Published in final edited form as:

Behav Brain Sci. 2013 August ; 36(4): 438. doi:10.1017/S0140525X12002051.

Mirror neurons are central for a second-person neuroscience: Insights from developmental studies

Elizabeth Ann Simpson^{a,b} and Pier Francesco Ferrari^a

^aDipartimento di Neuroscienze, Università di Parma, 43100 Parma, Italy

^bLaboratory of Comparative Ethology, Animal Center, Eunice Kennedy Shriver National Institute of Child Health and Human Development, Dickerson, MD 20842.

Abstract

Based on mirror neurons' properties, viewers are emotionally engaged when observing others – even when not actively interacting; therefore, characterizing non-participatory action-viewing as isolated may be misleading. Instead, we propose a continuum of socio-emotional engagement. We also highlight recent developmental work that uses a second-person perspective, investigating behavioral, physiological, and neural activity during caregiver–infant interactions.

We comment on two points: one conceptual, relating to the implications of the discovery of mirror neurons, and the second methodological, relating to the application of a second-person perspective in developmental psychology. Schilbach et al. wish to distinguish two types of social interactions – active participation among individuals (e.g., face-to-face), and passive social viewing (e.g., watching a movie of someone) – claiming there may be key differences in the neurophysiology underlying these different types of interactions. However, we think this is in part a false dichotomy; rather, there is a continuum of social-emotional engagement, influenced by a variety of factors. The level of (current or future) active interaction is one such factor, but others include the relationship between individuals, the perceiver's goals, and the types of actions viewed (e.g., Breithaupt 2012). We are in agreement with Rizzolatti and colleagues that mirror neurons allow viewers to go beyond cold, detached, third-person, mere spectator perspectives, even if viewers make no active interaction attempts (Rizzolatti & Sinigaglia 2010; Sinigaglia 2010). Therefore, the characterization of non-participatory action viewing as isolated (an “isolation paradigm”) may be misleading.

Instead, viewers can be emotionally engaged by simply viewing others. Anyone who has felt the emotional pain of a favorite actor or actress while watching a movie can testify to this. The importance of phenomenology in theorizing – that viewers are not pure spectators, but that social perception involves emotional engagement – has been arguably the greatest implication of the discovery of mirror neurons. Several scholars, including Husserl, who is considered the father of phenomenology, and Merleau-Ponty, previously reasoned and theorized that our perception of the world activates sensorimotor programs and thus allows

our bodies to have first-person knowledge about the object of our perception. Work on the mirror neurons system for facial expressions (Ferrari et al. 2003) and emotions – by Iacoboni, Aglioti, Wickler, Singer, and others from our group in Parma – demonstrate that when we see emotions, there is a brain mirroring in the traditional mirror areas (premotor-parietal), as well as in deep areas of the brain involved in first-person perception of emotion, such as the cingulate cortex and the anterior insula. In other words, it is *as if* viewers experience the same emotion as that displayed by the other. The simulation account (Gallese & Goldman 1998) is tightly linked to the empirical work on mirror neurons, and the simulation account is indeed an empirical bridge between the mirror neuron work and the phenomenological grounding previously mentioned. Moreover, nearly all work on single cell recordings of mirror neurons involves second-person interactions; thus, the simulation paradigm and the mirror neuron discovery are of utmost importance for theorizing about a neuroscience of social interaction.

We agree with the authors that there is a need to look more at interactions involving brain networks for coordinating actions and second-person engagements. The dynamics occurring during a social interaction have different requirements when the observer is passively viewing a scene, compared to actively engaging with another individual. For example, in an active engagement there is concurrent activation of executive function networks, which plan and coordinate online movements with the interacting agent, during potential intersubjective exchanges.

Developmental psychological studies have utilized this second-person perspective, and in doing so have been useful in describing the complexity of social interaction from early in the postnatal period. In particular, emotional responses between caregivers and infants are of utmost importance in tracking the developmental emergence of social understanding. Early interactions between care-givers and infants are formative in a number of ways, giving infants opportunities for learning and also strengthening bonds between infants and caregivers. Studying caregiver–infant interactions is particularly important, as those early interactions can have lasting impacts on later social and emotional development. Interactions with real social partners – not simply avatars – can provide more ecologically valid measures of social engagement and perception. Moreover, caregiver–infant interactions can be used as a guide for the creation of ecologically valid adult studies (e.g., Dumas 2011).

A number of developmental studies (not mentioned by Schilbach et al.) have successfully utilized a second-person perspective, investigating behavioral, physiological, and neural synchrony during caregiver–infant interactions, which may serve as models for second-person developmental research. For example, in work with humans, Feldman and colleagues found heart rate synchrony between mothers and infants during face-to-face interactions (Feldman et al. 2011), Messinger and colleagues discovered stable individual differences in infants' attention to mothers' faces, controlling for maternal behaviors, such as smiling (Messinger et al. 2012), and Musser and colleagues found neural correlates of maternal sensitivity during face-to-face interactions (Musser et al. 2012). Recent work in our lab examined newborn infant monkeys' live face-to-face interactions with human caregivers. Electroencephalogram (EEG) recordings revealed a 5–6 Hz activity suppression when the infants produced facial gestures and when infants observed facial gestures, but not when

they observed non-biological stimuli (Ferrari et al. 2012). This EEG suppression, named mu-rhythm, is considered a signature of the mirror neuron system. This finding suggests that the basic elements of the mirror neuron system are operational in the first week of life and might be central for early face-to-face interactions.

REFERENCES

- Breithaupt F. A three-person model of empathy. *Emotion Review*. 2012; 4:84–91. Available at: <http://dx.doi.org/10.1177/1754073911421375>.
- Rizzolatti G, Sinigaglia C. The functional role of the parieto-frontal mirror circuit: Interpretations and misinterpretations. *Nature Reviews Neuroscience*. 2010; 11(4):264–74. Available at: <http://dx.doi.org/10.1038/nrn2805>.
- Sinigaglia C. Mirroring and making sense of others. *Nature Reviews Neuroscience*. 2010; 11:449. Available at: <http://dx.doi.org/10.1038/nrn2805-c2>.
- Ferrari PF, Gallese V, Rizzolatti G, Fogassi L. Mirror neurons responding to the observation of ingestive and communicative mouth actions in the monkey ventral premotor cortex. *European Journal of Neuroscience*. 2003; 17:1703–14. Available at: <http://dx.doi.org/10.1046/j.1460-9568.2003.02601.x>. [PubMed: 12752388]
- Gallese V, Goldman A. Mirror neurons and the simulation theory of mind-reading. *Trends in Cognitive Sciences*. 1998; 2:493–501. [PubMed: 21227300]
- Dumas G. Towards a two-body neuroscience. *Communicative and Integrative Biology*. 2011; 4(3): 349–52. [PubMed: 21980578]
- Feldman R, Magori-Cohen R, Galili G, Singer M, Louzoun Y. Mother and infant coordinate heart rhythms through episodes of interaction synchrony. *Infant Behavior and Development*. 2011; 34:569–77. Available at: <http://dx.doi.org/10.1016/j.infbeh.2011.06.008>. [PubMed: 21767879]
- Messinger DS, Ekas NV, Ruvolo P, Fogel AD. Are you interested baby? Young infants exhibit stable patterns of attention during interaction. *Infancy*. 2012; 17:233–44. Available at: <http://dx.doi.org/10.1111/j.1532-7078.2011.00074.x>. [PubMed: 22523476]
- Musser, ED.; Kaiser-Laurent, H.; Ablow, JC. *Developmental Cognitive Neuroscience*. Vol. 2. Advance Online Publication; 2012. The neural correlates of maternal sensitivity: An fMRI study.; p. 428–36. Available at: <http://dx.doi.org/10.1016/j.dcn.2012.04.003>.
- Ferrari PF, Vanderwert RE, Paukner A, Bower S, Suomi SJ, Fox NA. Distinct EEG amplitude suppression to facial gestures as evidence for a mirror mechanism in newborn monkeys. *Journal of Cognitive Neuroscience*. 2012; 24:1165–72. Available at: http://dx.doi.org/10.1162/jocn_a_00198. [PubMed: 22288390]