Identification of Emotion in Faces Engages the Mirror Neuron System

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Introduction

- Mirror Neurons are visuo-motor neurons that become active when a person either initiates or observes a motor action (Pellegrino et al, 1992)
- Previous research has looked at the role of mirror neurons in embodied cognition, the ability to obtain implicit knowledge of other people's intentions through internal neural simulation
- Many prior studies used different stimuli for different conditions, leaving open the possibility that prior observed effects were driven by stimulus differences, and not by processing differences (Oberman et al., 2006; Muthukumaraswamy et al., 2004; Pitcher et al., 2008)

Questions

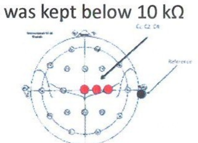
- Are mirror neurons involved in the processing and understanding of facial expressions?
- Is the human mirror neuron system modulated by task or by stimulus characteristics?

We addressed these questions by having subjects perform two different tasks using exactly the same face stimuli to investigate task-related modulation of mirror neuron activity.

Methods

EEG Acquisition

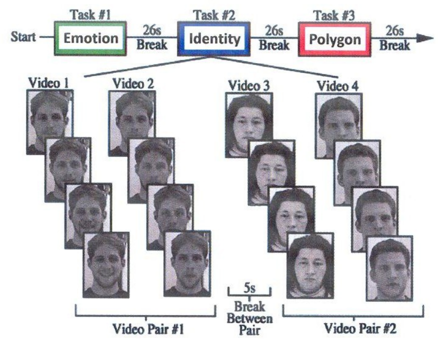
- Biopac Systems Inc. MP-36
- Electrodes placed over right motor cortex at Cz, C2, C4, selected based on previous EEG mirror neuron research (Olberman et al., 2007; Pitcher et al., 2008)
- Impedance was kept below 10 kΩ



EEG analysis

- EEGLAB software (Delorme & Makeig, 2004)
- Epoched by trial type (1 second before and 3 seconds after stimulus onset)
- Filtered with high-pass filter with a cutoff of 1 Hz
- Noisy epochs were removed automatically

Matching Tasks



- Pairs of ~3s videos presented, with 5s between pairs
- Two tasks with face movies in different blocks:
  - Identity: Same individual regardless of emotion
  - Emotion: Same emotion regardless of identity
- Subjects counted number of matching pairs and reported during break
- ***Importantly, stimuli were the same for both tasks***

Baseline Polygon Task

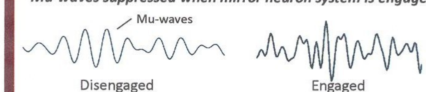
- Baseline task was pairs of ~3s videos of rotating geometric shapes with 5 s between pairs
- Shapes rotated to equate with other tasks in terms of motion component
- Subjects counted matching shape pairs
- ***Not expected to engage mirror neuron system***

Mu-Wave Suppression

Mu-wave (8-13 Hz)

- Represents synchronized neural activity measured over sensorimotor cortex when neural systems are ***not*** engaged
- Modulated when viewing or performing actions, and thus may be part of mirror neuron system (Muthukumaraswamy et al., 2004)
- Suppressed when MNS is engaged, thus mu-wave suppression is taken as an index of MNS activity

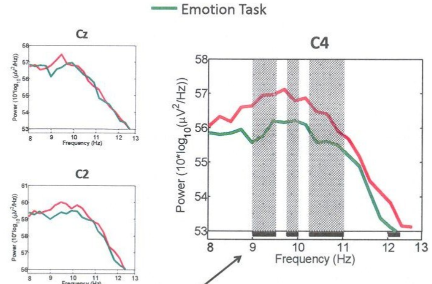
Mu-waves suppressed when mirror neuron system is engaged.



Results – Spectral Power

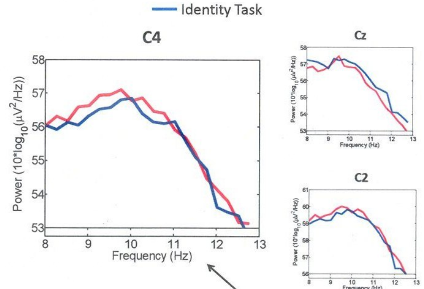
Mu-wave energy was assessed by averaging the power spectra for each subject within the 8-13 Hz (Mu-wave) range using a fast-Fourier transformation

Emotion Task vs. Polygon Baseline



Grey regions indicate significant Mu-Wave Suppression ($p < .05$, FDR corrected)

Identity Task vs. Polygon Baseline

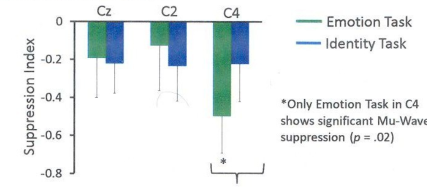


No significant Mu-Wave Suppression

Significant Mu-wave suppression in the Emotion Task, but not the Identity Task, in the most lateral and inferior electrode C4.

Suppression Index

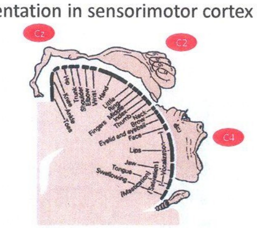
Suppression indices are the log of the ratio of integrals between 8-13 Hz for power spectra of a task of interest relative to a baseline task. A negative index is suppression, zero is no effect, and positive index is enhancement relative to baseline (Olberman et al, 2007).



Significantly more Mu-Wave suppression for Emotion than Identity Task in electrode C4 ($p = .044$ for main effect of task in C4)

Implications

- Mirror neuron system is differentially engaged by task demands:
  - Mirror neuron system engaged more for face ***emotion*** detection than face ***identification***
  - Cannot be due to stimuli, as they were identical for both tasks
- Electrode C4 shows differential effects, perhaps because this electrode is nearest the face representation in sensorimotor cortex



Future Research

- Is mu-wave suppression related to mirror neuron system or involuntary facial mimicry?
  - Simultaneous recording of brain activity and facial muscle activity using electromyography
- Additional data collection from other cortical regions could provide more insight into the role of mirror neurons in the processing of facial expressions

Acknowledgments

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Project Summary

As a social species, the ability to process and understand emotional signals is central to our daily function. Without it, we would be incapable of deciphering the intentions or motivations of those around us. Given this integral role of emotional signaling, I designed and conducted a summer research project that explored the neural basis of our ability to identify the emotions of others through their facial expressions. Specifically, I explored the role of the human mirror neuron system (hMNS) in the accurate identification of emotional expressions. Mirror neurons are specialized neurons that are activated when an individual performs a motor action (e.g., reaching for a ball), as well as when an individual observes another person perform a similar motor action. Thus, the name "mirror neuron" refers to the literal mirroring of an observed behavior as if performed by the observer. Similar to bodily movements, facial expressions involve very complex and specific muscle actions, and recent studies have begun investigating the role of mirror neurons in recognizing facial expressions.

Previous studies have reported increased mirror neuron activity in people during active discrimination between facial expressions (van der Gaag, Minderaa, & Keysers, 2007). Furthermore, the ability to correctly identify emotions from facial expressions has been reported to decrease when mirror neuron activity is inhibited (Pitcher, Garrido, Walsh, & Duchaine, 2008). But while these reports are compelling, most are unable to rule out stimulus effects as the stimuli is typically changed across conditions. Thus, whether changes in mirror neuron activity are due to different tasks, or simply different stimuli, is unknown. The goal of the current study was to determine whether changes in mirror neuron activity during active facial expression discrimination reflects the internal processing of identifying emotional facial expressions, or due to changes in external stimuli.

To examine the role of the hMNS in facial expression recognition, we measured mirror neuron activity while participants performed a series of video-matching tasks that tested their ability to distinguish between facial expressions. Electroencephalography (EEG) was used to measure Mu wave suppression in the somatosensory cortex—an indirect measure of mirror neuron activity—while participants performed two tasks that involved matching video pairs of facial expressions. In the identity-matching task, participants determined whether each video contained the same person. In the emotion-matching task, participants determined whether the video pairs depicted the same emotion. The emotion-matching task measured the ability to identify emotions from facial expressions, while the identity-matching task tested the general ability to recognize architectural differences in faces. Importantly, the same stimuli were used in both conditions to minimize stimulus effects. Given the suggested role of mirror neurons in emotional facial expression processing, we predicted that there would be a higher degree of Mu suppression during the emotion-matching task as compared to the identity-matching task.

Results and conclusions:

Analyses of the results revealed greater Mu wave suppression during the emotion-matching condition compared to the identity-matching condition, suggesting that mirror neuron activity was greater when participants performed the emotion task. These findings not only align with those of previous studies, but also exclude the possibility of stimulus effects, demonstrating that the observed changes in mirror neuron activity between emotion and identity tasks do not simply reflect a reaction to facial expressions as an external stimulus, but rather the intrinsic process identifying the emotional state of another person.

References:

Pitcher, Garrido, Walsh, & Duchaine, 2008).

van der Gaag, Minderaa, & Keysers, 2007).