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Discussion forum

What do the mirror system, embodied cognition, and synaesthesia have to do with each other?

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Much of the debate about mirror neurons has come to focus on whether the apparently imitative properties of the mirror system can be explained by learned associations between stimulus and response, and are therefore just one type of association among many, including object-action links, complementary responses to others' actions, and so on (Byrd, 2013, this issue).

However, what is missed is the issue of *what kinds of things our minds choose to make associations among*. While associationism is undeniably a powerful and evolutionarily ancient principle, there are also reasons to believe that humans are not merely unbiased associators. Instead, our minds are also active, strategic associators, harnessing the power of one domain of thought to aid in representing another. In this respect, three hot topics in cognitive science that appear unrelated in fact coalesce under a single explanatory framework. These are the mirror system, embodied cognition, and synaesthesia. I will argue that *the exploitation of isomorphisms for representational purposes* is a key feature of human cognition.

1. The mirror system

Others have noted the sheer complexity of the mapping that must be achieved when one's own body schema, encompassing a complex, multi-jointed set of effectors, is linked to another's body. This is a remarkable achievement, and one that it is not clear could be reliably achieved anew by every unbiased learner, given its importance in human interaction.

While laboratory tasks with "counter-mirroring" suggest no privileged status of imitative mappings (e.g., Catmur, Mars, Rushworth, & Heyes, 2011), everyday observation should make us suspicious of this conclusion. People can do "one-trial-learning", in which they imitate fairly complex actions of others that they themselves have never performed before (e.g., Wilson & Fox, 2007). The only plausible explanation is reliance on a body-schema, for which the isomorphism to others' bodies is already understood and can be exploited for novel purposes. That it is indeed an isomorphism, and not a uni-directional stimulus-response pathway, is made clear by the fact that actions can influence perception, as well as vice versa (Blaesi & Wilson, 2010; Wilson & Knoblich, 2005).

Further, we should note that an associationist origin is not incompatible with the ultimate emergence of a specialized mechanism. This is the Baldwin effect: acquired adaptive traits lead to a selective advantage for genes that predispose for those traits. The Baldwin effect becomes likely when a trait that has previously been acquired from scratch by each individual becomes of heightened importance for a species, as mirroring arguably has for humans. Just as modern ostriches are born with calluses on their knees, so modern representatives of social species (certain primates, cetaceans, birds, elephants, and others) and especially humans may be born with a mirror system. I propose here that the evolving human brain did in fact begin to specialize in using the body representation as a template for representing other things, with profound consequences.

2. Embodied cogntion

Turning our attention to embodied cognition, what is of interest here is "central" or "abstract" cognition that is not about

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nor in service of the immediate situation, but which is nevertheless subserved by concrete, bodily representations – what I have termed "off-line" embodied cognition (Wilson, 2002). What is remarkable about this phenomenon, and remarkable in its similarity to the mirror system, is the brain's ability to use its representation of the body as a map for some other stimulus or phenomenon to be understood (see Wilson, 2008, for review). Animals' bodies are mapped onto our own. Shapes are represented with body postures or tracing gestures. Spatial relationships are represented with our hands. We understand time in terms of bodily movement. We conceptualize emotions and social relationships in terms of bodily experiences of temperature and proximity. We gesture to help ourselves articulate our thoughts. We invent the number line to represent abstract quantities in a concrete dimension. We use metaphors to explain complex ideas. Again what is striking is the mind's ability to find the right mapping. This is not just associationism run amok, but a sophisticated ability to harness associations to serve our purposes. Indeed, it begins to look as though the ability to find and exploit isomorphisms between domains is a defining feature of human cognition (cf. Wilson, 2010).

3. Synaesthesia

This leads us to the case of synaesthesia, an "abnormality" in which certain individuals experience automatic and unbidden sensory impressions in response to ostensibly unrelated sensory stimuli. One of the most common varieties is grapheme-colour synaesthesia, in which letters or numbers elicit an impression of colour, but numerous other combinations can arise as well, such as music-colour, taste-touch, and so on (see Cytowic & Eagleman, 2009, for review). At first blush, synaesthesia appears to be a quirk of a small percentage of human brains. Some form of hyperconnectivity, or leaky boundaries between domains, causes these people to have cross-modal experiences that go beyond the physical stimulus.

But a suspicion is growing among researchers that synaesthesia may be the extreme end of a continuum which encompasses a more general human tendency to create mappings across domains (e.g., Mondloch & Maurer, 2004). A number of universal or near-universal phenomena of cross-modal equivalences may have more in common with synaesthesia proper than has previously been thought. These include phonological symbolism (e.g., Kovic, Plunkett, & Westermann, 2010), pitch-height, -brightness, and -size correspondences (e.g., Mondloch & Maurer, 2004), and spatial synaesthesias such as the spatial-numerical association of response codes (SNARC) effect (e.g., Dehaene, Bossini, & Giraug, 1993; Eagleman, 2009). It is remarkable that it has been missed, in the literature, that these phenomena – which have so much in common with synaesthesia – also have so much in common with embodied cognition. Indeed, these appear to be yet further examples of the human brain finding the right isomorphism to exploit.

In fact, the rarer forms of synaesthesia, such as tastes eliciting tactile sensations on the hands, may simply be a more exuberant form of a general principle of human cognition, in which dimensions that resemble one another in important respects are mapped onto one another to facilitate mental representation.

4. Conclusion

Which brings us full circle back to the mirror system. As humans evolved, the growing importance of using one's own body representation to facilitate the processing, predicting, and understanding of other people may have led to a whole flood of evolutionary consequences. This facility with using the mind's body-representation to map onto something else may have been the starting point, the pre-adaptation, that led to a remarkable new suite of representational abilities in the human mind.

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