

Using EEG mu-suppression to explore group biases in motor resonance

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Abstract

Similar neural circuits are activated during action and the observation of action, and such motor resonance is said to support action understanding and to facilitate social coordination. In this chapter we describe a line of research that uses suppression of electroencephalographic mu-oscillations as an indicator of motor resonance to look at motor resonance in an intergroup context. We discuss findings showing that group biases can restrict motor resonance to the ethnic ingroup, with potential negative consequences for intergroup encounters and relations. We, then, present research that tests the boundary conditions of the ingroup bias in motor resonance. We show that when motivational relevance of the outgroup is increased, because participants are in an inclusive, perspective taking mindset, group biases in motor resonance disappear. Similarly, when the situation is highly motivationally relevant, such as when the behavior poses a potential threat, people will show motor resonance in response to anyone independent of group membership.

“The opposite of love is not hate, it is indifference.” ~ Elie Wiesel

Humans have an incredible capacity to empathize with others, to understand their actions and intentions, and to use this information to coordinate their own behavior with the behavior of these others. When it comes to our loved ones, our family and friends, or our social ingroup, we use the full extent of our empathic abilities. We automatically catch their emotions, and the meaning and intentions of their actions, which provide us with an intuitive understanding of their inner states. Thereby, we help them when they are in need, we bond with them, and we can act in unison and close cooperation. With those we hate, our adversaries or competitors, it is different. We still have a need to understand their emotions, actions and intentions, but for more selfish reasons. Here we use our empathic abilities to anticipate our opponent's next move and to be prepared. Hence, despite our selfish reasons, we still are receptive to the inner states of our enemies. But, what about those towards whom we feel nothing but indifference, the homeless person on the street, maybe the nameless service person, or simply those who we consider part of a social outgroup? Could it be that we do not intuitively catch their intentions, needs and emotions?

We started wondering about this question not, as usually, because we read an interesting article in a social psychology journal, nor because we saw an inspiring talk at a social psychology conference. Instead, we came across an interesting phenomenon primarily discussed in the neurosciences – the mirroring process or motor resonance – and were intrigued by its potential implications for social psychology.

Motor resonance is a very basic and simple process: A subset of motor neurons are active not only during motor activity, but also when the perceiver remains completely still and observes someone else engaging in motor activity (Di Pellegrino, Fadiga, Fogassi, Gallese, Rizzolatti, 1992; Rizzolatti, Fadiga, Fogassi, & Gallese, 1996). Despite its simplicity motor resonance seems to contribute to many much more complex and important social

functions. For instance, motor resonance has now been associated with better performances in tasks that require emotional empathy (Pineda & Hecht, 2009), and it is said to foster an intuitive understanding of the other's actions and emotions (Iacoboni, 2009; Hurley, 2008), potentially facilitating interpersonal coordination and cooperation (Knoblich & Sebanz, 2006).

Reading about motor resonance was fascinating and the phenomenon seemed to be incredible relevant for social psychology; here was a mechanism that could potentially explain how and why people can so easily and effortlessly connect with each other. We noticed, however, that it was often implied that motor resonance happens relatively automatically, without much influence from top-down processes (e.g., Chong, & Mattingley, 2009; Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Iacoboni, 2005; van Schie, Waterschoot, & Bekkering, 2008) and only a few studies have investigated the nature of top-down influences on motor resonance (e.g. Aglioti, Cesari, Romani, & Urgesi, 2008; Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2005; Iacoboni, 2005; Oberman, Ramachandran, & Pineda, 2008; Sartori, Cavallo, Bucchioni, & Castiello, 2011). Moreover those that did mostly focused on relatively basic processes such as attention or situational context. At the same time, we know from research on social cognition that even very basic perceptual processes are susceptible to higher order cognitive processes. For instance, face recognition (Bernstein, Young, & Hugenberg, 2007), the interpretation of facial expression (Elfenbein & Ambady, 2002), and memory (Rothbart, Evans, & Fulero, 1979) are all very basic processes that are still influenced by social categorization and prejudice. The same could be true for motor resonance, and finding a group bias in motor resonance could have important implications for both the literature on intergroup processes and the literature on motor resonance. If people indeed resonated less with outgroup members, they would potentially have a harder time to predict their actions and intentions and to coordinate their actions with

them. Moreover, to show that motor resonance is indeed influenced by social categorization and prejudice would suggest that motor resonance is susceptible to culturally learned attitudes and biases.

We were intrigued by the mirror mechanism and its potential for answering important social psychological questions, and then we came across an article by Pineda (2005) in which he discussed a method that uses EEG to investigate motor resonance. Being experienced with EEG it was clear to us that this technique would enable us to measure motor resonance, cost efficiently and relatively conveniently. In addition, because EEG is easily applicable, and a relatively unobtrusive measure of brain activity so that participants would be left relatively unconstrained, allowing them to perform complex actions, and potentially even to interact with others during EEG recording.

Here we describe four studies that use EEG to investigate group biases in motor resonance. Specifically, we used EEG to measure neural activity in sensory motor areas during observation of actions performed by ingroup and outgroup members. We propose that, as a default, people do not resonate with ethnic outgroup members, but once outgroup members' behavior becomes motivationally relevant, either because group boundaries are blurred, or because the outgroup member poses a threat, people become sensitive to outgroup members' inner states.

Motor resonance

A now classic effect in social psychology is that perceiving someone else's behavior increases a tendency in the perceiver to behave similarly (James, 1890; Chartrand & Bargh, 1999). This happens because actions and the mere perception or imagination of the same action share common representations (Prinz, 1987; Preston & de Waal, 2002). In the brain, this action-perception link is said to be implemented by the so called mirror neurons; A subset of sensory motor neurons that are active during motor activity, but also when the

perceiver remains completely still and sees someone else engaging in motor activity (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003; Rizzolatti & Craighero, 2004). Mirror neurons have been discovered using single cell recordings in monkeys, but, being an invasive method requiring open brain surgery, single cell recordings in humans are hard to get due to ethical considerations, and thus far only one study has shown mirror neurons in humans using single cell recording (Mukamel, Ekstrom, Kaplan, Iacoboni, & Fried, 2010). For the lack of opportunities for single cell recording studies in humans, mirror neuron activity is usually investigated using corresponding neural activation of sensory motor areas within an observer in response to the mere perception of motor activity in the target as a proxy. This motor resonance is considered to underlie the understanding of actions and intentions which is in turn essential for interpersonal and social processes such as learning through observation and interpersonal coordination. For example, research shows that motor resonance goes beyond the mere mechanics of a motion, but seems to map the function and goal of the action; Mirror neurons fire, even when the “observer” can only partially (Umiltà, et al., 2001) or not at all (Kohler et al., 2002) see the action. Moreover, motor resonance is more pronounced for goal directed action (Cattaneo, Caruana, Jezzini, & Rizzolatti, 2009) and specific groups of mirror neurons respond to specific and unique goals of actions (Gallese, Gernsbacher, Heyes, Hickok, & Iacoboni, 2011), such as grasping to put something into a container vs. grasping to bring something to one's mouth (Bonini et al., 2010).

Generally, motor resonance has been suggested to be automatic and to occur without conscious effort (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti & Craighero, 2004; Wilson & Knoblich, 2005), but this does not mean that everyone resonates with just anyone in any situation. What it probably comes down to is whether the action in question is motivationally relevant to the observer or not.

The functional approach to motor resonance

People tend to allocate their limited cognitive and perceptual resources towards others who are motivationally relevant to them (Ackerman, et al., 2006). These relevant others are most often members of the social ingroup. One reason for this is that from an evolutionary perspective ingroup members are more often beneficial for one's reproductive fitness. According to the concept of inclusive fitness (Hamilton, 1964, as cited in Cialdini, Brown, Lewis, Luce, & Neuberg, 1997), individuals can promote their own evolutionary success by helping others who share some of their genes (Sime, 1983). The degree of genetic overlap, however, is impossible to detect, and thus people have to use proxies of genetic overlap such as the degree of kinship, similarity, familiarity, and affiliation. Ingroup members are generally perceived as more similar to oneself than outgroup members (Turner, Brown, & Tajfel, 1979). Moreover, ingroup members are usually the ones with whom we most often interact, and if we interact with outgroup members this mostly happens on a group level rather than in one on one intimate interactions (Fiske, 1992). Consequently, intra group interactions are most important to us, and since cognitive resources are limited, processing outgroup members inner states most often does not take priority (Ackerman et al., 2006).

Indeed, research in social cognition and social neuroscience revealed several group biases in the processing of others' inner states. Research participants show less neural activity in areas for social perception and social cognition in response to outgroup members (Harris & Fiske, 2006; Van Bavel et al., 2008), and they have a harder time recognizing outgroup members' faces and to interpret their facial expressions (Sporer, 2001; Elfenbein & Ambady, 2002). Moreover, they react less strongly to emotions such as happiness and fear when displayed by outgroup members (Weisbuch & Ambady, 2008), and they show less neural activity in the neural pain circuit when they see outgroup members experiencing physical pain (Xu, Zuo, Wang, & Han, 2009), or emotionally painful situations (Mathur, Harada, Lipke, & Chiao, 2010) than when they see pain in ingroup members. Taken together, these

findings suggest that across perceptual domains, people are less sensitive and perceptive to the inner states of social outgroup members. However, this does not necessarily mean that social perception is entirely reserved for the social ingroup. When the outgroup becomes motivationally relevant, it is possible that people would be as responsive to outgroup members as to ingroup members. For example, Ackerman and colleagues (2009) showed that, although usually people have problems to tell different outgroup faces apart, when the faces are angry, research participants performed even better in recognizing outgroup members' faces than ingroup faces. Hence, when outgroup members become motivationally relevant, in this case because they potentially could pose a threat, group biases in social perception are alleviated or even reversed.

Given the role of behavioral relevance and social group membership in social perception, it is likely that group biases also exist in motor resonance. Such a bias could leave people to be less responsive to the inner states of outgroup members, potentially hampering cross-group interactions and cooperation. In what follows, we will describe a series of studies that investigate how group categories, prejudice and motivational relevance influence the amount of motor resonance in response to others. In all studies reported here we used suppression of electroencephalographic mu oscillations during the observation of actions as an index of motor resonance.

Mu-suppression as a measure of motor resonance

The mu-rhythm is a well established measure of neural activity in the sensory motor cortex (Kuhlman, 1978; Pfurtscheller, & Aranibar, 1979). The alpha component of the mu-rhythm (8-12 Hz) seems to originate from primary somatosensory cortex (Hari, 2006) and shows a synchronized activity at rest, which is desynchronized, both during movement and during passive observation of movement, leading to a suppression of mu (Pineda, 2005).

During execution of movement, neurons in the premotor, motor and in the sensorimotor cortices are activated. Therefore, mu-suppression while a person is moving is probably the result of motor neurons and mirror neurons. In the absence of overt movement, motor neurons should no longer be active, leaving only mirror neurons to contribute to mu-suppression (Pineda, 2005). Mu-suppression during action observation should, therefore, be exclusively attributed to the discharge of mirror neurons. Anatomically, mirror neurons located in the ventral premotor cortex could affect neurons in the primary sensorimotor cortex through existing strong connections between these two regions, resulting in mu-suppression (Pineda, 2005). Mu-suppression, thus, seems to be a good indicator of motor resonance and mirror neuron activity (Puzzo, Cooper, Cantarella, & Russo, 2011).

Studies measuring mu-suppression differ in the experimental and control conditions during which mu is measured, but they mostly follow the same general principle. At the beginning of the experimental session, researchers assess participants' baseline brain activity. For example, EEG is recorded while the participant sits completely still either looking at a blank screen, or visual white noise. Following, participants usually are shown videos of others performing a goal directed action. These videos often only depict the hands of the other person to keep other target related factors controlled (e.g., Oberman et al., 2008), but richer stimuli can sometimes be beneficial. For example, in our research we usually choose to present videos depicting large parts of the body and even the face. We do this to create an experience similar to actual social interactions. Across studies using mu-suppression, the length of the videos varies, but in general the methods used can be split into two kinds of protocols: The long exposure protocol and the multiple repetitions protocol. Long exposure protocols use longer videos, usually longer than 10 seconds, and each video is shown once or sometimes twice (e.g. Oberman et al., 2005; Gutsell & Inzlicht, 2010). In contrast, in the multiple repetitions protocol, the videos are much shorter, usually 3-seconds or less, and the

same videos are presented multiple times each trial preceded by a fixation cross (e.g., Puzzo et al., 2011). Research shows that the multiple repetitions protocol can elicit stronger mu-suppression for relatively minimal stimuli (e.g., a hand squeezing a ball; Puzzo et al., 2011). Nonetheless, because in our research the stimulus videos are more complex, and because we are interested in social processes, we chose to use a long exposure protocol in order to create a more realistic experience for the participants. The fact that it is possible to use relatively rich stimuli depicting complex actions makes mu-suppression a flexible tool that is particularly suitable for answering social psychological questions. Moreover, this method allows participants to be relatively unrestrained by the equipment so that they themselves can move and perform actions. Both these assets could potentially enable researchers to measure motor resonance during actual interactions with real people, and when using a portable EEG system, this interaction could even take place outside of the laboratory. This flexibility is certainly an advantage over more cumbersome methods such as MRI or TMS.

Mu-suppression is usually strongest over the contralateral sensory motor areas (C3 or C4 depending on laterality), but can still be measured in the adjacent more frontal areas (FC-strip) and more posterior areas (CP-strip; Puzzo et al., 2011). We measured mu-suppression primarily looking at C3 — since right handed participants were presented with right-hand actions.

Biased motor resonance

Our first study using mu-suppression to assess motor resonance in an intergroup context was aimed to test the general effect: Is there a group bias in motor resonance (Gutsell & Inzlicht, 2010). We expected that, by default, people would only show motor resonance in response to seeing members of their ingroup performing an action, and not in response to the actions of outgroup members. Moreover, we expected that such an ingroup bias in motor resonance would be strongest for people high in prejudice. To test this prediction, we first

assessed participants' level of prejudice in a mass testing session at the beginning of the term. Specifically, we used the symbolic racism 2000 scale (Henry & Sears, 2002) — a measure of modern racism, indicative of a subtle form of racism that obscures racist feelings with abstract values, such as justice and order. Several weeks later, we invited participants to the laboratory one at a time and showed them videos of ingroup and outgroup members performing a simple action, while we measured their EEG. Specifically, we used a one-way within subject design showing each participant videos of ingroup members and outgroup members, and then had them perform the action themselves. For the purpose of all the studies described here, we defined group in terms of ethnic group membership. Following video presentation we asked participants to perform the same action themselves.

The data obtained during the self condition confirmed that we were indeed picking up neural motor activity. When people actually performed the action they showed a suppression of mu over electrode C3 — the contra lateral electrode site over motor areas compared to mu during baseline. Interestingly, and more central to our hypotheses on motor resonance we did also find mu-suppression when participants were sitting completely still, simply observing ingroup members performing the action. These results are indicative of motor resonance in response to the ingroup. Critically, the same test for mu-suppression was not significant for EEG activity during the outgroup condition. Participants did not show mu-suppression for the ingroup. Moreover, mu-suppression for the outgroup was significantly less than mu-suppression in response to the ingroup, further supporting a group bias in motor resonance. These findings suggest that people do not resonate with the actions of outgroups. We take this as evidence that people experience less vicarious action and their associated somatic and autonomic states when confronted with outgroups than with ingroups (please see Gutsell & Inzlicht, 2010 for a full description of the findings).

Although our findings suggest that people in general show this bias, not everyone seems to show it to the same degree. When we looked at the influence of prejudice, we found a negative correlation between mu-suppression for the outgroup and level of prejudice reflected in participant's score on the symbolic racism scale. Thus, the more prejudiced participants were the less mu suppression they showed in response to outgroups. In contrast, mu-suppression for the ingroup was unrelated to prejudice. The degree of bias in motor resonance is, therefore, influenced by how much people dislike the respective ethnic group. This is also reflected in the fact that when we break down the omnibus correlation into the specific ethnic groups, we find results that are consistent with a Canadian context: the correlation was strongest for South-Asians and followed by Blacks; the correlation for East Asians, however, was not significant. Thus, motor resonance, seems indeed to be limited to the ingroup and more so when the perceiver is prejudiced or when the group in question is disliked.

According to social identity theory the psychological self extends to include other people and our social ingroups so that the ingroup becomes part of the self (Turner et al., 1979). Hence, if we take a functional approach to motor resonance, it makes sense that people resonate with ingroup members but not with outgroup members; since ingroup members are the ones people feel closest to, it is important to understand their actions and intentions. In contrast, people might not feel the same need to resonate with outgroup members, especially not when these groups are disliked. If a lack in closeness and liking indeed, at least partly, explains the ingroup bias in motor resonance, then somehow bringing the ingroup closer to the self and reducing prejudice should alleviate such biases. One mean to increase closeness to social outgroups and to reduce prejudice is cognitive perspective taking.

Facilitating cross-group motor resonance by blurring group boundaries

Cognitive perspective taking refers to the active contemplation of others' psychological experiences, and facilitates altruistic behavior (Batson et al., 1997) and cooperation (Batson & Moran, 1999), and promotes conflict resolution (Galinsky, Maddux, Gilin, & White, 2008). In addition to these more general benefits, perspective taking can be helpful in an intergroup context (Batson et al., 1997, Dovidio et al., 2004, Galinsky & Moskowitz, 2000). For example, perspective taking improves evaluations of specific members of the outgroup (Shih, Wang, Trahan Bucher, & Stotzer, 2009) and of the outgroup more generally (Dovidio et al, 2004; Galinsky & Ku, 2004). Given all the benefits of perspective taking, a perspective taking mindset could potentially be a powerful tool to decrease intergroup biases, including biases in motor resonance.

To investigate the effects of cognitive perspective taking on motor resonance in an intergroup context, we used the same design as in the first study, but this time before participants saw the videos, they completed a mindset manipulation. Specifically, they saw a picture of a young Black university student and were asked to write a short story about a day in his life, either taking his perspective and writing in first person, or remaining objective and writing in third person. Following, we had participants complete the same action video task as in the previous study while we recorded their EEG. Please see Gutsell and Inzlicht (2012a) for a more detailed description of the study and findings.

The results suggest that the kind of mindset really does matter, and that a perspective taking mindset can indeed reduce group biases in motor resonance. When in an objective mindset, participants did not show mu-suppression, neither for the ingroup nor for the outgroup. Hence, taking a step back and distancing oneself from the emotions and intentions of others can reduce motor resonance even for ingroup members. Similarly, when in a perspective taking mindset, participants showed mu-suppression in response to ingroup and outgroup members, reflecting a facilitating effect of a perspective taking mindset on motor

resonance in general, and motor resonance in response to outgroup members in particular. Moreover, while participants in the objective mindset condition show an ingroup bias in motor resonance – mu-suppression is stronger for the ingroup than for the outgroup, those in a perspective taking mindset do not show such group distinction – mu-suppression for the ingroup and outgroup did not differ.

Taken together, the two studies described so far suggest that as a default, people tend not to resonate with the actions of outgroup members. Consequently they might not intuitively grasp outgroup member's actions, intentions and inner states. Study 2 provides evidence for the utility of perspective taking as a strategy for combating this subtle consequence of racial bias. A potential mechanism for the beneficial effects of perspective taking is an increase in self-other overlap with the outgroup. Taking the perspective of another person increases the link between the mental representations of the self and the mental representations of the other (Davis, Conklin, Smith, & Luce, 1996; Galinsky & Moskowitz, 2000). It leads people to ascribe more of their own traits to the other (Galinsky & Ku, 2004). Moreover, perspective taking makes people see more of the other in themselves (Ku, Wang, & Galinsky, 2010), such that the self concept extends to include the other, and this is thought to assist goals related to social connection (Tiedens & Jimenez, 2003), and to increase social coordination (Galinsky et al., 2008). Through this mechanism, taking the perspective of the Black student in the story writing task would increase a feeling of connectedness and affiliation with the student, and this affiliation goal would lead to increases in motor resonance. Thus Study 2 suggests that by blurring the boundary between the self and the outgroup, people are more likely to resonate with the actions of outgroup members. In a third study (Gutsell & Inzlicht, 2012b) we aimed to test this mechanism once more, this time using a more direct route in manipulating feelings of similarity and

connectedness to outgroup members: people's beliefs in genetic overlap between ethnic groups.

Despite the fact that people actually share all but a minuscule portion of their genetic information with everyone else on the planet (Feldman, Lewontin, & King, 2003), for centuries, people have been classified into different racial groups (Frederickson, 2003). How does the belief in genetic overlap between people relate to motor resonance? Do people who think that they share more of their genes with any other person, tend to be more likely to resonate with the actions of those around them? We, once more used EEG mu-suppression as an indicator of motor resonance. This time, however, we used a correlation design and correlated mu-suppression scores in response to actions of ethnic ingroup and outgroup members with people's score on a self-report measure of beliefs in genetic overlap. Specifically, we asked participants: "If you were to choose two people at random from the entire world, what percentage of genetic material would they have in common? (0-100%)". This measure of genetic overlap has been shown to be correlated with the tendency to see racial groups as clear-cut categories, and when people are led to believe in a high degree of genetic overlap, they expressed more implicit racial bias (Plaks, Malahy, Sedlins, & Shoda, 2011).

The results further support the functional account of motor resonance. We found a negative correlation between beliefs in genetic overlap and mu-suppression, such that participants of European-Canadian or East Asian-Canadian descent who believe in much genetic overlap, show more mu-suppression while they watch videos of ethnic ingroup members, but also ethnic outgroup members (African-Canadian and South Asian-Canadian descent). Therefore, when people believe to be more genetically related and thus closer and more connected to others in general, they are more likely to resonate with them, potentially leading to richer, more intuitive understanding of their actions and intentions.

Taken together, the findings on a perspective taking mindset and on beliefs for genetic overlap suggest that creating a sense of interconnectedness or closeness indeed can positively influence motor resonance and might potentially be a good mean to alleviate the ingroup bias in motor resonance. Motor resonance most likely helps people to get an intuitive understanding of other's actions and intentions (Fogassi et al., 2005) and might even be involved in basic empathic processes such as emotional contagion (Pineda & Hecht, 2009). Hence, group biases in motor resonance might ultimately translate to misunderstandings and impaired social rapport, empathy, and social coordination. Perspective taking and beliefs in strong genetic overlap across groups have been shown to successfully reduce prejudice (Batson et al., 1997; Galinsky & Ku, 2004; Plaks et al., 2011), and to create a sense of connectedness to the outgroup. Alleviating group biases in motor resonance might yet be another important benefit (Galinsky & Ku, 2004; Plaks et al., 2011) of these techniques. Other techniques that reduce the psychological gap between different ethnic groups might be similarly effective in reducing group biases in motor resonance. For example, Hogeveen and Obhi (2011) found that when videos of simple hand motions were paired with words that prime an interdependent self-construal such as "social", "family", and "help" (Aron, Aron, & Smollan, 1992) participants showed an increase in motor resonance, as measured with transcranial magnetic stimulation, in the interdependent trials as opposed to control trials. Once someone is perceived as similar, and once they are part of our inner circle of close others whose actions, intentions and goals we care about, it seems, our neural system for action understanding becomes sensitive to outgroup members.

Increasing closeness to the target, however, is not the only possible approach to make a target motivationally relevant. If we truly take a functional approach to motor resonance, it does not seem sensible to think that people only resonate with those who they feel close to. Altruism and reciprocity are not the only reasons for why we need to understand others goals

and intentions, for why other's behavior is motivationally relevant. Another reason for why a behavior might be relevant is that it poses a potential threat.

Motor resonance for threatening behavior

It is a well known psychological effect that people are particularly sensitive to negative information. This negativity bias (see reviews by Cacioppo & Bertson, 1994; Peeters & Czapinski 1990; Taylor 1991) has been shown in various domains, such as impression formation (Skowronski & Carlston, 1989), person memory (Ybarra & Stephan, 1996) and stimulus processing. For example, people spend more time looking at negative than positive stimuli, and perceive negative stimuli to be more complex than positive stimuli (DuCette & Soucar, 1974). In an intergroup context, the negativity bias is particularly powerful when anger is concerned. For example, research has shown that angry facial expressions capture and hold our attention (Öhman, Flykt, & Esteves, 2001). The reason probably is that anger is an interpersonal emotion and poses a threat if it is directed at the observer (Ackerman et al., 2006). Threatening outgroup behavior should therefore be particularly motivationally relevant for the individual and consequently should be a likely target for motor resonance. In fact, threatening outgroup behavior might even override any existing group biases in motor resonance.

In order to test this idea, we invited participants of European-Canadian and East Asian-Canadian descent to the lab and measured their EEG while they watched videos of European-Canadian or East Asian-Canadian actors respectively (ingroup condition), and while they watched South Asian- Canadian and African-Canadian actors (outgroup condition) (Gutsell & Inzlicht, 2012b). The design differed from the previous studies in that this time actors did not only display a neutral action (moving their arm up and down with a neutral face); they also displayed a positive action (repeatedly making the “thumb up” hand gesture with a

positive facial expression) and a threatening action (repeatedly doing the “giving someone the finger” hand gesture with an angry facial expression).

Replicating Study 1, participants did not show significant mu-suppression when observing neutral actions performed by outgroup members, but they did show significant mu-suppression in response to neutral ingroup actions. Once again, these findings show that as a default people have an ingroup bias when it comes to motor resonance. A similar pattern was found for positive actions — participants only showed significant mu-suppression during the observation of positive actions performed by ingroup members, but not during the observation of positive actions performed by outgroup members. Interestingly and as predicted, when the observed behavior was threatening, people did show significant mu-suppression in response to all targets — ingroup members as well as outgroup members, and the amount of mu-suppression in response to outgroup members no longer differed from the amount of mu-suppression in response to the ingroup. Thus, in the threat condition, participants no longer show an ingroup bias in motor resonance. We resonate with threatening outgroup members as much as we would usually only resonate with ingroup members.

These findings are consistent with a functional perspective on person perception. No matter whether the behavior of outgroup members is neutral or positive, people show an ingroup bias in motor resonance. In contrast, when outgroup behavior is negative and threatening, people seem to allocate cognitive resources to the threatening individual and start processing them as thoroughly as ingroup members – the ingroup bias in motor resonance disappears. Friendly outgroup members might be more likable and pleasant, but as long as we do not include them in our inner circle of relevant others we will not resonate with them. Thus, it is not so much about valence of the behavior, but about whether or not the behavior in question has implications for one's own goals, and behavior.

Added value

A failure to resonate with outgroup member's actions and intentions, and so to speak, to spontaneously "catch" the meaning of their actions and intentions can potentially have serious consequences for intergroup interactions. We presented research suggesting that, as a default, people do not resonate with ethnic outgroup members. However, once an outgroup member becomes motivationally relevant, either because the observer is in a perspective taking mindset, or because the outgroup member's behavior poses a potential threat, people start resonating, thereby becoming more sensitive to the inner states of outgroup members.

Our findings advance current theoretical understanding of cross-group interactions showing that one of the most basic processes underlying action perceptions is affected by group biases. Motor resonance, and the sharing of somatic, autonomic, and emotional states, facilitate social understanding and might foster smooth and rewarding intergroup interactions and coordination (Knoblich & Sebanz, 2006). Hence, people might not be as responsive to outgroup member's needs and goals and be less likely to intuitively grasp their intentions; They might also have a harder time to synchronize their own behavior with that of outgroup members and to compliment it during cooperation (Sebanz, Bekkering, & Knoblich, 2006). Therefore, investigating the limits and facilitating factors of motor resonance in an intergroup context is important in order to understand the challenges of intergroup interactions. Moreover, our findings provide a possible mechanism for effective interventions to improve cross-group interactions. For example, adopting a perspective taking mindset has been shown to be conducive to smooth and pleasant intergroup interaction experiences. The findings reported here suggest a potential mechanism: When in a perspective taking mindset, people are more likely to resonate even with outgroup members, which potentially could provide them with a richer, more intuitive understanding of the other's actions and intentions leading to smoother and more positive intergroup interactions. Taken together, eventually the

insights on motor resonance in an intergroup context might inform us on how one can potentially facilitate smoother intergroup encounters, and on how to create circumstances that support intergroup coordination and cooperation.

Finally, our findings contribute to the understanding of motor resonance by shedding light on the factors that facilitate and hamper motor resonance. We show that not only is motor resonance influenced by social categorization, but it can also be influenced by culturally learned prejudice and by temporarily induced mindsets. After all, motor resonance, like many other basic perception processes before, has turned out not to be as automatic as previously thought to be, but instead seems to be susceptible to the multifaceted and rich world of higher order cognitive processes that constitute human social cognition.

Strengths and weaknesses

In the studies described here we used EEG mu-suppression as an index for motor resonance. We chose to use EEG, because it is easily applicable, and a relatively unobtrusive measure of brain activity. Participants are, thus, left relatively unconstrained, enabling them to perform complex actions and potentially even to interact with others during EEG recording. Moreover, because each EEG session is relatively affordable compared to other methods of neural resonance such as fMRI, it allows for large enough samples to combine brain imaging with the use of more traditional measures used in social psychology, such as implicit reaction time measures of prejudice or self-report scales.

Motor resonance per definition is a phenomenon of the brain; it is the activation of the neural sensory motor system during observation of other's action. Theoretically it is linked to activity of a specific kind of neurons in these brain regions — the mirror neurons (Rizzolatti & Craighero, (2004). Therefore, in order to understand motor resonance, we need to adopt neuroscience techniques to measure brain activity. That said, motor resonance is related to at least two phenomena that can be studied using more traditional social psychological measures

— Automatic imitation and motor mimicry (Heyes, 2011), but the specific nature of the relationship between these phenomena is still unclear. Automatic imitation is a type of stimulus-response compatibility effect similar to well known effects such as the Stroop effect (Stroop, 1935). In automatic imitation paradigms (e.g. Stürmer, Aschersleben, & Prinz., 2000; Proctor & Vu, 2006), participants show response slowing when they have to perform one kind of action (e.g. opening their hand) in response to a stimulus, while a task-irrelevant and action incompatible (e.g. image of a closing hand) is presented, and they respond faster while an action compatible (e.g. image of an opening hand) is presented (e.g. Brass, Bekkering, Wohlschläger, & Prinz, 2000; Stürmer et al., 2000; Heyes, Bird, Johnson, & Haggard, 2005). The task irrelevant stimuli interfere with performing the required action, because participants co-represent the incompatible action depicted in the picture or video. Theoretically this co-representation and the resulting interference are the result of motor resonance and ultimately the mirror neuron system (Kilner, Paulignan, & Blakemore, 2003; Press, Bird, Flach, & Heyes, 2008, van Schie et al., 2008). Catmur, Walsh & Heyes (2009) showed that temporally disrupting the function of relevant motor areas using TMS impaired automatic imitation, suggesting that motor resonance indeed is underlying implicit imitation. Unfortunately, other than this finding, experimental evidence is still scarce and more research is necessary.

In contrast to automatic imitation, motor mimicry can be observed in naturalistic social situations and real interactions (Hess, 2011). When we interact with others, we unconsciously mimic their postures and mannerisms (Chartrand & Bargh, 1999) and this seems to have many interpersonal benefits. For example, motor mimicry promotes liking (Chartrand & Barth, 1999, Hove & Risen, 2009), and feelings of closeness (van Baaren, Holland, Kawakami, & van Knippenberg, 2004). Moreover, motor mimicry also seems to be influenced by group biases: Although people mimic others' expressions, gestures, and body

postures, this occurs with less frequency for outgroup members (Likowski, Mühlberger, Seibt, Pauli, & Weyers, 2008). This similarity in findings suggests that potentially group biases in motor resonance might translate to reduced motor mimicry depriving intergroup interactions of the many benefits mimicry can have on interpersonal rapport.

Intuitively it does make sense, that motor mimicry depends on motor resonance and is based on the same psychological process responsible for automatic imitation, but thus far, there is not much research integrating the three. Hence, how motor resonance, automatic imitation, and motor mimicry are related, and specifically, whether motor resonance is the neurological process that gives rise to the two behavioral phenomena is still relatively unclear. Therefore, motor resonance is a neural process that might not always and not necessarily be expressed in reaction times or actual motor behavior, and in order to research motor resonance one has to employ brain imaging methods such as fMRI, TMS or EEG. Which one of these methods best to use depends on the researcher's preferences, the availability of the equipment, and on the specific requirements and restrictions the specific research question poses on experimental design. Using EEG mu-suppression gave us the opportunity to have relatively large sample sizes, making between subject designs and the use of self-report measures possible. We also appreciated that this method is relatively unobtrusive and tolerant to movement artifacts. Finally, we think that the ability to present continuous and rich stimuli opens up opportunities to create studies that more accurately simulate the experience during real life interactions.

Ultimately, we need to link motor resonance back to behavior in actual interactions. We know that motor resonance gives rise to an intuitive understanding of another's experiences (Iacoboni, 2009; Hurley, 2008). Motor resonance has also been associated with many other cognitive processes, such as learning and the experience of empathy (Gallese et al., 2011), but how does this translate to intergroup behavior? If we did not resonate with

outgroup members, would we have a harder time predicting their next move, and would we have trouble coordinating our actions with theirs? Would we be less likely to learn from their mistakes, or to help them when they are in need? Ultimately, these are the kind of questions we as social psychologists are most interested in. Understanding motor resonance in an intergroup context is the first step on a journey to understand how it is expressed on a behavioral level, and how group biases in motor resonance affect intergroup experiences and interactions.

Recommended Readings

An in depth discussion about controversial topics regarding mirror neurons. Leading experts on the subject debate the functions of mirror neurons:

Gallese, V., Gernsbacher, M.A., Heyes, C., Hickok, G., & Iacoboni, M. (2011) Mirror Neuron Forum. *Perspectives on Psychological Science*, 6, 369-407.

A detailed description of the mirror neuron system, which provides a good overview of the theory and the supporting empirical evidence:

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual review of neuroscience*, 27

A stimulating and engaging account on how we understand others. This book provides a good overview on the philosophical debate surrounding simulation theory and covers empirical supporting findings from developmental psychology, social psychology and neurosciences.

Goldman, A. I. (2006). *Simulating minds: The philosophy, psychology, and neuroscience of mindreading*. Oxford: Oxford University Press.

This article describes the findings of Study 1 discussed in this chapter and provides additional information on how we measured mu-suppression:

Gutsell, J. N., & Inzlicht, M. (2010). Empathy constrained: Prejudice predicts reduced mental simulation of actions during observation of outgroups. *Journal of Experimental Social Psychology*, 46(5), 841-845.

A discussion of the mu-rhythm and its relation to mirror neuron activity:

Pineda, J. A. (2005). The functional significance of mu rhythms: Translating "seeing" and "hearing" into "doing". *Brain Research Reviews*, 50, 57-68.

A study exploring methodological questions on how best to use EEG-mu suppression as an index of motor resonance:

Puzzo, I., Cooper, N. R., Cantarella, S., & Russo, R. (2011). Measuring the effects of manipulating stimulus presentation time on sensorimotor alpha and low beta reactivity during hand movement observation. *NeuroImage*, 57, 1358-1363.

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