



# Skin color has no impact on motor resonance: Evidence from mu rhythm suppression and imitation



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## ABSTRACT

It has been suggested that physical similarity with an observed model facilitates action-perception and understanding. Indeed, a number of studies have shown that observing actors of one's own race facilitate motor, sensory and pain resonance, possibly mediated by the human mirror-neuron system (hMNS). However, most of these studies have used stimuli that included emotional or cultural components, hence obscuring the precise contribution of physical similarity to resonance phenomena per se. The goal of the present study was to assess the effect of physical similarity (skin color) on motor resonance using stimuli that have no emotional and cultural components. We used both behavioral (imitation) and electrophysiological measures (mu-rhythm) to assess the effects of skin color on the hMNS during the observation of simple finger movements. Our results show that, in line with previous results, observation of biological movements resulted in faster reaction times and greater mu-rhythm suppression compared to non-biological movements. However, physical similarity did not affect imitation speed or mu-rhythm desynchronization. These results suggest that physical similarity with an observed action in terms of skin color does not modulate hMNS activity, and that the enhanced resonance effects reported in the previous studies are likely attributable to cultural and emotional aspects.

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## 1. Introduction

Many theorists explain concepts such as imitation by the fact that action perception precedes motor action through a common mechanism that creates shared representations of the action to be reproduced (Brass and Heyes, 2005). Neurophysiological evidence in favor of this shared representation hypothesis comes in part from the discovery of mirror neurons in the brain of the macaque monkey. Mirror neurons become active when an individual executes an action or observes that same action being performed by someone else (Rizzolatti et al., 1996; Gallese et al., 1996). These cells were originally discovered in the premotor region and are now thought to be part of a complex system that includes frontal, parietal, and arguably motor areas (Rizzolatti and Craighero, 2004; Tkach et al., 2007). In humans, direct evidence for the existence of mirror neurons comes from single-cell recordings in epileptic patients where neurons in regions such as the supplementary motor area discharge

during both observation and execution of actions (Mukamel et al., 2010).

In addition to direct evidence of mirror neuron function in humans, numerous studies using behavioral and electrophysiological techniques have greatly enhanced our understanding of the human mirror neuron system (hMNS). Imitation, for example, appears to be a direct product of the matching between action observation and execution. Indeed, it has been shown that imitation of biological motion is associated with the activation of hMNS areas (Iacoboni et al., 1999). Furthermore, transient disruption of frontal regions thought to be rich in mirror neurons significantly impairs imitation of distal movements (Heiser et al., 2003). At the neurophysiological level, the rolandic mu rhythm, an Alpha band rhythm that is suppressed when an individual observes or performs a motor act (Cochin et al., 1998; Muthukumaraswamy and Johnson, 2004), is believed to reflect hMNS activity (Pineda, 2005). Indeed, mu rhythm has been shown to be a sensitive marker of somatomotor regions activity during observation of biological movement (Ulloa and Pineda, 2007) and goal-oriented hand action (Muthukumaraswamy et al., 2004), as well as in context of imitative learning (Bernier et al., 2007), and motor imagery (Pineda et al., 2000).

In the last few years, efforts have been made to define the factors that can modulate motor resonance and hMNS activity. Attentional

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processes, for example, have been shown to have an important influence on the automatic imitation of bodily states (Bach et al., 2007; Chong et al., 2008). Using behavioral paradigms, Longo and colleagues showed that instructions given to a subject prior to an imitation task could have an important effect on imitation speed (Longo et al., 2008; Longo and Bertenthal, 2009). They found that when participants were instructed to pay attention to the fact that some of the observed hand movements were physically impossible to achieve, subjects' reaction times increased for these trials. In contrast, no difference in reaction time was observed when indications about the specific aspects of the movements presented were omitted (Longo et al., 2008). Longo and colleagues also showed that making participants conscious of the virtualness of an observed hand increased their reaction time compared to conditions when the same virtual hand was observed and imitated, but that aspect was not pointed out by the experimenter (Longo and Bertenthal, 2009).

Physical characteristics of a stimulus have also been suggested as modulating factors of motor resonance. For example, Press et al. (2005) showed that human hand actions elicit faster imitation than robotic hand. In another experiment, beliefs were separated from stimulus variables to explain the observed difference in automatic imitation of human and robotic hands (Press et al., 2006). It was found that variables such as the physical appearance of a hand stimulus had a greater effect on the imitative response than beliefs. Physical similarity with an observed action could thus theoretically influence mirror activity, whereby motor resonance would be achieved more readily when the action that is viewed or imitated looks more like the observer. Following on this idea, it has been shown that tactile perception is increased when individuals watch a model of their own race being touched (Serino et al., 2009). In a TMS study, increased corticospinal excitability was found in participants observing actors of their own race performing culture-specific hand movements, suggesting that mirror activity is modulated by race in action observation tasks (Molnar-Szakacs et al., 2007). A similar race bias was recently reported during observation of pain being inflicted to a human model, where it was found that activity in the anterior cingulate cortex, which has been implicated in empathic resonance (Singer et al., 2004), was stronger for racial in-group members (Xu et al., 2009). More recently, it was also shown in a fMRI study that the passive observation of faces of the same race as the observer activated more strongly hMNS areas than the observation of faces of a different race performing culturally meaningful gestures (Liew et al., 2011). While these results suggest the existence of modulatory effects of physical similarity on motor resonance, the stimuli used in these studies induced cultural interpretations and had obvious emotional content. Given that the hMNS is thought to play a role in action understanding and empathy, it is not possible from previous studies to delineate the precise contribution of physical similarity to motor resonance. To our knowledge, only one study has addressed this issue, and revealed some effect of physical similarity on motor cortex activity during action observation (Désy and Théoret, 2007). However, this effect seemed limited to female participants and involved the right hemisphere only, raising doubt about generalization of the findings.

The goal of the present study was to further investigate the effect of physical similarity on pure motor resonance. To this end, we conducted two studies using behavioral and electrophysiological measures to assess the effect of physical similarity on hMNS activity. In a first study, participants were asked to imitate simple finger movements that could either be similar or dissimilar to them in terms of skin color. In a second experiment, participants passively watched the same stimuli while EEG was used to measure mu rhythm activity over somatomotor regions.

## 2. Study 1

### 2.1. Materials and methods

#### 2.1.1. Participants

Fourteen healthy right-handed caucasian volunteers (7 females, 7 males), aged 19–28, participated in the study. All participants gave written informed consent, and the study protocol was approved by the *Comité d'éthique de la recherche des Sciences de la santé* and was conform to the 1964 Declaration of Helsinki.

#### 2.1.2. Stimuli and experimental procedure

Reaction times (RT) for imitation of hand actions were recorded following the presentation of video stimuli. The basic visual stimulus was based on a previous study by Jonas et al. (2007) and consisted of a right hand resting on a white horizontal plane with fingers slightly flexed. Hands were videotaped from a slightly lifted frontal view and were visible up to approximately one centimeter above the wrist. Female hands were presented to female participants, whereas male hands were shown to male participants. The stimuli also displayed hands with black skin and white skin, allowing half of the stimuli to be similar (white hands) or dissimilar (black hands) to the observer. All participants were asked at the end of the testing session what they had seen. Every participant reported having seen black and white hands. A red dot of a diameter of approximately 0.9° was labeled on both nails of the index and little fingers of each hand stimulus. In the center of the stimulus screen, a red cross was placed at the same distance from each of the two red dots. The dots placed on the fingernails allowed for two different types of movements to arise. The biological movement consisted of an up-and-down movement of either the little or index finger, including the dot. The non-biological motion presented a still hand with an up-and-down movement of one of the dots, in front of one of the still fingers. The movement made by the dot had the same kinematical profile as the biological motion, following identical spatial trajectory, speed, and movement amplitude. Each video began with a presentation of the still hand for 1500 ms, followed by the up-and-down movement of a dot or finger, lasting approximately 400 ms. The interstimulus interval was 5000 ms. Stimuli were presented on a 17-in. computer screen using MatLab. Before presentation of the stimuli, the participant's index and little fingers were connected to a reaction time detector. The custom-made apparatus consisted of a large aluminum surface on which the subject's right hand rested flat, palm down. Two finger-sized aluminum boards were attached to the index and small fingers of the hand. Every time the subject lifted a finger, the apparatus detected the movement and reaction time was recorded starting from movement onset in the video. Participants were seated 70 cm away from the screen and were instructed to fixate the red cross in the center of the screen at all times. The videos were presented in counterbalanced blocks of 96 trials. Two blocks were shown while the subject had to respond with the left hand, and two more while the imitation was done with the right hand. Hence, four blocks were presented, for a total of 384 trials. For each trial, the subject was instructed to imitate the observed movement, being the biological movement, with the finger going up-and-down, or the dot moving in front of a finger. The participant was to imitate as fast as possible, without trying to guess which finger would move next. The experiment lasted approximately 60 min.

#### 2.1.3. Data analysis

Trials where the participant made the wrong response were discarded. Responses of the index and little fingers were collapsed since differences in reaction times between fingers were of no interest. The same was done with the *Gender of participants* factor, as preliminary analysis revealed no significant difference between

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