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Response to Lametti & Mattar's *Mirror Neurons and the Lateralization of Human Language*

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We thank Lametti and Mattar for their comments. However, we do think that mirror neurons are involved in language evolution. In our study (Aziz-Zadeh et al., 2006) we show that a visuo-motor component of the human mirror neuron system is bilateral. This is consistent with the bilateral motor control of premotor areas in primates. However, it is important to consider that the mirror neuron system also has an auditory component (Kohler et al., 2002). In humans, this auditory component can be left lateralized (Aziz-Zadeh et al., 2004, Gazzola et al., 2005). Laterality for vocalization is evolutionarily the oldest left lateralized system, dating back to amphibians (Corballis, 2002). Perhaps this primitive auditory-motor laterality for vocalization influenced the laterality of the auditory mirror system.

The critical idea here is that while the right hemisphere has motor and visual representations of actions, only the left hemisphere may have a multimodal representation of a given action (visual, auditory, motor). This multimodality might have given the left hemisphere the privilege of forming abstract conceptual representations necessary for the emergence of language (Geschwind, 1964). In fact, in a recent study we localized premotor areas that respond to action observation of the hand, foot, or mouth, and we considered how each of these areas would respond to sentences pertaining to each effector. The results indicated that the voxels that were most active for observing a hand action were also most active for listening to language related to hand actions. This was also true for the foot and the mouth. This correspondence between language and action observation was found only in the left hemisphere (Aziz-Zadeh et al., 2005).

Hence we argue that the left lateralized multimodal representation of actions evolved into left lateralized conceptual representations of actions. Furthermore, our data indicate that one difference between humans and monkeys is that humans exhibit hemispheric specialization for a multimodal mirror neuron system. Our data suggest that hemispheric specialization may have led to greater sophistication of the system. If temporal binding is essential to the creation of a symbolic system (Hummel and Holyoak,

2003), it may be that hemispheric specialization, by grouping related processes together, may have allowed for the temporal resolution necessary for symbolic processing. Finally, as Lametti & Mattar point out, the learning of speech is a multimodal function (visual observation, auditory feedback, motor learning), and multimodal mirror neurons may be essential for this development and learning.

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