

The blocking of mimicry helped to reveal the role of embodiment in emotion priming. Preventing the expected effect. However the increase of the effect under sad and anger, by blocking was something not expected. Why could this happen? The answer should be in the specificities of our blocking procedure. One possibility is that the blocking procedure acts not only upon the amount of activity that is generated by the muscle (as it was the case of the *zygomaticus*) but also over muscle movement properties, that is to say, the

ability of the muscle to change its own state. If this is the case, it would be this "prevention of change" that promoted the impact of blocking on "happiness". If muscle change is what is relevant in the embodiment features engaged in the priming effects, we should, for example, assume that change of muscles as a reaction to anger and sad stimuli is higher under blocking procedure than under free conditions, in order to explain the increasing of priming effects observed in this experiment.

The "change hypothesis" could be refuted with the evidence we had in Experiment 2. Remember that, although blocking impact muscle activity, it did not impact its variability (see Experiment 2). However, in that study our subjects were not reacting to any stimulus. So it was not possible to know if "muscle change in activity", under blocking instructions was prevented or increased. In order to know that, we should promote muscle changes under blocking instructions. Both Experiment 4 and 5 had that goal in order to investigate the hypothesis that blocking involved the idea of impairment of muscular change in voluntary and involuntary facial action. In line with the results of Experiment 3, we expected that the blocking procedure produces a kind of a ceiling effect in the activation of *zygomaticus*. We expected that the manipulation activated the *zygomaticus* above a threshold that makes it unable to move (change its state). We will name this as *freezing activation effect*. This difficulty in changing its activation should be revealed, when we promoted a change in the musculature through requiring the subjects to voluntarily produce facial expressions or when we induce a more subtle change of activity in muscles promoted by the presentation of an emotional photo. On the contrary, since *orbicularis oris* did not show in Experiment 2 the same kind of hyperactivation as *zygomaticus*, we did not expect freezing activation effect, but an activation that still allows the muscle to move. We do not expect any interference of the manipulation on the activity of *corrugator*.

Experiment 4: Testing muscle change hypothesis requesting voluntary facial expressions

In the present experiment we investigated the hypothesis of the notion of blocking involving the idea of impairment of muscular change. We asked participants to make deliberate facial expressions while performing the blocking manipulation. Our analysis was

centered on *zygomaticus* and facial expression mostly associated to it: the smile, once it was the muscle which revealed to be most affected by the blocking manipulation.

If change is the feature in which our manipulation is acting over, participants wouldn't be able to activate the *zygomaticus* more than it is already activated when they perform the blocking task. For the *corrugator* we did not expect any particular difference.

Method

Participants and Design

Twelve ISPA's undergraduates students (50% women), with ages ranging between 22 e 31 years (*M*=27.92; *SD*=2.31) were randomly assigned to the within subject design: 3 (Muscle: *zygomaticus major*; *corrugator supercilii*; *orbicularis oris*) x 2 (Mimicry: blocked; free) x 3 Facial expression requested: happy; angry; none).

Procedure

Again, participants were informed this experiment would involve the collection of physiological measures, and for that reason electrodes would be attached to the skin. The experimenter explained that procedures would constitute no harm for the participant. Participants had the opportunity of posing questions about the equipments so they were made comfortable with the procedures. After this, the experimenter rubbed their skin with alcohol.

Participants performed two blocks of trials in which they had to voluntarily produce facial expressions of happiness, anger or no expression at all, for 5 seconds. In one block, the participants performed the task in free mimicry, in the other the participants had their mimicry blocked with Niedenthal and colleagues' procedure. Again we recorded the activity of *zygomaticus*, *orbicularis* and *corrugator* according to Fridlund and Cacioppo's (1986) recommendations. Each condition was repeated three times. This technique of performing holding a pen while performing facial expressions was fully developed by us and no other study was found to do this.

EMG measurement. Muscle activity was measured with pairs of adjacent silver/silver-chloride electrodes placed on the left side of the participant's face. An additional ground electrode was placed in the upper portion of the forehead. The impedance was reduced to less than 10 kΩ. The attachment of the electrodes was performed according Cacioppo, Tassinary and Fridlund, (Cacioppo, Tassinary, & Fridlund, 1990). The acquisition of the signal was through MP150 Amplifiers and Acknowledge 3.1 by Biopac. The gain was 5000, and data was filtered online with a lowpass filter of 100Hz and a highpass filter of 1.0Hz and sampled at 1000 times per second.

Results and Discussion

EMG measures were integrated (root mean square) and rectified and screened for movement artefacts. Data were standartized within subjects and muscle sites, attenuating the impact highly reactive participants.

In order to test our hypothesis, data were submitted to a three-way ANOVA, defined by the following factors: Muscle x Facial Expression x Mimicry. We were expecting a three-way interaction. This is because we assumed the blocking to impair the *zygomaticus* activation when a smile is requested. That is, its level of activation, should not be overcame by the over imposed smile. In addition, we do not expect an activation of the *orbicularis* or *corrugator*, when the blocking is promoted, since in Experiment 2 both muscles were shown not to be sensitive to the procedure (at least when compared to the *zygomaticus*), and this should not occur when a smile is superimposed to it, also. These two muscles, however, are expected to be activated by the anger expression, which we do not assume to be blocked by our blocking procedure. So differences between anger and not anger conditions are expected.

Before focusing these specific hypothesis we analysed our data in order to: a) assure that instructions regarding facial expressions created the expected muscular activity (increased activity over the *zygomaticus* when smiling and increased activity for the *corrugator* when frowning) and to b) verify the pattern of activation promoted by the blocking procedure, as characterized by Experiment 2: activation over the *zygomaticus* and non significant results for *orbicularis oris* or *corrugator*.

Instruction seem to be effective, since the analysis of data associated with the free mimicry condition allowed us to confirm that the different facial expressions had an impact on the general activity of the face $t(11)=6.38$; p<.000.

Also a main effect was found for emotion ($F(2, 22)=24.887$; $p<.000$; $\eta^2=.69$), expressed in a linear trend $t(11)=6.06$; $p<.000$ between the three expressions. Frowning expression ($M=.33$; $SD=.06$) produced more activity than smiling ($M=-.01$; $SD=.04$) which in turn, was responsible for more activity than no expression at all ($M=-.33$; $SD=.06$). This effect was impacted the by various muscles ($F(4, 44)=37.83$; $p<.000$; $\eta^2=.77$). Frown ($M_{frown}=1.23$; $SD=.17$) produced higher levels of *corrugator*'s activity than the other two expression conditions ($M_{smile}=-.65$; $SD=.09$; $M_{no\text{-}expression}=-.58$; $SD=.09$; $t(11)=7.16$; $p<.000$). For *zygomaticus* we found a linear trend ($t(11)=3.76$; $p=.003$): smile ($M=.40$; $SD=.12$) was the expression condition which produced a greater increase in the activity followed by frown ($M=-.12$; $SD=.07$) and no expression condition ($M_{no\text{-}expression}=-.28$; $SD=.07$). Concerning the *orbicularis oris* activity we can say that smile ($M_{smile}=.23$; $SD=.06$) triggered its activity in a larger extent than the remaining conditions ($M_{frown}=-.11$; $SD=.05$; $M_{no\text{-}expression}=-.12$; $SD=.06$; $t(11)=3.25$; $p=.008$).

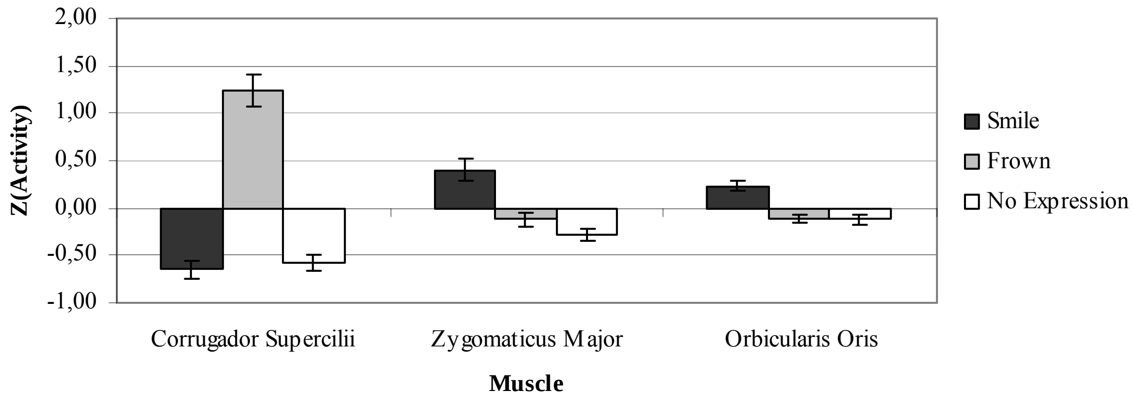


Figure 13. Interaction: Muscle x Expression.

Analysing the control condition where no expression was induced, we expected to confirm the pattern of muscle activation associated with the blocking procedure $t(11)=4.83$; $p=.001$). Contrary to Experiment 2, we found a main effect of mimicry ($F(1, 11)=13.75$; $p=.003$; $\eta^2=.55$), meaning that, blocked mimicry ($M=.22$; $SD=.06$) produced higher values of activity than free mimicry condition ($M=-.22$; $SD=.06$). As in Experiment 2 we found this

activity to be qualified by the type of muscle in question ($F(2, 22)=16.497$; $p<.000$; $\eta^2=.60$). As in Experiment 2, *zygomaticus* in the blocking condition produced more activity than free mimicry condition ($M_{blocked}=.28$; $SD=.10$; $M_{free}=-.28$; $SD=.10$; $t(11)=2.99$; $p=.012$). Now, the effect of *orbicularis*, that was not significant in Experiment 2, achieved significance ($M_{blocked}=.44$; $SD=.09$; $M_{free}=-.44$; $SD=.09$; $t(11)=4.97$; $p<.000$). No effect was found for the *corrugator*. For this muscle, any significant difference emerged between blocked and free condition ($M_{blocked}=-.05$; $SD=.04$; $M_{free}=.05$; $SD=.04$; $t(11)=-1.34$; $p=.208$), suggesting that the muscle was not activated by our procedure, as in Experiment 2.

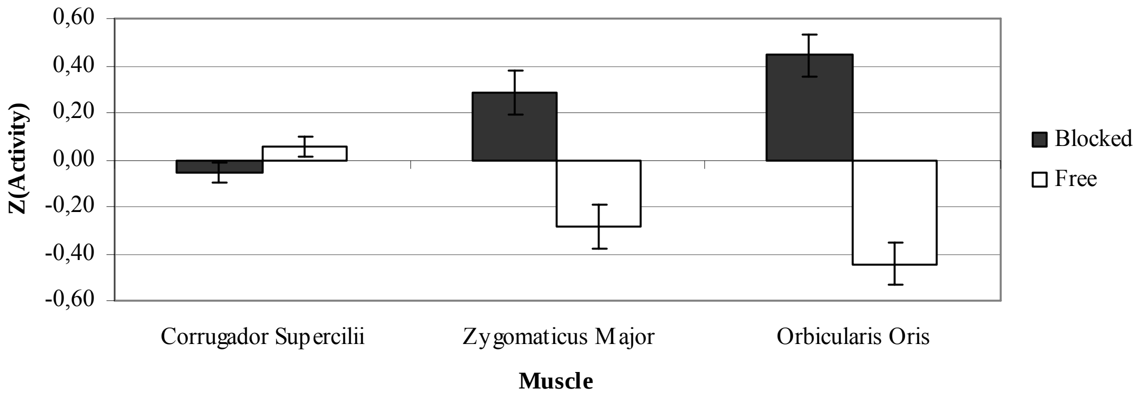


Figure 14. Interaction: Muscle x Mimicry.

No evidence of any other two-way, ($F(2,22)=2.08$; $p=.149$; $\eta^2=.16$) or three-way interaction ($F(4, 44)=1.11$; $p=.365$; $\eta^2=.09$) interaction involving mimicry was found.

In order to test our hypothesis, regarding how blocking prevent “change”, we computed the interaction Muscle x Mimicry x Expression. Contrary to what we expected, this effect was not significant. However, given the focus of our hypothesis, we found, planned contrasts to be an useful tool to answer them.

We analyzed *zygomaticus*’ activity. In free condition, as expected, this muscle was recruited to a larger extent when the participant was required to smile than required to stay with no expression ($M_{smile}=.02$; $SD=.19$; $M_{no\text{-}expression}=-.53$; $SD=.07$; $t(11)=2.76$; $p=.019$). However, this pattern of results does not seem to differ from blocked mimicry, ($t(11)<1$), meaning that the blocking procedure wasn’t able to impair the variation that had origin in the smiling instruction.

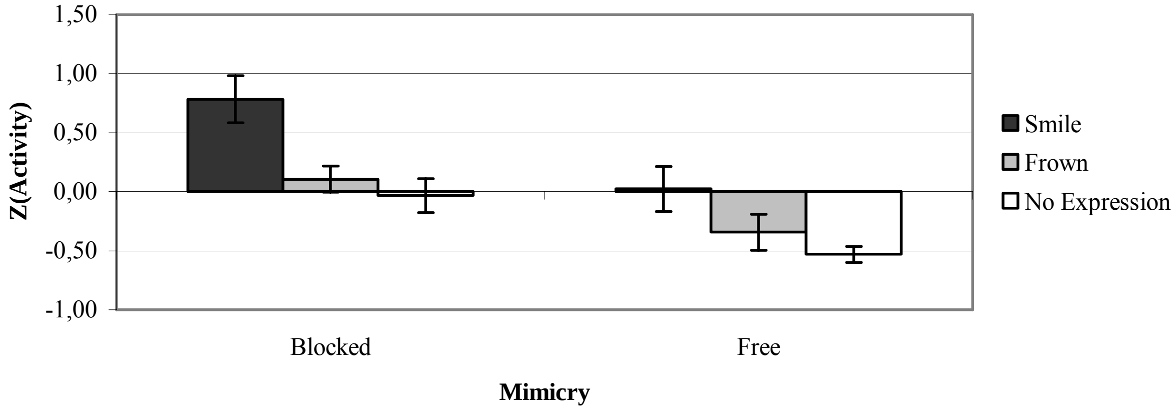


Figure 15. Interaction: Mimicry x Expression for *Zygomaticus*.

As concerns *orbicularis oris*' activity, we observed that it was recruited when in the free condition the participant was required to smile. In fact its activation was higher than when participants were simply required to stay with no expression (M_{smile}=-.20; *SD*=.17; $M_{no\text{-}expression}$=.57; *SD*=.08; *t*(11)=2.83; *p*=.016). The muscle was not activated when participants were asked to frown, not differing from the no expression condition (*t*(11)<1). The *orbicularis oris* seemed to be activated by the instruction of smile when compared to the control condition where no expression was required. This pattern of activation of *orbicularis* in smiling seems to be consistent both for blocked and free conditions, meaning that no significant difference was found (t(11)<1) between the two patterns. Again, no effects of blocking in priming task could be attributed to this muscle.

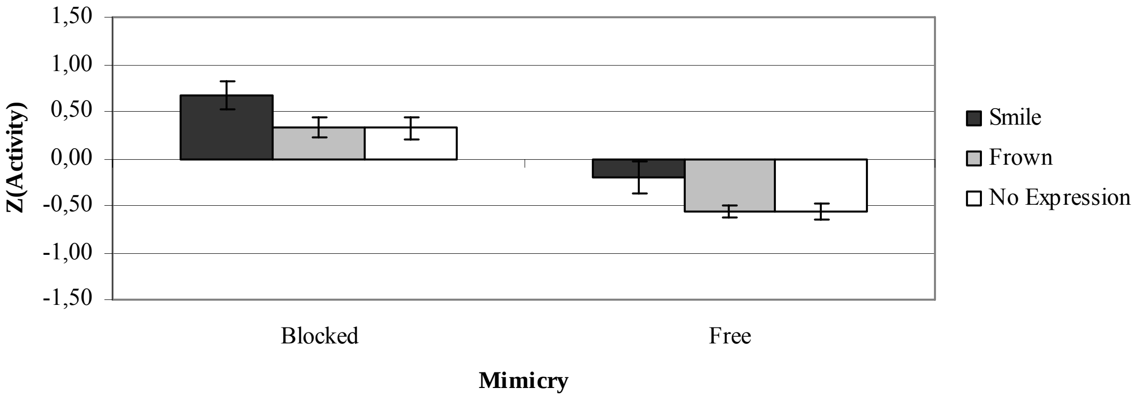


Figure 16. Interaction: Mimicry x Expression for *Orbicularis Oris*.

Regarding the *corrugator*, as expected, in free condition this muscle was recruited in a larger extent when the participant was required to frown than in the no expression

condition (M_{smile}=1.45; *SD*=.21; $M_{no\text{-}expression}$=-.57; *SD*=.12; *t*(11)=6.59; *p*<.000). This muscle was also activated under blocking condition when individuals were asked to frown. Although this activation seemed to be less than the one verified in individuals which were freely frowning, (*t*(11)=1.81; p=.097). The absence of a difference between blocking and free patterns was consistent with the fact that the manipulation was not able to eliminate the variation imposed by the frowning instruction.

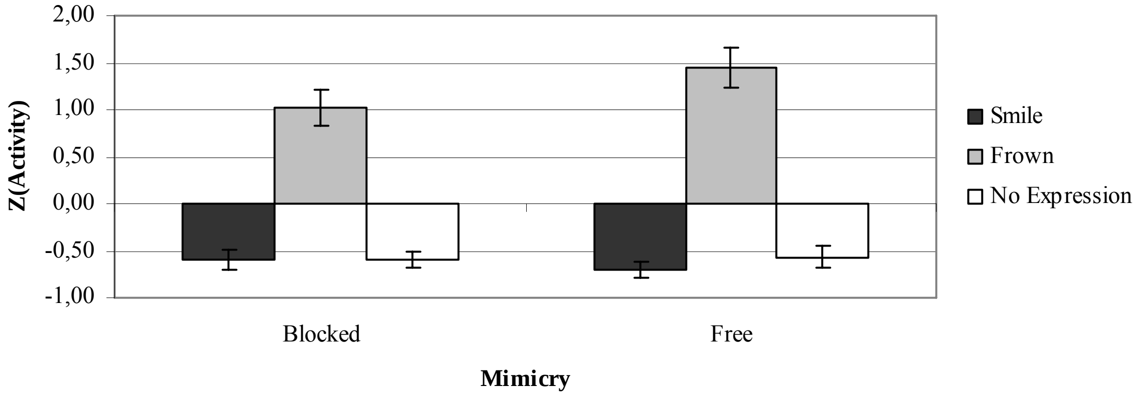


Figure 17. Interaction: Mimicry x Expression for *Corrugator*.

At this point, we know that Niedenthal's blocking:

1) Promotes the activation of the *zygomaticus* and the *orbicularis oris*, but not the *corrugator's* (Experiment 2),
2) Does not prevent changes of activations resulting from the production of voluntary facial expressions, (Experiment 4). The fact that *zygomaticus* and the *orbicularis* were able to change their state during the blocking procedure means that it was not completely efficient in preventing a forced smile. The *corrugator* is also able to change its state when a forced frown was superimposed.

Notice that the fact that this blocking was not able to prevent changes in the *orbicularis*, helps to explain the pattern of results in Experiment 3. The fact that the manipulation allowed *orbicularis* to move, suits the data that revealed the priming effect associated with sadness didn't disappear when the blocking was introduced. Should be also assumed that the *zygomaticus* is also able to change and so the null effects observed in Experiment 3 were not caused by blocking itself? Although it is possible, one question is here opened. The fact that we observed activation under instructions of a forced smile does

not mean necessarily that it would not interfere with a spontaneous activation. Thus, the present study leaves room to speculate whether the manipulation is not able to impair the production of explicit facial expressions, as smile but is able to impair the production of subtle muscular movements which arise during the exposure to emotional stimuli, similar to the primes used in Experiment 1 and 3, and suffered behavioural impact of this manipulation. To test this hypothesis we ran a study in which we exposed participants to photos of emotional facial expressions that subtly would trigger muscle activation, that we, in the present experiment activated by explicit instructions.

Experiment 5: Testing muscle change hypothesis under involuntary conditions of muscle activation

Although blocking procedure under the request of voluntary change in the facial expression of the individual did not disable the individual to perform this change, we found necessary to test the hypothesis of this impairment occurring if the muscular change was promoted under involuntary conditions. For this reason, we ran a study in which the muscular change was induced by the exposure to supraliminal photos of facial expressions, in similar conditions than those in Experiments 1 and 3.

Method

Participants and Design

Thirty-one ISPA's undergraduate students (81% women), between 18 and 58 years (*M*=26.77; *SD*=10.49) were randomly assigned for the within subject design: 3 Muscle (*zygomaticus major* vs. *corrugator supercilii* vs. *orbicularis oris*) x 2 Mimicry (blocked vs. free) x 4 Facial expression (happy vs. angry vs. sad vs. none).

Materials

In the present study, we used the previous set of facial expressions from Karolinska database (16 happy, 16 angry and 16 sad expressions).

Procedure

After participants were informed that the experiment involved attaching electrodes to the skin, the experimenter assured them that the procedures constituted no harm for the participant. The participant was then given the opportunity to raise any questions about the equipments. Skin cleansing and electrode attachment was performed. The participants were asked in a random order to adopt the blocking procedures introduced in the previous experiments. After being in the correct position, participants were asked to just look at facial expressions which would appear on the screen for 500 and preceeded by a fixation point that lasted on the screen for 500ms. The intertrial interval was 6 seconds. When the experiment began, participants were exposed to facial expression, just looking at a fixation point.

Results and Discussion

EMG data refers to the temporal window of priming in the first priming studies between 350 and 450 milliseconds. Since activations are detected between 300 and 500 ms, we decided to start the measurement at 350 ms and stop at 450 ms after the onset of the prime, discarding the last 50 ms of the prime exposure due to response artefacts. Again, EMG measures were integrated (root mean square) and rectified and screened for movement artefacts. Data were standartized within subjects and muscle sites, attenuating the impact highly reactive participants.

In order to test our hypothesis regarding the efficiency of the blocking procedure, data was submitted to a three-way ANOVA defined by the following factors: Muscle (*corrugator* vs. *zygomaticus* vs. *orbicularis oris*); Emotional Expression (happy vs. sad vs. angry vs. no expression); Mimicry (blocked vs. free). We expected a three-way interaction associated with a different pattern of activations associated with each muscle. So that spontaneous reaction of a smile or a frown would change muscle activation in a blocking condition. At least, with regard to the *zygomaticus* which was not expected to overcome the activation know already to be associated with the blocking procedure itself.

The three-way ANOVA, revealed the already known general effect of blocking (F=(1, 30)= 12.90; p=.001; η^2=.30), producing higher levels of activation than the free mimicry condition ($M_{blocked}$=.60; SD=.21; M_{free}=.19; SD=.05). The effect was a again more accentuated with regard to the *zygomaticus* and less regarding the *corrugator*, as revealed by the Muscle x Mimicry interaction (F=(2,60)=5.68; p=.005; η^2=.16). *Zygomaticus* had higher

values of activity for the blocked condition (*M*=.55; *SD*=.08) than for free condition (*M*=-.33; *SD*=.08; *t*(30)=6.18; *p*<.000). The same has happened for *orbicularis oris* ($M_{blocked}$=1.29; *SD*=.60; M_{free}=-.34; *SD*=.10; *t*(30)=2.68; *p*=.012). For the *corrugator*, no differences arose between free and blocked mimicry conditions (*t*(30)=.71; *p*=.483).

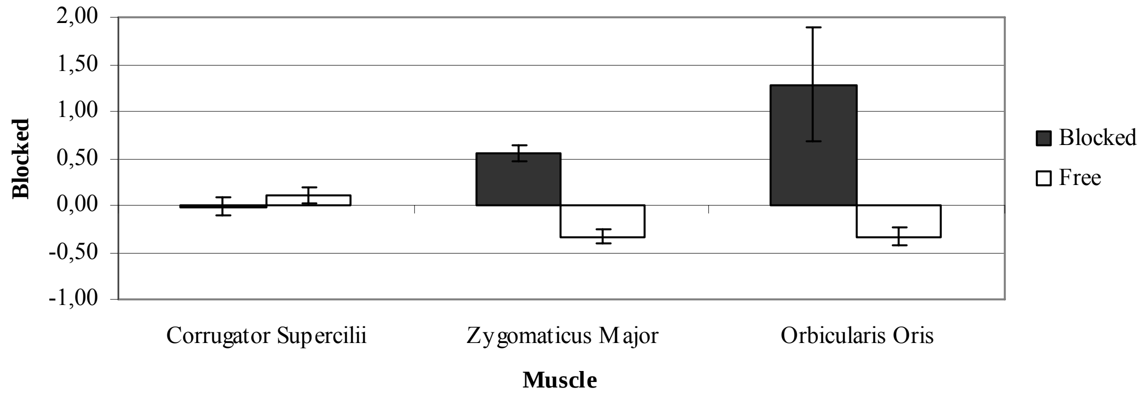


Figure 18. Interaction: Muscle x Mimicry.

As in the previous experiment the general three-way Muscle x Mimicry x Emotion interaction was not significant (*F*=(4, 120)=.94; *p*=.442; η^2=.03). However our hypothesis are defined by focused questions associated with specific effects, interactions and specific pattern of these interactions regarding each muscle, which we will approach separately.

Our expectation, regarding the *zygomaticus* was that emotional stimuli would promote more changes relative to a baseline of non-expression in the free conditions than blocking. We contrasted different emotions (+1; +1; +1) to its baseline of non expression (-3) in the two experimental mimicry conditions (1; -1) and found a null effect *t*(30)<1). However this null effect can hide a specific pattern of effects that would be only observed in the free condition. So we tested the significance of the pattern of activation observed in the data (see Figure 19) defined by a linear trend (*t*(30)=2.30; *p*=.028) which has happy photo eliciting more activation, followed by the angry and control conditions, being less activated in the sad condition (M_{happy}=-.23; *SD*=.14; M_{angry}=-.25; *SD*=-.12; $M_{no\ expression}$=-.35; *SD*=.12; M_{sad}=-.50; *SD*=.11). Suggesting that blocking interferes with *zygomaticus* to change, the contrast of this linear trend in both experimental conditions is significant (*t*(30)=1.95; *p*=.061). No differences (all *t*(30)<1) are found in the level of activation of the *zygomaticus* in the blocked condition (M_{happy}=.48; *SD*=.14; M_{angry}=.50; *SD*=.10; $M_{no\ expression}$=.62; *SD*=.15; M_{sad}=.58; *SD*=.13).

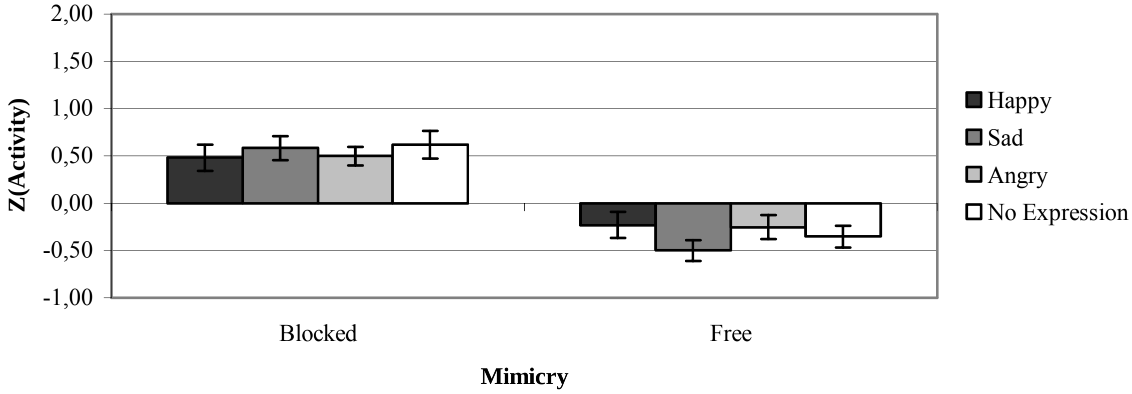


Figure 19. Interaction: Mimicry x Expression for *Zygomaticus*.

Our hypothesis concerning the *orbicularis oris* is that blocking did not prevent its change (see Experiment 4). This hypothesis translated a null effect of blocking over the change observed in reactions to different type of stimuli under free mimic. In fact, the difference between the patterns of muscle activation (for emotional photos vs. no expression) under blocking and free mimicry didn't approach statistical significance ($t(30)=1.68$; $p=.103$).

However, when we analysed the overall pattern of *orbicularis* presented in Figure 20 it seemed that there was a flat configuration on the free condition, that does not stand with the introduction of the blocking procedure which induced an elevated activity when emotional photos were presented compared to the non-expression condition ($M_{happy}=1.46$; $SD=.80$; $M_{sad}=1.30$; $SD=.52$; $M_{angry}=1.34$; $SD=.59$; $M_{no\ expression}=1.05$; $SD=.52$; $t(30)=2.07$; $p=.047$).

Thus, although this data is clear in telling us that the *orbicularis* is not prevented to change under this blocking conditions, we should be careful in future studies to raise the possibility that the procedure can in same way stimulate this muscle to produce more reactions to emotional stimuli. This can happen for one of two reasons: because small activation induced by the procedure can stimulate those reactions, or because the observed

freezing of the *zygomaticus*, can in some way be compensated by this related muscle.

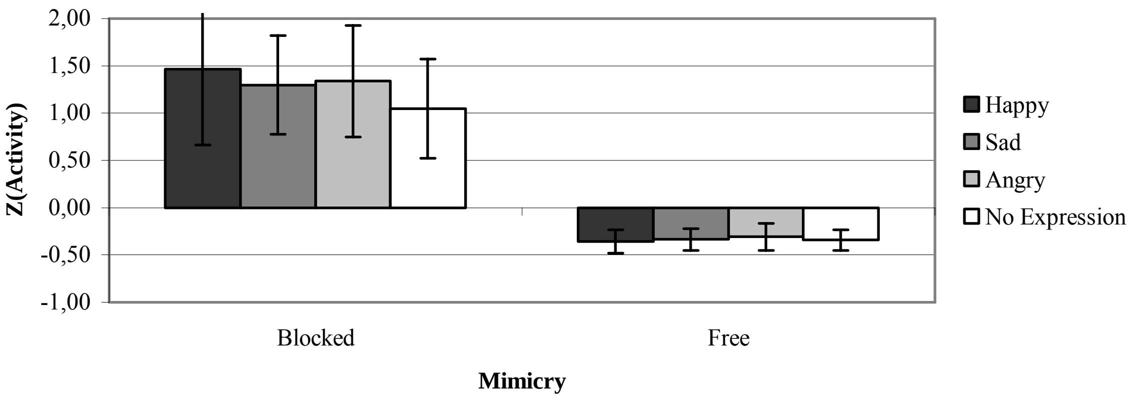


Figure 20. Interaction: Mimicry x Expression for *Orbicularis Oris.*

Our hypothesis regarding the *corrugator* assumed that this muscle was not prevented to change its activity by the blocking procedure. So its variation would be associated with type of emotion presented. So we expected this muscle to be recruited to a larger extent with sad and angry faces and that this activity was also observed in blocking conditions.

Analysing the overall pattern of the various emotions compared to the baseline condition of no-expression in both experimental conditions, we found that expected null effect (t(30)<1). As expected the pattern of activation is similar for blocking and mimicry conditions. The three type of stimuli produced an elevated activity relatively to the no-expression both in free mimicry (M_{happy}=.14; *SD*=.16; M_{sad}=.16; *SD*=.15; M_{angry}=.20; *SD*=.12; $M_{no\ expression}$=-.10; *SD*=.12; *t*(30)=2.17; *p*=.038) but not in the blocking condition (M_{happy}=.19; *SD*=.13; M_{sad}=-.15; *SD*=.12; M_{angry}=.00; *SD*=.13; $M_{no\ expression}$=-.11; *SD*=.18; *t*(30)=.79; *p*=.433).

Analysing the specificities of the activation of the *corrugator* both experimental conditions, we found that when participants were exposed to photos of angry expression (*M*=.10; *SD*=.06.) they exhibited more *corrugator* activity than the no exposure condition (*M*=-.10; *SD*=.07; *t*(30)=2.27; *p*=.031). Congruently with the analysis presented above the effect is not moderated by experimental condition (*t*(30)<1).

Regarding reaction to sad photos, we expected the *corrugator* to be activated at least in the free condition. Our results suggest that across the two experimental conditions when participants were exposed to sad expression (*M*=.00; *SD*=.09) they did not exhibited more *corrugator* activity than the no exposure condition (*M*=-.01; *SD*=.07; *t*(30)=1.10; *p*=.282). In

addition, this effect was not moderated by experimental mimicry conditions ($t(30)<1$). Concluding, although it seemed that blocking was preventing the *corrugator* to exhibit sadness (in Figure 21) that fact is that sadness did not activate differentially the *corrugator*.

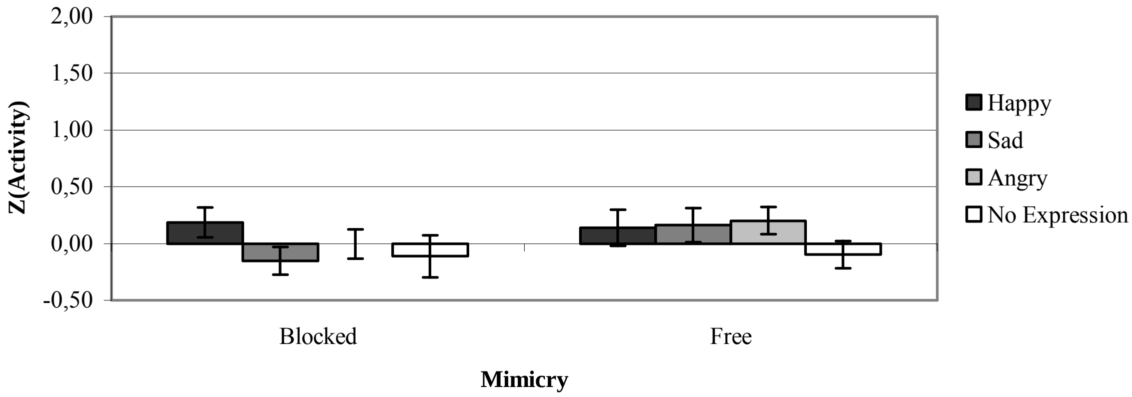


Figure 21. Interaction: Mimicry x Expression for *Corrugator*.

Summarizing, in this study we could conclude that *corrugator* is not being affected by the blocking manipulation as it was expected. The absence of interference of the manipulation with *corrugator* is consistent with the fact that priming in Experiment 3 emerged even in blocked conditions.

We also found that activation of *zygomaticus* that followed the presentation of happy facial expressions was slighter than the one promoted by the blocking procedure. Blocked individuals did not produce an increased level of activation significantly different from the control free condition. This absence of difference may be related to a successful effect of the procedure or an inefficiency of the happy photo to elicit proper activation on the *zygomaticus*. This means the key for understanding the effects of this manipulation over the *zygomaticus* lies not only in the fact that it activates the muscle, but it prevents changes in the pattern of activation across emotional expressions.

On the other hand, our results suggest that blocking was unable to prevent *orbicularis* change. In addition it may be inducing an increased activity when photos are presented, which did not happened in the free condition spontaneously. This is congruent with previous data, in Experiment 3, when individuals presented facilitation effects for sad primes were even stronger for blocked individuals. We shall think this manipulation may have an "activity-inductive" power on this muscle in particular, that produced this effect. Clearly,

this manipulation is not acting over *orbicularis* in the same hyperactivating fashion as for *zygomaticus*.

However, for activations following the presentation of photos of facial expressions, the manipulation prevented subjects from increasing their activation of *zygomaticus* above the levels of activity promoted by the blocking procedure, for happy photos. Unfortunately, because in the free condition, happy facial expressions weren't able to increase in a significant way, the *zygomaticus*' activity compared to the control condition, we cannot assume that the absence of increasing in the blocking condition is due to a successful restraining of the manipulation. Perhaps this failure to observe the eliciting of *zygomaticus* when happy photos are presented in free condition happened due to the time gap we used. That was chosen to match the interval in which we exposed the primes to the subjects in the previous priming experiments. Remember that the analysis was focused on 350 to 450 ms which is the temporal window in which differential activity emerges. Note that, for *zygomaticus* was only able to exhibit increased activation for happy stimuli compared to others only after 400 ms.

General Discussion

Our work focused on the role of embodiment features such as face muscle activity in emotional category priming. According to embodiment framework, affective representations are partial simulations of emotions instances (Niedenthal et al., 2005). Among other simulations, re-enacting an emotion may involve the activation of correspondent facial mimicry. In the present work we postulated that muscle activation can have a role in emotional category priming effects and so we expected the priming effect to occur across nonverbal (facial expressions) and verbal (a word) representations, which share emotional semantic features associated with facial muscular activation.

Two experiments here presented showed that emotional category based priming effects that are, in some features, similar to those of Carroll and Young (2005). In both Experiment 1 and 3, results suggested that emotional faces prime emotional judgments for both congruent and incongruent emotional targets, not having any effect on non-emotional targets. This indicates that perceiving an emotion primes facilitates emotional judgments of emotional stimuli in general. From this pattern of results we infer several relevant aspects of the processes underlying priming effects:

1) The fact that the results didn't follow a classical pattern of a pure semantic priming experiment, lead us to suspect that when it comes to emotion, the mechanism involved is much more complex, and have space for an embodiment feature.

2) Emotions' common elements (disregarding their valence and category) may be relevant to the process. One of such elements may be embodiment features. Emotions share muscular activations and that may be supporting the priming phenomenon. The introduction of a muscular blocking mechanism helps us to understand whether this emotional specificity came from a semantic process or an embodied muscular one.

Experiment 3, in addition to a general emotion priming effect, we found some evidence of category emotional priming effects. The evidence was however qualified by type of emotion. Although the effect was clear for happiness, it was absent of anger, and it was generalized for sadness. For sadness the incongruent trials were also facilitated. The reason for these results could be that only in the case of happiness we could assure the probes had the maximum level of association to happiness (100%) and the minimum of association to other emotions (0%) the effect was visible with no ambiguity.

From this data we concluded that: as Rossell and Nobre (2004) found, emotional primes do not have generalized facilitatory-inhibitory effects across all categories of

emotion. Happiness opposes to other emotions showing congruence effects, sadness showing a generalized priming effect and anger did not impact emotional judgments at all.

Experiment 3 show that emotional category based priming effects are interfered by a facial muscle blocking manipulation (Niedenthal et al., 2001) suggesting muscle facial activation to have a role in emotional category priming effect. Although the blocking procedure in our experiments was previously used to demonstrate the involvement of mimicry in a variety of tasks including priming tasks (Foroni & Semin, 2009, 2011) no previous study offered a clear understanding of its impact on facial muscle activity and changes. A set of three studies here presented gave us a more full understanding of this procedure, shaping the hypothesis of its impact on emotional category priming effects in a more precise way.

Electromyographic measures associated with the blocking procedure (Experiment 2) suggested it to have a preponderant blocking impact over the *zygomaticus* (hyperactivation), followed by the *orbicularis oris*. Results are not so clear regarding the *corrugator* since we observed an increase of activity in the control condition. Notice that the *corrugator* is expected to be activated when attention calling stimuli enters into play (Cohen, Davidson, Senulis, & Saron, 1992) and so its activation may be related to the presence of a fixation point in the screen. The impact of the blocking procedure seemed to promote muscle activation (see also Oberman et al., 2007). Thus, a muscle to be "blocked" seems to be "activated". So if blocking does not prevent activation, but instead promotes it, why should we expect it to interfere with priming effects? The only reason would be that, because the muscle is occupied in reacting to a stimulus, it does not react to other. This would mean that blocking effects may arise because they prevent a muscle to change its states as a reaction to a stimulus. However, as it was shown by our Experiment 4, when subjects are required to perform different expressions under blocking instructions they were always able to do so, and muscles change their state. But this capacity of voluntary change may not be associated with a spontaneous change, as the one arising due to reaction to emotional stimuli. In fact, as our experiment 5 suggested when it comes to activity elicited by perceiving a facial expression, blocking seems to interfere with muscle activity (change). But congruently with data from experiment 2, that suggested blocking to hyperactivate only the *zygomaticus*, it was also the *zygomaticus* that was clearly prevented to change by the blocking manipulation. That is, the natural activation of the zygomaticus reacting differently to a happy face with regard to other emotional expressions was prevented by its previous activation by the

blocking procedure. The muscle simply did not change. Also congruently with the idea that blocking only clearly acts over zygomaticus (suggested by experiment 2) nor the *corrugator* or the *orbicularis oris* were prevented of changing as reaction to sad and anger faces by the blocking procedure. Although it needs more clear support, it seems that the small activation of the *orbicularis*, following the blocking procedure, may stimulate its change as a reaction to any face presentation.

This knowledge about how muscle react to blocking procedure allowed us a clearer test of how the procedure should interfere with priming effect if it depends upon embodiment features.

The first important understanding is that blocking in our Experiment 3, was not expected to eliminate all priming effects. Blocking was only expected to eliminate happiness priming effects. And this is what happened. Priming happiness effects disappeared in blocking conditions. As expected knowing the pattern of muscle activation under blocking conditions, blocking did not prevent priming effects associated with sadness or anger. On the contrary, it seems to facilitate them. Remember that in experiment 5, we registered greater changes of activity in *orbicularis oris* in the blocking condition than in the control condition, suggesting that the manipulation induced activity that may have been capitalized to perceive negative primes in experiment 3. This is in fact what seems to happen, since the effect of negative primes seemed to be stronger under blocking than in free condition. The pronounced facilitation for anger and sadness may be because these muscles have a level of activation that stimulates reactions, or because other mechanisms such as the elimination of feedback from happiness should leave more resources for other facial embodiments to take place, namely the ones concerning different emotions. So, future studies would have to carefully attend to the possibility that blocking has different meaning for different muscles. It may activate them, and it may prevent it from change or by the contrary facilitate its changes.

Several methodological flaws should be overcome in future studies, in order to make data more clear. Power seems to be relevant to detect emotion category priming effect, and so, not only number of participants should be higher as other procedures should be taken to maximize effects size. Critical trials should be in higher number than we had. In our studies we only used four in each emotion. This was motivated by the difficulty to find words that established clear association with one and only one emotion.

The fact that we found few target words mostly associated to a single emotion, had implications in the design we chose for the experiment. This led us to decide using a number of prime-target pairs as few as possible. For this reason we converted the emotion of the prime into a between factor. As this would make the task being monotonous and predictable for the participants, filler trials with other primed emotions have been intermerged. A limitation of this design was the fact that there were, for each participant, targets that consistently established stronger associations to a certain emotion than the targets of the other emotions. This could have made the decisions, concerning relevant targets in a condition, more simple, to a point that made more difficult for us to detect differences between relevant emotions, between conditions.

In order to apply a more parsimonious design that does not arise this kind of limitations, is not only relevant to find words that are tightly associated with the relevant emotion, but also that have the minimal associations to other different emotion, so that a full within design can be applied. As previously referred minimizing this overlap between emotions should decrease the emergence of this general emotion priming effect, allowing the observation of emotional specificity.

Another problem arising from our analysis is that we collapsed all congruent trials of every emotion and all incongruent trials also for every emotion. So, trials concerning positive emotions and negative emotions were analysed together. Literature have shown already that different emotions can have different behaviours in terms of priming effects. The collapsing into a group of "congruent" and "incongruent" could be merging effects that can really differ. This could also be the reason for the emergence of the general effect above the emotional specificity.

Muscle measurement procedures must be carefully attended to, since they produced a lot of noise in our data. Different muscles do not react in the same time window and to different stimuli in the same way. For example, the activation of the *zygomaticus* only starts around 400ms, but we had to measure the activity between 350 and 450 ms, in order to capture the early activation of the *corrugator* (that starts around 300ms), and to avoid the artifacts related to the preparation of the response to the probes (that start at 500ms). It could be, thus, the case that the interval was not able to fully capture the triggering of the *zygomaticus* in some of our studies. And time windows on *orbicularis oris,* should be further explored, to discard the possibility of the absence of variation in no exposure condition (Experiment 5) be due to the graphic stimuli used.

Summarizing…

Our studies furnish evidence of category emotion priming effects.

The processing of emotions is different from the processing of valence and the processing or simple semantic category priming. Not pure category priming emerges, but also a general emotion component appears. Also supporting this view that a pure semantic view is not adequate is the fact that there is not a similitude in the way negative emotions are processed. In the particular case of sadness various results have been found. Future studies in priming should see why sadness can have so different behaviours. For example in Matthews and Southall (1991) sadness priming effect occurs in a similar way than other emotions, in Rossel and Nobre (2004) sadness seems to slow down reaction times for congruent trials. Finally in our study, although there seems to be slower results for congruent sad trials, also a general priming effect occurs over all targets, meaning that at least it had a facilitating impact in the detection of happiness and anger. The fact that sadness is closely associated to slowing makes us suspect that different embodied component may be involved here, other than facial expressions. Supporting this view Reed (2002) indicates that facial expression is not the prominent embodiment for sadness, but it is more internally experienced. Studies inducing different rhythms in a previous procedural priming fashion would be a good idea to test sadness responding accuracy rather than reaction times.

We could observe in our studies that semantic association to different emotions overlapped. This association level concerns the degree of relatedness within the semantic network. However face has also a degree of overlap in the activation of facial muscles that should be in the root of our general priming effect. The third study is also clear in suggesting facial muscle activity to have a role in emotion category priming effects. At least for happy trials. The fact that the effects of sadness and anger were highlighted in a blocking condition remains partially unexplained. Our results are congruent with the idea that the manipulation stimulates *orbicularis* in a way that promotes its variation instead of freezing its activity as in the case of *zygomaticus*. However, in the case of sadness, as we said above, facial expression is not the most relevant embodiment, nor the blocking mechanism is especially effective on it. So the stronger priming effect may be related to the fact that not only this embodiment is activated but also because happiness is inhibited. For this reason, a future study that separates these two sources of muscular feedback would be desirable.

Another point of interest of our results is that indeed, priming can be explained by a muscular mechanism. Above, we made clear that the fact that embodied cognition can

account for task dependence issues is an advantage over spread of activation account. As those models have some trouble in explaining priming effects that do not involve evaluative tasks, a way to discard those would be demonstrating the effect of simulation in a task that does not involve an evaluative component but at the same time could trigger embodied simulation of meaning in a difficult lexical decision task (using pseudowords) that required access to meaning rather than allowing participants to make decisions based on simple phonological routes.

In addition, our studies clarify the effects of Nidenthal et al.'s (2001) blocking procedure in facial muscle activity. Once this manipulation was shown to only impact muscles in the lower part of the face, it would be interesting in future approaches, to find other manipulations that could block the activity in a selective way, and that could exclude chemical alternatives as botox, which raise the issue of invasiveness of the procedures, that can have unpredictable behavioural consequences.

Although our studies suggested that the disruption of the priming pattern for happiness occurs because the blocking manipulation activates at a greater extent the *zygomaticus*, Oberman and colleagues (2007) suggested that this occurs because the manipulation creates a great amount of activity that would disturb the perception of emotions that produce greater general activity as happiness. However, Oberman's hypothesis is less sharp in explaining why we obtained the results we had for anger. Applying the same reasoning, for anger, which was the emotion that created the greater amount of general activity in our studies, we couldn't find a match. As we observed, the priming effects in this case were highlighted instead of being disturbed. For this reason it would be interesting to have a study that tests directly these two opposite hypothesis.

Another relevant issue is to further explore whether blocking procedures operate through a process of hyperactivating muscles or through preventing muscles to change their state (not allowing variability in the amount of muscular activity). If muscle's change is the informative bit, varying the level of pressure imposed by teeth of the pen, in the blocking manipulation, should lead to equivalent results in a priming task. On contrary, if level of activation is relevant, then we should find differences between different amounts of muscular activation. Another relevant point is to capture if is there any threshold responsible for informing the individual what is a natural smile or a noisy activation of the *zygomaticus*. Giving that the manipulation allows voluntary change, it maybe that blocking could be associated to a difficulty in the perception of spontaneous change and not to actual change. It

would also be important to study the amount of activity involved in inducing a smile and which properties others than the amount of activity make them have a different behavioural impact. What could also help the individual to distinguish between an increasing of activation promoted by blocking and an elevated activation in smile would be the pattern of muscles around the mouth that are activated. When manipulation is used this would result in an unrecognizable pattern, that doesn't match the activation pattern of a smile, leading the individual to signal an abnormal occurrence that should not be labelled as a smile.

The literature on the representation and processing of emotion concepts is not yet a large one, and most of the accounts assume that emotion concepts are represented as amodal symbols. The embodied simulation account which guided our present research appears to be a suitable alternative for those models. This is because spread of activation accounts is not able to explain why blocking procedures can have a detrimental effect in performance. In amodal accounts the only thing that predicts the efficiency of priming is the strength of the association between concepts. For this reason our findings add support to the previous evidence for the involvement of facial expressions in emotion recognition to processing of emotion words (Niedenthal et al., 2001; Oberman et al., 2007; Niedenthal et al., 2009). Present findings assure us that the blocking procedure only clearly hyperactivates *zygomaticus*, it was on the emotion associated with this muscle that we interfere with priming. We are however aware that more research is needed to clarify the full mechanism through which priming emotions occurs, speacially in the case of negative emotions.

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Appendixes

Appendix A: Pre-testing emotional and non-emotional targets

This pre-test had the aim to access the levels of association of a variety of words to three specific emotions (happiness, sadness and anger). These words would integrate the first two experiments of this thesis, which required us to manipulate the association of words to one of the three specific emotions and with minimal associations to the others.

Given that our experiment would require rapid responses, and would use as dependent measure the reactions times of those responses it was of the greatest importance to control factors the would interfere with the reading times, so they don't confound our data. Two main factors that may have this impact are familiarity and the length of words (measured in number of letters). For this reason, in addition to pre-testing emotion levels of association it was also important to pre-test familiarity of those words and registered the number of letters per word, so that we could control the stimuli for this variables.

Method

Participants

Two hundred and six volunteers of Universidade Lusófona (75,3% women; M_{age}=22,46; *SD*=5.34) received a list of words they were required to rate.

Material

The pre-tested words were taken from several databases as Nelson, McEvoy & Schreiber data base and ANEW, database (Bradley & Lang, 1999) and Garcia-Marques' Norms (2003) . Non-emotional words, were also taken from those databases, however, were words which revealed scores in terms of valence which were around the midpoint of the scales of each database. The pre-tested list was composed by 114 word for each type of word (happy, sad, angry and neutral), totalizing 456 words.

All 456 words were randomly distributed to four different lists. For each list of 114 words, we generated four different random orders with the help of www.randomizer.org.

Procedure

Three groups of 64 Participants were asked whether each word was associated to a specific emotion “Is this word associated to happiness?”. The participants had to fill in the yes or no box that was presented in front of the word. This question required a yes or no response. “ This emotion could be happiness, sadness or anger. A group of 64 participants was questioned about “How familiar was each word” (1- *Not very familiar*; 5 – *Very familiar*). The number of letters of each word was registered. Each word was evaluated in each dimension around 16 times.

Results

For every word was computed the percentage of association to each emotion. This percentage was the number of individuals who reported that the word was associated to a specific emotion over the number of individuals who were asked about the existence of this association.

Table1
Sellection criterions

		Association (%) to an emotion		
		Happiness	**Anger**	**Sadness**
Words	**Happiness**	>75%	<50%	<50%
	Anger	<50%	>75%	<50%
	Sadness	<50%	<50%	>75%
	Neutral	<50%	<50%	<50%

After selecting a group of stimuli that met the above criterions, we were interested in selecting a subset for each type of emotion (happy, sad, angry and neutral) eight stimuli that should be equilibrated in terms number of letters, and familiarity. Because it was difficult to select from the remaining stimuli, words with roughly the same ratings for familiarity and number of letters, we selected the stimuli so that compensate each other between the groups, revealing no differences in an Analysis of variance for each emotional group.

Word Selection by Emotional category

Table 2
Words for Anger category

	Letters	Proportion of Association to Emotions			Familiarity			
		Happiness	Anger	Sadness	CI (95%)			
	N	*P*	*P*	*P*	*M*	*LL*	*UL*	*SD*
murro (punch)	5	0	0,75	0,25	5,17	3,64	6,7	2,41
furibundo (raging)	9	0	0,75	0,38	4,42	2,76	6,07	2,61
enfurecido (furious)	10	0	0,75	0,5	4,75	3,34	6,16	2,22
feroz (fierce)	5	0,08	0,77	0,25	5,22	3,56	6,89	2,17
mau (bad)	3	0	0,77	0,5	5,9	4,66	7,14	1,73
bomba (bomb)	5	0	0,83	0,38	5,42	4,1	6,73	2,07
zaragata (fight)	8	0,08	0,85	0,5	4,11	2,17	6,05	2,52
irritante (irritating)	9	0	0,92	0,5	5,7	4,63	6,77	1,49

Table 3
Words for Sadness category

	Letters	Proportion of association to emotions			Familiarity			
		Happiness	anger	sadness	CI (95%)			
	N	*P*	*P*	*P*	*M*	*LL*	*UL*	*SD*
arruinado (ruined)	9	0	0,36	0,92	3,82	2,29	5,34	2,27
vagabundo (homeless)	9	0	0,25	1	4,67	2,67	6,66	2,6
lamento (regret)	7	0,1	0,27	1	4,64	3,28	5,99	2,01
desânimo (disencouragement)	8	0	0,36	1	4,73	3,32	6,14	2,1
adeus (goodbye)	5	0,17	0,42	1	6,11	4,81	7,41	1,69
cancro (cancer)	6	0	0,45	1	4,82	3,29	6,34	2,27
lágrima (tear)	7	0	0,45	1	4,91	3,85	5,97	1,58
depressão (depression)	9	0	0,5	1	6,17	5,36	6,97	1,27

Table 4
Words for Hapiness Category

	Letters	Proportion of association to emotions			Familiarity			
		Happiness	Anger	Sadness	CI (95%)			
	N	*P*	*P*	*P*	*M*	*LL*	*UL*	*SD*
férias (vacation)	6	1	0	0	5,78	4,52	7,04	1,64
prenda (gift)	6	1	0	0	6,42	5,78	7,05	1
alegre (cheerful)	7	1	0	0	6,6	5,91	7,29	0,97
galhofa (frolic)	7	1	0	0	4,92	3,58	6,26	2,11
paraíso (paradise)	7	1	0	0	5,67	4,34	7	1,73
harmonia (harmony)	8	1	0	0	6,56	5,88	7,23	0,88
bem-estar (well-being)	9	1	0	0	6,56	5,88	7,23	0,88
gratificação (gratification)	12	1	0	0	4,67	3,39	5,94	1,66

Table 5
Words for Neutral Category

	Letters	Proportion of association to emotions			Familiarity			
		Happiness	Anger	Sadness	CI (95%)			
	N	*P*	*P*	*P*	*M*	*LL*	*UL*	*SD*
zip (zipper)	3	0	0	0	3,82	2,1	5,54	2,56
rolo (roll)	4	0,08	0,08	0	4,67	2,6	6,74	2,69
diagrama (diagram)	8	0,1	0	0	4,27	2,93	5,62	2
tinteiro (tonner)	8	0,1	0,09	0	5,18	3,88	6,49	1,94
paralelo (paralell)	8	0,1	0	0,08	5,18	3,63	6,74	2,32
tabuleiro (tray)	9	0,1	0	0	4,64	3,35	5,92	1,91
protótipo (prototype)	9	0,1	0,09	0	5,36	4,4	6,33	1,43
recipiente (recipient)	10	0	0	0	4,73	3,05	6,4	2,49

Apart from those critical words we selected, we also were interested in drawing from this pool, ambiguous 32 filler words to integrate Experiment 1. Those words were selected taking in account they should have also a maximum of association to one emotion and a minimum to the remaining emotions. However they had higher associations to the remaining emotions, raging from (above 50%) to more than one emotion and didn't obey any criterium of familiarity or number of letters.

Word levels of association to each emotion. We tested the levels of association of three groups of words (happy, sad and angry) to each emotion in separate. Firstly we tested the differences of the four groups of words in terms of variable level association to happiness. The one-way anova revealed that there was one difference at least between the tested groups (F(3, 28)=958.13; p=.000; η^2=.99)

We concluded the words selected to be in the group of happy words exhibited the highest mean (M=1.00; SD=.02) for this variable. Post-hoc compairions (LSD Test) revealed that this mean was significantly different from remaining mean level of association of the other groups of words such as angry words (M=.02; SD=.02; p<.000), sad words (M=.04; SD=.02; p<.000) or neutral words (M=.07; SD=.02; p<.000).

The one-way aNOVA revealed that there was one difference at least between the tested groups for the level of association to anger (F(3, 28)=319.82; p=.000; η^2=.97). We concluded the words selected to be in the group of angry words exhibited the highest mean (M=.80; SD=.02) for the level of association to anger. This mean was significantly different from remaining mean level of association of the other groups of words such as happy words

(*M*=.00; *SD*=.02; *p*<.000), sad words (*M*=.38; *SD*=.02; *p*<.000) or neutral words (*M*=.03; *SD*=.02; *p*<.000).

The one-way anova revealed that there was one difference at least between the tested groups for the level of association to sadness (*F*(3, 28)=494.81; *p*<.000; η^2=.98). We concluded the words selected to be in the group of angry words exhibited the highest mean (*M*=.99; *SD*=.02) for the variable: "level of association to sadness". This mean was significantly different from remaining mean level of association of the other groups of words such as happy words (*M*=.00; *SD*=.02; p<.000), angry words (*M*=.41; *SD*=.02; *p*<.000) or neutral words (*M*=.01; *SD*=.02; *p*<.000).

In terms of the mean number of letters that each group of words had, it was desirable that no difference occurred between groups. That was what we verified (*F*(3, 28)=.31; *p*=.821; η^2=.03).

In terms of the mean level of familiarity it was also desearble that no differences emerged. However, in this case, there were at least a difference between the groups of different words (*F*(3, 28)=4.34; *p*=.012; η^2=.32). Happy and Neutral words differed in their level of familiarity, being happy words (*M*=5.89;*SD*=.24) more familiar than controls (*M*=4.73;*SD*=.24; *p*=.002), and more familiar than angry (*M*=5.09;*SD*=.24; *p*=.025) and sad words (*M*=4.98;*SD*=.24; *p*=.012).

Discussion

Each group of emotional words revealed significant higher levels of association to the emotion they were assigned to represent. As expected the number of letters didn't differ from group to group, so any differences found in experiments that involve this stimuli found should not be attributed to the length of the string of letters.

Familiarity levels between groups revealed no difference excepting for happy and controls. This two groups revealed differences. This could have an influence in terms of reading times for happy words compared to the controls in the main experiments, increasing an existing priming effect.

Appendix B: Pre-testing of emotional face primes

Given the universality of facial expressions, we decided to randomly pre-select the 48 faces of different people from the Karolinska Directed Emotional Faces database - KDEF (Lundqvist, Flykt, & Öhman, 1998). Although we had already the 48 stimuli needed to the priming phase of experiment 1 of the thesis, we needed to equilibrate the intensity and familiarity of facial expression across the four groups of words that this faces would prime. Both this factors could have a differential impact in the priming task if not well equilibrated across conditions.

Method

Participants

Fifty-four ISCTE's volunteers (85% women; M_{age}=21.16; SD=4.65) were asked to rate photos of facial expressions.

Material

16 individual's were selected from the The total set of Karolinska Directed Emotional Faces database - KDEF (Lundqvist et al., 1998). For each individual we selected their photos expressing happy, sad and angry expressions. On total, we drawn from the database 48 photos, divided in three groups of 16 of them expressing happiness, sadness and anger.

Procedure

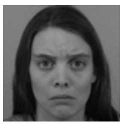
The experiment was presented as a pre-test of characteristics of the photos of certain individuals. The participants were asked to evaluate 48 black and wight photos (5x5cm) delivered by E-Prime v1.9 (Psychology Software Tools Inc., PA, USA) (Schneider et al., 2002), according to a duration of 500ms. The evaluation involved rating the photos in terms of intensity of the facial expression they presented and the familiarity of the face, which are variables hat could interfere with processing time of the stimuli during the main experiment. For each emotional expression we asked "How intense was this facial expression?" (1- *Not*

very intense; 7 – *Very intense*), "How familiar was the face to the participant" (1- *Not very familiar*; 7 – *Very familiar*).

Results and Discussion

The above tables express the resulting evaluations for intensity of facial expressions and familiarity of the individual.

Table 1
Stimuli evaluations: sad faces (ascending order for emotional intensity)

	Intensity				**Familiarity**			
	CI (95%)				***CI (95%)***			
	M	***LL***	***UL***	***SD***	***M***	***LL***	***UL***	***SD***
	3,33	1,95	4,72	1,80	1,89	0,99	2,79	1,17
	3,56	2,40	4,72	1,51	2,44	1,67	3,22	1,01
	3,56	2,61	4,51	1,24	1,56	0,78	2,33	1,01
	3,67	2,23	5,10	1,87	1,67	1,12	2,21	0,71
	3,89	2,59	5,19	1,69	2,78	1,30	4,26	1,92
	4,00	3,23	4,77	1,00	3,44	2,28	4,60	1,51
	4,11	2,81	5,41	1,69	2,11	1,21	3,01	1,17
	4,33	2,84	5,82	1,94	1,33	0,56	2,10	1,00

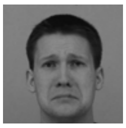
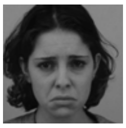
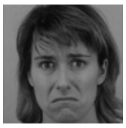
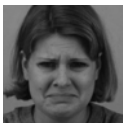
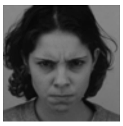
	Intensity				**Familiarity**			
	CI (95%)				***CI (95%)***			
	M	***LL***	***UL***	***SD***	***M***	***LL***	***UL***	***SD***
	4,44	3,28	5,60	1,51	2,33	0,75	3,92	2,06
	4,89	4,18	5,60	0,93	2,89	1,59	4,19	1,69
	4,89	3,43	6,35	1,90	1,78	0,85	2,70	1,20
	5,00	3,98	6,02	1,32	2,44	1,11	3,78	1,74
	5,00	3,37	6,63	1,55	1,83	1,04	2,62	0,75
	5,11	4,21	6,01	1,17	3,11	1,76	4,47	1,76
	5,33	4,32	6,35	1,32	1,67	0,81	2,53	1,12
	5,44	4,67	6,22	1,01	1,44	0,89	2,00	0,73

Table 2

Stimuli Evaluations: Angry Faces (ascending order for emotional intensity)

	Intensity				**Familiarity**			
	CI (95%)				***CI (95%)***			
	M	***LL***	***UL***	***SD***	***M***	***LL***	***UL***	***SD***
	3,56	2,27	4,84	1,67	1,78	1,14	2,42	0,83
	3,78	2,58	4,98	1,56	1,67	0,65	2,68	1,32
	4,00	2,78	5,22	1,58	2,33	1,06	3,61	1,66
	4,00	2,91	5,09	1,41	2,00	1,23	2,77	1,00
	4,11	3,30	4,92	1,05	3,00	1,28	4,72	2,24
	4,22	3,02	5,42	1,56	2,11	1,14	3,09	1,27
	4,33	3,47	5,19	1,12	2,67	1,23	4,10	1,87
	4,56	3,33	5,78	1,59	2,33	1,25	3,42	1,41
	5,00	4,06	5,94	1,22	1,56	0,78	2,33	1,01
	5,00	4,06	5,94	1,22	2,33	0,84	3,82	1,94

	Intensity					Familiarity			
					CI (95%)				
	M	***LL***		***UL***			***CI (95%)***		
	5,00	4,33	5,67	***SD***		***M***	***LL***	***UL***	***SD***
	5,22	4,15	6,29	0,87		1,56	0,27	2,84	1,67
	5,67	4,58	6,75	1,39		1,78	1,03	2,52	0,97
	5,67	4,81	6,53	1,41		1,33	0,95	1,72	0,50
	5,89	5,08	6,70	1,12		1,89	0,99	2,79	1,17
	6,33	5,47	7,19	1,05		2,00	0,98	3,02	1,32

Table 3
Stimuli evaluations: happy faces (ascending order for emotional intensity)

	Intensity				**Familiarity**			
	CI (95%)				***CI (95%)***			
	M	***LL***	***UL***	***SD***	***M***	***LL***	***UL***	***SD***
	2,78	1,71	3,85	1,39	1,56	1,00	2,11	0,73
	3,33	1,66	5,01	2,18	2,56	1,27	3,84	1,67
	3,56	2,46	4,65	1,42	2,56	1,40	3,72	1,51
	3,78	2,16	5,40	2,11	2,33	1,12	3,55	1,58
	4,00	3,23	4,77	1,00	1,78	0,94	2,62	1,09
	4,22	3,02	5,42	1,56	2,11	0,81	3,41	1,69
	4,56	3,33	5,78	1,59	3,00	1,67	4,33	1,73
	4,78	3,94	5,62	1,09	2,44	0,90	3,99	2,01
	4,89	3,65	6,13	1,62	3,67	2,58	4,75	1,41

	Intensity				Familiarity			
	CI (95%)				*CI (95%)*			
	M	***LL***	***UL***	***SD***	***M***	***LL***	***UL***	***SD***
	5,00	3,98	6,02	1,32	2,56	1,27	3,84	1,67
	5,00	3,73	6,27	1,66	1,89	1,08	2,70	1,05
	5,22	3,85	6,60	1,79	2,00	1,06	2,94	1,22
	5,33	4,39	6,27	1,22	2,00	0,85	3,15	1,50
	5,56	4,88	6,23	0,88	3,22	1,70	4,75	1,99
	5,67	4,90	6,44	1,00	2,22	1,15	3,29	1,39
	5,67	4,81	6,53	1,12	1,67	0,81	2,53	1,12

All subjects were able to identify correctly the presented emotions. In terms of the intensity of the facial expression, the evaluations of the subjects didn't differ from group of emotional faces, to the others (F(2, 45)=0.81; p=.453; η^2=.03). Meaning that no group was revealed to have facial expression more intense than the others.

Also, in terms of the variable familiarity, the evaluations of the subjects didn't differ from group of emotional faces, to the others (F(2, 45)=1.39; p=.259; η^2=.06). Meaning that no group was revealed to have facial expression more familiar than the others.

Appendix C: Statistics for words and facial expressions per condition

Table1

One-way Anova: Differences in terms of level of association to happiness for each group of words

	SS	Degr. of	MS	F	P	η^2
Intercept	2,54	1	2,54	1324,35	0,000	0,98
Emotion	5,51	3	1,84	958,13	0,000	0,99
Error	0,05	28	0,00			

Table 2

Descriptive statistics of the level of association to happiness for each group of words

Emotion	Mean	SD	LL	UL	N
Neutral	0,07	0,02	0,04	0,10	8,00
Angry	0,02	0,02	-0,01	0,05	8,00
Sad	0,03	0,02	0,00	0,07	8,00
Happy	1,00	0,02	0,97	1,03	8,00

Table 3

Post hoc test exploring the differences in terms of level of association to happiness for each group of words

					CI 95%	
Condition		Mean Difference	SD	*p*	*LL*	*UL*
Neutral	Angry	0,05	0,02	0,024	0,01	0,10
	Sad	0,04	0,02	0,081	-0,01	0,08
	Happy	-0,93	0,02	0,000	-0,97	-0,88
Angry	Sad	-0,01	0,02	0,573	-0,06	0,03
	Happy	-0,98	0,02	0,000	-1,02	-0,93
Sad	Happy	-0,97	0,02	0,000	-1,01	-0,92

Error: Between MS = ,00348, df = 28

Table 4

One-way Anova: Differences in terms of level of association to anger for each group of words

	SS	Degr. of	MS	F	p	η^2
Intercept	2,96	1	2,96	848,92	0,000	0,97
Emotion	3,34	3	1,11	319,82	0,000	0,97
Error	0,10	28	0,00			

Table 5

Descriptive statistics of the level of association to anger for each group of words

emotion	Mean	SD	LL	UL	N
Neutral	0,03	0,02	-0,01	0,08	8
Angry	0,80	0,02	0,76	0,84	8
Sad	0,38	0,02	0,34	0,43	8
Happy	0,00	0,02	-0,04	0,04	8

Table 6

Post hoc test exploring the differences in terms of level of association to anger for each group of words

					CI 95%	
Condition		Mean Difference	SD	*p*	*LL*	*UL*
Neutral	Angry	-0,77	0,03	0,000	-0,83	-0,71
	Sad	-0,35	0,03	0,000	-0,41	-0,29
	Happy	0,03	0,03	0,282	-0,03	0,09
Angry	Sad	0,41	0,03	0,000	0,35	0,47
	Happy	0,80	0,03	0,000	0,74	0,86
Sad	Happy	0,38	0,03	0,000	0,32	0,44

Error: Between MS = ,00192, df = 28

Table 7

One-way Anova: Differences in terms of level of association to sadness for each group of words

	SS	Degr. of	MS	F	p	η^2
Intercept	3,96	1	3,96	1128,98	0,000	0,98
Emotion	5,20	3	1,73	494,81	0,000	0,98
Error	0,10	28	0,00			

Table 8

Descriptive statistics of the level of association to sadness for each group of words

emotion	Mean	SD	LL	UL	N
Neutral	0,01	0,02	-0,03	0,05	8
Angry	0,41	0,02	0,36	0,45	8
Sad	0,99	0,02	0,95	1,03	8
Happy	0,00	0,02	-0,04	0,04	8

Table 9

Post hoc test exploring the differences in terms of level of association to sadness for each group of words

Condition		Mean Difference	SD	*p*	*CI 95%*	
					LL	*UL*
Neutral	Angry	-0,40	0,03	0,000	-0,46	-0,34
	Sad	-0,98	0,03	0,000	-1,04	-0,92
	Happy	0,01	0,03	0,727	-0,05	0,07
Angry	Sad	-0,58	0,03	0,000	-0,64	-0,52
	Happy	0,41	0,03	0,000	0,35	0,47
Sad	Happy	0,99	0,03	0,000	0,93	1,05

Error: Between MS = ,00350, df = 28

Table 10

One-way Anova: Differences in terms of number of letters between each group of words

	SS	Degr. of	MS	F	p	η^2
Intercept	1725,78	1	1725,78	363,66	0,000	0,93
Emotion	4,34	3	1,45	0,31	0,821	0,03
Error	132,88	28	4,75			

Table 11

Descriptive statistics of the number of letters in each group of words

emotion	Mean	SD	LL	UL	N
Neutral	7,38	0,77	5,80	8,95	8
Angry	6,75	0,77	5,17	8,33	8
Sad	7,50	0,77	5,92	9,08	8
Happy	7,75	0,77	6,17	9,33	8

Table 12

Post hoc test exploring the differences in the number of letters between each group of words

Condition		Mean Difference	SD	*p*	*CI 95%*	
					LL	*UL*
Neutral	Angry	0,63	1,09	0,571	-1,61	2,86
	Sad	-0,13	1,09	0,909	-2,36	2,11
	Happy	-0,38	1,09	0,733	-2,61	1,86
Angry	Sad	-0,75	1,09	0,497	-2,98	1,48
	Happy	-1,00	1,09	0,366	-3,23	1,23
Sad	Happy	-0,25	1,09	0,820	-2,48	1,98

Error: Between MS = 4,7455, df = 28

Table 13

One-way Anova: Differences in terms of familiarity between each group of words

	SS	Degr. of	MS	F	p	η^2
Intercept	856,37	1	856,37	1834,50	0,000	0,98
Emotion	6,08	3	2,03	4,34	0,012	0,32
Error	13,07	28	0,47			

Table 14

Descriptive statistics of familiarity in each group of words

emotion	Mean	SD	LL	UL	N
Neutral	4,73	0,24	4,24	5,23	8
Angry	5,09	0,24	4,59	5,58	8
Sad	4,98	0,24	4,49	5,48	8
Happy	5,89	0,24	5,40	6,39	8

Table 15

Post hoc test exploring the differences in familiarity between each group of emotional targets

					CI 95%	
Condition		Mean Difference	SD	*p*	*LL*	*UL*
Neutral	Angry	-0,35	0,34	0,308	-1,05	0,35
	Sad	-0,25	0,34	0,469	-0,95	0,45
	Happy	-1,16	0,34	0,002	-1,86	-0,46
Angry	Sad	0,10	0,34	0,764	-0,60	0,80
	Happy	-0,81	0,34	0,025	-1,51	-0,11
Sad	Happy	-0,91	0,34	0,012	-1,61	-0,21

Error: Between MS = ,46681, df = 28

Table 16

One-way Anova: Differences regarding intensity of facial expression between each group of emotional targets

	SS	Degr. of	MS	F	p	η^2
Intercept	1010,54	1	1010,54	1553,57	0,000	0,97
Emotion	1,05	2	0,52	0,81	0,453	0,03
Error	29,27	45	0,65			

Table 17

Descriptive statistics of the intensity of facial expression in group of emotional targets

emotion	Mean	SD	LL	UL	N
Sad	4,41	0,20	4,00	4,82	16
Angry	4,77	0,20	4,37	5,18	16
Happy	4,58	0,20	4,18	4,99	16

Table 18

Post hoc test exploring the differences in familiarity between each group of emotional targets

Condition		Mean Difference	SD	*p*	*CI 95%* *LL*	*UL*
Sad	Angry	-0,36	0,29	0,211	-0,94	0,21
	Happy	-0,18	0,29	0,542	-0,75	0,40
Angry	Happy	0,19	0,29	0,516	-0,39	0,76

Error: Between MS = ,65046, df = 45

Table 19

One-way Anova: Differences regarding familiarity of the facial expression between each group of emotional targets

	SS	Degr. of	MS	F	p	η^2
Intercept	228,03	1	228,03	740,45	0,000	0,94
Emotion	0,86	2	0,43	1,39	0,259	0,06
Error	13,86	45	0,31			

Table 20

Descriptive statistics regarding the familiarity of the facial expression in group of emotional targets

emotion	Mean	SD	LL	UL	N
Sad	2,17	0,14	1,89	2,45	16
Angry	2,02	0,14	1,74	2,30	16
Happy	2,35	0,14	2,07	2,63	16

Table 21

Post hoc test exploring the differences in familiarity of the facial expression between each emotional targets

Condition		Mean Difference	SD	*p*	*CI 95%* *LL*	*UL*
Sad	Angry	0,15	0,20	0,454	-0,25	0,54
	Happy	-0,18	0,20	0,367	-0,57	0,22
Angry	Happy	-0,33	0,20	0,103	-0,72	0,07

Error: Between MS = ,30796, df = 45

Appendix D: Statistics of Experiment 1

Analysis of Reaction Times

Table 1
Repeated Measures Anova (3 x 2 x 3)

	SS	df	MS	F	p	η2
Intercept	10439,45	1	10439,45	19076,94	0	0,998325
emo	2,46	2	1,23	2,25	0,122139	0,123144
Error	17,51	32	0,55			
Congruence	0,03	2	0,02	0,18	0,8377	0,005519
Congruence*Emotion	0,19	4	0,05	0,5	0,738853	0,030054
Error	6,08	64	0,1			
Prime	0,56	1	0,56	5,91	0,020878	0,155802
Prime*Emotion	0,43	2	0,21	2,25	0,121828	0,123283
Error	3,05	32	0,1			
Congruence*Prime	0,59	2	0,3	2,63	0,079871	0,075941
Congruence*Prime*Emotion	0,25	4	0,06	0,56	0,693486	0,033736
Error	7,19	64	0,11			

η^2= partial eta-square

Table 2
Descriptive statistics of the main effect of the Prime

Condition	*M*	*SD*
Prime	1197,59	67,03
No Prime	1352,94	83,72

Table 3
Contrasts revealing an impact of the presence of the, per level of congruence between and prime and target

	Prime		No Prime				*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*t(32)*	*p*	*LL*	*UL*
Congruent	1133,56	81,05	1475,00	153,04	2,17	0,037	0,01	0,40
Incongruent	1194,91	92,71	1374,53	97,70	1,96	0,058	-0,01	0,30
Neutral	1264,29	83,63	1209,30	81,45	0,71	0,485	-0,08	0,17

Table 4

Contrast of the interaction between presence of the prime and level of congruence between the prime and the target

Condition	Prime (-1)		No Prime (1)		t(32)	p	CI 95%	
	M	*SD*	*M*	*SD*			*LL*	*UL*
Congruent (1)	1133,56	81,05	1475,00	153,04	2,11	0,04	0,01	0,49
Neutral (-1)	1264,29	83,63	1209,30	81,45				
Incongruent (1)	1194,91	92,71	1374,53	97,70	1,97	0,057	-0,39	0,01
Neutral (-1)	1264,29	83,63	1209,30	81,45				

Appendix E: Statistics of Experiment 2

Analysis of EMG activity (Means)

Table 1
Repeated Measures Anova (3 x 2)

	SS	df	MS	F	p	η2
Intercept	1,58	1	1,58	3,53	0,090	0,26
Error	4,46	10	0,45			
MUSC	0,65	2	0,33	1,21	0,320	0,11
Error	5,39	20	0,27			
MIMICRY	0,95	1	0,95	1,55	0,241	0,13
Error	6,12	10	0,61			
MUSC*MIMICRY	13,58	2	6,79	6,30	0,008	0,39
Error	21,55	20	1,08			

Table 2
Contrast revealing the impact of blocking manipulation, compared to free mimicry condition, for each muscle.

	Blocked mimicry		Free mimicry				*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*t(10)*	*p*	*LL*	*UL*
Corrugator	-0,40	0,25	0,63	0,22	2,51	0,031	-1,94	-0,11
Zygomaticus	0,81	0,29	-0,23	0,18	2,52	0,031	0,12	1,97
Orbicularis Oris	0,41	0,30	-0,30	0,15	1,74	0,112	-0,20	1,60

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Analysis of EMG activity (Standard Deviations)

Table 3
Repeated Measures Anova (3 x 2)

	SS	df	MS	F	p	η2
Intercept	0,00	1	0,00	4,62	0,060	0,34
Error	0,00	9	0,00			
Mimicry	0,00	1	0,00	1,38	0,269	0,13
Error	0,00	9	0,00			
Muscle	0,00	2	0,00	0,64	0,537	0,07
Error	0,00	18	0,00			
Mimicry*Muscle	0,00	2	0,00	0,99	0,392	0,10
Error	0,00	18	0,00			

Appendix F: Statistics of Experiment 3

Analysis of Reaction Times

Table 1
Repeated Measures Anova (3 x 2 x 3) – Only Free Mimicry Condition

	SS	df	MS	F	p	η2
Intercept	8595,08	1	8595,08	14689,32	0,000	1,00
Emotion	1,37	2	0,68	1,17	0,324	0,07
Error	18,14	31	0,59			
Congruence	0,43	2	0,22	3,89	0,026	0,11
Congruence*Emotion	0,54	4	0,14	2,46	0,054	0,14
Error	3,43	62	0,06			
Prime	0,48	1	0,48	6,13	0,019	0,17
Prime*Emotion	0,21	2	0,10	1,34	0,277	0,08
Error	2,40	31	0,08			
Congruence*Prime	0,35	2	0,18	3,16	0,050	0,09
Congruence*Prime*Emotion	0,49	4	0,12	2,22	0,077	0,13
Error	3,44	62	0,06			

η^2= partial eta-square

Table 2
Descriptive statistics of the main effect of the Prime

Condition	*M*	*SD*
Prime	688,43	52,05
No Prime	772,05	70,37

Table 3
Descriptive statistics of the main effect of the Level of Congruence of the Prime

Condition	*M*	*SD*
Congruent	723,82	69,20
Incongruent	794,46	74,83
Neutral	672,42	42,87

Table 4
Contrasts revealing an impact of the congruence between prime and target, in the priming effect

	Prime		No Prime				*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*T(31)*	*p*	*LL*	*UL*
Congruent	659,09	76,07	788,55	67,51	7,12	0,01	0,04	0,33
Incongruent	757,74	69,25	831,18	104,73				

Table 5
Contrasts revealing an impact of the congruence between prime and target, per emotion

	Congruent		Incongruent		Neutral				*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*T(31)*	*p*	*LL*	*UL*
Happy (-1;2:-1)	638,40	116,39	803,48	125,85	672,77	72,10	2,672	0,01	0,16	1,20
Sad (1;1;2)	883,67	121,56	984,93	131,44	721,61	75,31	2,410	0,02	0,10	1,23
Angry (-2;1;1)	649,40	121,56	594,98	131,44	622,89	75,31	-0,931	0,36	-0,55	0,21

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Table 6
Contrasts revealing an impact of the presence of the, per emotion and considering the level of congruence between and prime

	Prime		No Prime				*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*t(31)*	*p*	*LL*	*UL*
Happy; Congruent	575,88	127,93	700,91	113,54	2,99	0,005	0,07	0,39
Happy; Incongruent	858,21	116,47	748,76	176,14	0,51	0,612	-0,18	0,30
Happy; Neutral	592,38	69,38	753,16	96,75	2,49	0,018	0,05	0,48
Sad; Congruent	780,96	133,62	986,38	118,59	3,39	0,002	0,11	0,44
Sad; Incongruent	809,70	121,65	1160,15	183,98	1,58	0,123	-0,06	0,45
Sad; Neutral	717,76	72,47	725,46	101,06	-0,51	0,611	-0,28	0,17
Angry; Congruent	620,44	133,62	678,37	118,59	1,59	0,123	-0,04	0,30
Angry; Incongruent	605,31	121,65	584,64	183,98	0,46	0,649	-0,20	0,31
Angry; Neutral	635,20	72,47	610,58	101,06	0,50	0,624	-0,17	0,28

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Table 7

Repeated Measures Anova (3 x 2 x 3 x 2) – Adding participants with blocked mimicry

	SS	df	MS	F	p	η2
Intercept	15771,8	1	15771,8	14276,17	0	0,995954
Emotion	1,36	2	0,68	0,62	0,54401	0,020774
Mimicry	2,01	1	2,01	1,82	0,182315	0,030458
Emotion*Mimicry	1,45	2	0,73	0,66	0,521916	0,022173
Error	64,08	58	1,1			
Congruence	1,41	2	0,71	5,63	0,004635	0,088494
Congruence*Emotion	1,78	4	0,44	3,54	0,009202	0,108744
Congruence*Mimicry	0,12	2	0,06	0,46	0,631087	0,007905
Congruence*Emotion*Mimicry	1,27	4	0,32	2,54	0,043723	0,080447
Error	14,57	116	0,13			
Prime	2,25	1	2,25	20,99	0,000025	0,265698
Prime*Emotion	0,94	2	0,47	4,41	0,016477	0,132013
Prime*Mimicry	0,31	1	0,31	2,87	0,095413	0,047204
Prime*Emotion*Mimicry	1,14	2	0,57	5,34	0,007459	0,155414
Error	6,21	58	0,11			
Congruence*Prime	0,98	2	0,49	3,53	0,032503	0,057365
Congruence*Prime*Emotion	1,31	4	0,33	2,36	0,057698	0,075152
Congruence*Prime*Mimicry	0,05	2	0,02	0,17	0,840095	0,003
Congruence*Prime*Emotion*Mimicry	0,4	4	0,1	0,72	0,582722	0,024091
Error	16,13	116	0,14			

Table 8

Descriptive statistics of the main effect of the Prime

Condition	*M*	*SD*
Prime	682,70	49,91
No Prime	785,31	55,14

Table 9

Contrast of the interaction between presence of thep prime and the mimicry condition

	Prime (-1)		No Prime (1)				*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*t(58)*	*p*	*LL*	*UL*
Blocked (-1)	676,96	72,73	798,57	80,35	1,70	0,095	-0,06	0,74
Free (1)	688,43	68,38	772,04	75,54				

Table 10

Contrast revealing diference between levels of congruence between prime and target

	Congruent		Incongruent		Neutral				*CI 95%*	
Contrast	*M*	*SD*	*M*	*SD*	*M*	*SD*	*T(58)*	*p*	*LL*	*UL*
(1;-2;1)	729,70	49,88	788,59	60,40	683,71	56,90	2,97	0,004	0,15	0,76

Table 11

Contrasts revealing an impact of the presence of the prime, per emotion and mimicry condition

	Prime (-1)		No Prime (1)				*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*T(58)*	*p*	*LL*	*UL*
Happy; Free	675,49	115,00	734,28	127,04	1,88	0,065	-0,03	0,90
Happy; Blocked	955,96	125,98	829,52	139,17	-0,56	0,580	-0,65	0,37
Sad; Free	769,48	120,11	957,33	132,69	1,73	0,089	-0,07	0,90
Sad; Blocked	547,89	125,98	828,18	139,17	5,15	0,000	0,80	1,81
Angry; Free	620,32	120,11	624,53	132,69	0,07	0,943	-0,47	0,50
Angry; Blocked	527,04	125,98	738,02	139,17	2,87	0,006	0,22	1,23

Appendix G: Statistics of Experiment 4

Analysis of EMG activity

Table 1
Repeated Measures Anova (3 x 2 x 3)

	SS	df	MS	F	p	η^2
Intercept	0,00	1	0,00	-4,97	1,000	-0,82
Error	0,00	11	0,00			
Muscle	0,00	2	0,00			
Error	0,00	22	0,00			
Mimicry	10,78	1	10,78	13,75	0,003	0,56
Error	8,62	11	0,78			
Expression	15,76	2	7,88	24,89	0,000	0,69
Error	6,97	22	0,32			
Muscle*Mimicry	9,40	2	4,70	16,50	0,000	0,60
Error	6,27	22	0,28			
Muscle*Expression	47,08	4	11,77	37,83	0,000	0,77
Error	13,69	44	0,31			
Mimicry*Expression	0,68	2	0,34	2,08	0,149	0,16
Error	3,63	22	0,16			
Muscle*Mimicry*Expression	0,59	4	0,15	1,11	0,365	0,09
Error	5,88	44	0,13			

η^2= partial eta-square

Table 2
Contrasts revealing differences of general facial activity between emotional expressions in free mimicry

Frown		No expression		Smile					*CI 95%*	
M	*SD*	*M*	*SD*	*M*	*SD*	contrast	*t(11)*	*p*	*LL*	*UL*
0,18	0,10	-0.56	0,06	-0,30	0.09	1 -2 1	6,38	0,000	1,95	4.01

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Table 3
Contrasts revealing main effect of emotional expressions on general facial activity (linear trend)

Frown		No expression		Smile					*CI 95%*	
M	*SD*	*M*	*SD*	*M*	*SD*	contrast	*t(11)*	*p*	*LL*	*UL*
0,33	0,06	- 0,33	0,06	-0,01	0,04	0 -1 1	6,06	0,000	2,53	5,41

Table 4
Contrasts revealing an impact of facial expression over each muscle

	Frown		No expression		Smile					*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	contrast	*t(11)*	*p*	*LL*	*UL*
Zygomaticus	-0,12	0,07	-0,28	0,07	0,40	0,12	0 -1 1	3,76	0,003	0,57	2,17
Corrugator	1,23	0,17	-0,58	0,09	-0,65	0,09	2 -1 -1	7,16	<0,000	5,12	9,67
Orb Oris	-0,11	0,05	-0,12	0,05	0,23	0,06	1 -1 2	3,25	0,008	0,30	1,59

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Table 5
Contrasts revealing an impact of mimicry manipulation compared to free mimicry, in no expression condition.

	Blocked mimicry		Free mimicry				*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*t(11)*	*p*	*LL*	*UL*
No Expression	-0,10	0,09	-0,56	0,06	4,83	0,001	0,74	1,98

Table 6
Contrasts revealing an impact of mimicry manipulation compared to free mimicry, per muscle.

	Blocked mimicry		Free mimicry				*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*t(11)*	*p*	*LL*	*UL*
Zygomaticus	0,28	0,10	-0,28	0,10	2,99	0,012	0,45	2,96
Corrugator	-0,06	0,04	0,06	0,04	-1,34	0,208	-0,91	0,22
Orbicularis Oris	0,44	0,09	-0,44	0,09	4,97	0,000	1,48	3,83

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Table 7
Contrasts revealing the impact of smile expression over the zygomaticus and orbicularis oris, compared to no exposure, when individuals are blocked and free to mimic.

	Smile		No expression				*CI 95%*	
Zygomaticus	*M*	*SD*	*M*	*SD*	*t(11)*	*p*	*LL*	*UL*
Free mimicry	0,02	0,19	-0,53	0,07	2,76	0,019	0,11	1
Blocked	0,78	0,2	-0,03	0,14	0,86	0,406	-0,4	-0,93
Free mimicry	0,02	0,19	-0,53	0,07				
	Smile		No expression				*CI 95%*	
Oribicularis	*M*	*SD*	*M*	*SD*	*t(11)*	*p*	*LL*	*UL*
Free mimicry	-0,2	0,17	-0,57	0,08	2,83	0,016	0,08	0,64
Blocked mimicry	0,67	0,15	0,33	0,11	-0,08	0,937	-0,55	0,51
Free mimicry	-0,2	0,17	-0,57	0,08				

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Table 8

Contrasts revealing the impact of frowning facial expressions over the corrugator and orbicularis oris, compared to no exposure, when individuals are blocked and free to mimic.

	Frown		No expression				*CI 95%*	
Corrugator	*M*	*SD*	*M*	*SD*	*t(11)*	*p*	*LL*	*UL*
Free mimicry	1,45	0,21	-0,57	0,12	6,59	0	1,34	2,69
Blocked	1,02	0,19	-0,6	0,08				
Free mimicry	1,45	0,21	-0,57	0,12	-1,81	0,097	-0,88	0,09
	Frown		No expression				*CI 95%*	
Oribicularis	*M*	*SD*	*M*	*SD*	*t(11)*	*p*	*LL*	*UL*
Free mimicry	-0,56	0,07	-0,57	0,08	0,08	0,939	-0,12	0,13

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Appendix H: Statistics of Experiment 5

Analysis of EMG activity

Table 1
Repeated Measures Anova (3 x 2 x 3)

	SS	df	MS	F	p	η^2
Intercept	31,93	1	31,93	3,58	0,068	0,11
Error	267,76	30	8,93			
Muscle	27,30	2	13,65	1,84	0,167	0,06
Error	444,06	60	7,40			
Mimicry	117,32	1	117,32	12,90	0,001	0,30
Error	272,81	30	9,09			
Emotion	2,67	3	0,89	1,97	0,124	0,06
Error	40,64	90	0,45			
Muscle*Mimicry	95,11	2	47,56	5,68	0,005	0,16
Error	502,14	60	8,37			
MUSCLE*EXPRESSION	1,62	6	0,27	0,62	0,715	0,02
Error	78,55	180	0,44			
Mimicry*Emotion	0,40	3	0,13	0,23	0,874	0,01
Error	51,94	90	0,58			
Muscle*Mimicry*Emotion	3,84	6	0,64	1,30	0,261	0,04
Error	88,91	180	0,49			

η^2= partial eta-square

Table 2
Contrasts revealing an impact of mimicry manipulation compared to free mimicry, per muscle.

	Blocked mimicry		Free mimicry				*CI 95%*	
Condition	*M*	*SD*	*M*	*SD*	*t(30)*	*p*	*LL*	*UL*
Zygomaticus	0,55	0,08	-0,33	0,08	6,18	0,000	-4,69	-2,36
Corrugator	-0,02	0,10	0,10	0,08	0,71	0,483	-0,91	1,89
Orbicularis Oris	1,29	0,60	-0,34	0,10	2,68	0,012	1,54	11,44

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Table 3

Contrasts revealing the impact of the blocking manipulation over the zygomaticus when different stimuli are processed.

	Blocked mimicry		Free mimicry				*CI 95%*	
	M	*SD*	*M*	*SD*	*t(30)*	*p*	*LL*	*UL*
Angry (1)	0,50	0,10	-0,25	0,12	0,56	0,581	-0,97	1,69
Happy (1)	0,48	0,14	-0,23	0,14				
Sad (1)	0,58	0,13	-0,50	0,11				
No expression (-3)	0,62	0,15	-0,35	0,12				
Angry (1)	-	-	-0,25	0,12	2,3	0,028	0,07	1,2
Happy (2)	-	-	-0,23	0,14				
Sad (-2)	-	-	-0,50	0,11				
No expression (-1)	-	-	-0,35	0,12				
Angry (1)	0,50	0,10	-0,25	0,12	1,95	0,061	-0,05	1,96
Happy (2)	0,48	0,14	-0,23	0,14				
Sad (-2)	0,58	0,13	-0,50	0,11				
No expression (-1)	0,62	0,15	-0,35	0,12				
Angry (1)	0,50	0,10	-	-	0,92	0,363	-1,04	0,39
Happy (2)	0,48	0,14	-	-				
Sad (-2)	0,58	0,13	-	-				
No expression (-1)	0,62	0,15	-	-				

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Table 4

Contrasts revealing the impact of the blocking manipulation over the orbicularis oris when different stimuli are processed.

	Blocked mimicry		Free mimicry				*CI 95%*	
	M	*SD*	*M*	*SD*	*t(30)*	*p*	*LL*	*UL*
Angry (1)	1,34	0,59	-0,31	0,14	1,68	0,103	-0,2	2,07
Happy (1)	1,46	0,80	-0,36	0,12				
Sad (1)	1,30	0,52	-0,34	0,11				
No expression (-3)	1,05	0,52	-0,34	0,11				
Angry (1)	1,34	0,59	-	-	2,07	0,047	0,01	1,91
Happy (1)	1,46	0,80	-	-				
Sad (1)	1,30	0,52	-	-				
No expression (-3)	1,05	0,52	-	-				

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Table 5

Contrasts revealing the impact of the blocking manipulation over the corrugator when different stimuli are processed.

	Blocked mimicry		Free mimicry				*CI 95%*	
	M	*SD*	*M*	*SD*	*t(30)*	*p*	*LL*	*UL*
Angry (1)	0,00	0,13	0,20	0,12	0,65	0,518	-0,92	1,78
Happy (1)	0,19	0,13	0,14	0,16				
Sad (1)	-0,15	0,12	0,16	0,15				
No expression (-3)	-0,11	0,18	-0,10	0,12				
Angry (1)	-	-	0,20	0,12	2,17	0,038	0,05	1,55
Happy (1)	-	-	0,14	0,16				
Sad (1)	-	-	0,16	0,15				
No expression (-3)	-	-	-0,10	0,12				
Angry (1)	0,00	0,13	-	-	0,79	0,433	-0,57	1,29
Happy (1)	0,19	0,13	-	-				
Sad (1)	-0,15	0,12	-	-				
No expression (-3)	-0,11	0,18	-	-				
Angry (1)	0,00	0,13	0,20	0,12	0,68	0,500	-0,38	0,76
No expression (-1)	-0,11	0,18	-0,10	0,12				
Sad (1)	-0,15	0,12	0,16	0,15	1,1	0,282	-0,26	0,87
No expression (-1)	-0,11	0,18	-0,10	0,12				

CI= Confidence interval (95%); LL= lower limit; UL= upper limit

Table 6

Contrasts revealing the impact of angry and sad photos compaired to the no expression condition.

					CI 95%	
	M	*SD*	*t(30)*	*p*	*LL*	*UL*
Angry (1)	0,10	0,06	2,27	0,031	0,04	0,78
No expression (-1)	-0,10	0,07				
Sad (1)	0,00	0,09	0,99	0,329	-0,23	0,66
No expression (-1)	-0,10	0,07				

CI= Confidence interval (95%); LL= lower limit; UL= upper limit