Mirror Neurons in Primates, Humans, and Implications for Neuropsychiatric Disorders

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Dr. Singh has no conflicts of interest to declare.
Outline
1. Mirror Neurons in Primates
3. Mirror Neuron System in Humans
4. Results from studies in schizophrenia
5. Current/Future Directions
6. Questions/Comments
Mirror Neurons in Primates

- Located in the premotor cortex
- Discharge both for execution and observation of goal-directed actions
Mirror Neurons in Primates: Action Recognition

- “full vision” condition: monkey was shown full visual action.
- “hidden condition”. Same action presented, but with the final critical part (hand-object part) missing.

Same Premotor Neurons were activated by both conditions, suggesting these are needed for action recognition.
Mirror Neurons in Primates: Code for purpose of action

- Human effector
- Mechanical effector

Same Premotor Neurons were activated by both conditions, regardless of effector arm.
Mirror Neurons in Primates: Multimodal

- Performs an action (breaking peanut)
- Watches experimenter perform that action
- and, Hears the sound of that action being performed

Same population of premotor cortical neurons are activated, suggesting auditory and visual mirroring
Mirror Neurons in Primates: Intention

- Grasp to eat vs. Grasp to place leads to different neuronal firing pattern, and suggests that these neurons -

Encode the purpose/intention of a given action, not just basic motor information.
Key Points: Mirror Neurons in Primates

• Encode goals of motor actions and are specialized for goal directed actions

• Appear to be activated automatically

• Respond to multiple sensory modalities
Mirror Neurons in Primates: Evolutionary Function

Sensory input → Simulation → Understanding Learning Imitation
Mirror Neuron System: Role in Social Cognition

Hypothesis: Primate action matching system becomes integrated with higher cognitive areas and emotion processing regions in humans

Neural mechanism for social cognition, theory of mind, empathy, facial affect processing

Measured through imaging, TMS, EEG.

Key Output to Sensorimotor cortex: modulation of alpha waves

Rizzolatti 1987
Iacoboni Review 2009
Oberman, Pineda 2005
Alpha/Mu Wave Suppression: Successfully used in typical and clinical populations

Typically Developing Subjects
- Suppression- while performing motor actions, *observing motor actions, imagining motor actions*
- Increased suppression for actions embedded in *social context*

Clinical population: Autism
- Reduced mu suppression in high functioning autistic children compared to typical children.

Is the same neural network implicated in social deficits in schizophrenia? If so, how does it relate to symptoms and functioning?
Schizophrenia

1. Schizophrenia: define schizophrenia; significant societal and individual burden

2. Social Impairment leads to functional disability

3. Evident early in illness, persists into chronic phase

4. Difficult to treat
Conditions:

Amplitude

Time (s)

Moving Balls

Involved observer

Biological Motion

Moving Human Hand
Results: FE subjects show impaired suppression for biological motion

Singh et al. Schizophrenia Research 2011
Poor social functioning is associated with impaired mu suppression

Social Adjustment Scale SAS-SR

Mu Suppression Index

$r = 0.65$
Mirror Neuron System as a Model Neural Circuit Underlying Social Processes

Information processing generates detectable neurophysiological (EEG, MEG) and neuroimaging signals (fMRI, PET).

Social Cognition

Community Function and Behavior: Social Function and Symptoms

oxytocin

Singh, F. and Feifel D. Schizophrenia Research 2013
Oxytocin

• Neurohormone
• Associated with trust, reduction of fear
• Attachment, bonding
• Found in high concentrations in new mothers
• Promotes social cohesion
• Appears reduced in schizophrenia
• Some recent small scale studies indicate that OT improves symptoms of schizophrenia
• Neural mechanism not known
Oxytocin’s effects on mu suppression

- Single dose pretreatment
- Followed by EEG
- Questions: Is there a change in EEG signal with single dose of OT, placebo
- Gender differences
- Healthy controls
- SCZ patients
Oxytocin’s effects on mu suppression

A. Males - Healthy

B. Males - Schizophrenia

C. Females - Healthy

D. Females - Schizophrenia

* = Significant effect of Treatment (RM-ANOVA, p<0.05)

Mirror Neuron System as a Model Neural Circuit Underlying Social Processes and Treatment

Information processing generates detectable neurophysiological (EEG, MEG) and neuroimaging signals (fMRI, PET).

Social Cognition

Community Function and Behavior: Social Function and Symptoms

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Molecules to Circuits- Social Processes

Molecules/Genes

Mirror Neurons

Mu rhythm suppression (Scalp EEG)

Behavior/ Schizophrenia

Diagnosis

Treatment
Cognitive Function Domain

Pyramidal Neuron/PV Interneurons

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Gamma oscillations (DLPFC)

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Distributed/ Large-scale Networks

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Cognition/ Working Memory

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Diagnosis

? Neurofeedback
Acknowledgements

Cognitive Neuroscience/ UCSD
Jaime Pineda PhD
Eduardo Herrera BS
Amanda Smith BS
Zinong (Sherry) Yang BS
Ruijia (Regina) Cheng

Neuropharmacology/ UCSD Psychiatry
David Feifel MD, PhD

Early Psychosis/ UCSD Psychiatry
Kristin Cadenhead MD
Jason Nunag BS
Meriah DeJoseph BS
Thank You

Questions