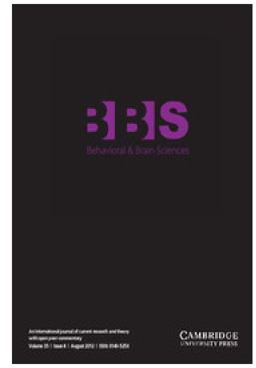

Causal beliefs lead to toolmaking, which require handedness for motor control

Lewis Wolpert

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Causal beliefs lead to toolmaking, which require handedness for motor control

Lewis Wolpert

Anatomy Department, University College London, London WC1E 6BT, United Kingdom. **1.wolpert@ucl.ac.uk**

Abstract: Toolmaking requires motor skills that in turn require handedness, so that there is no competition between the two sides of the brain. Thus, handedness is not necessarily linked to vocalization but to the origin of causal beliefs required for making complex tools. Language may have evolved from these processes.

The key question raised by Corballis is whether left-hemispheric dominance for vocalization came before or after handed asymmetry. It is important to recognize that lateralization of brain function is widespread among vertebrates (Wiltschko et al. 2002), although Corballis does not give this sufficient attention. What is the evolutionary origin of such lateralizations? The answer most likely lies in the original symmetry of the brain and the later advantage of specializing its functions to one hemisphere or the other. As McManus (2002b) puts it, the two hemispheres connected only by the corpus callosum would work much better by cooperating and specializing their functions rather than working as a single system, for doing so could easily result in competition, serious delays, duplication, and confusion.

This argument is of particular relevance to motor control (Wolpert 2003). From an evolutionary viewpoint, the brain has but one function to control movement. Movement was present in the cells that gave rise to multicellular organisms some 3,000 million years ago. This movement was a great advantage in finding food, dispersing to new sites, and escaping from predators. Muscle-like cells are found in all animals, including primitive ones like hydra. The first evidence for brain-like precursors is the collection of nerves that are involved in controlling movement like the crawling of earthworms or flatworms. Getting the muscles to contract in the right order was a very major evolutionary advance and required the evolution of nerves themselves. Here we find the precursors of brains – circuits of nerves that excite muscles in the right order. Its role in homeostasis is secondary.

Humans, as distinct from other primates, have a belief in cause and effect. There are experiments showing that chimpanzees do not have such concepts, particularly with respect to simple manipulation of their environment (Povinelli 2000). Children, by contrast, have causal beliefs as a developmental primitive, and these can be demonstrated in infants. I have suggested that the evolution of causal thinking is related to tool use, as it is not possible to make a complex tool without understanding cause and effect (Wolpert 2003). Moreover, it was technology that drove early human evolution, both biological and cultural.

Manipulating the environment with one's hands involves complex motor control, and on the basis of the arguments just given, it seems that it would not have been possible to make even simple tools without brain lateralization of the motor control system. The relationship in evolution between tool use, causal thinking, and language is an interesting but difficult problem; each might have served to haul along the others. It is striking that tool use and language both appear in children at about 18 months. All three involve what Calvin (1993) has referred to as stringing things together.

Most theories see language as helping how tools are used, and toolmaking and tool use as learned. However, my emphasis is on tool use preceding the use of gestures, because of its great adaptive significance. There is no point in gesturing if one does not have a clear concept of cause and effect. One needs language only if one has something useful to say, and until cause and effect were understood, there was little to say. It was cause and effect that required language for further understanding.

But it is recognized that tools and language share some critical features – rule-governed behavior and common sequencing neurology. Human technology involves the cooperation with others – individuals do not make tools alone. This is true today of the Aborigines. Calvin proposes an interesting possibility related to throwing. He examines the idea that throwing evolved to capture game. It provided action at a distance, and improved accuracy and distance would have been adaptive evolutionary steps. There could have been a transition from sticks to stones to a fast handaxe which might spin and inflict serious damage. Throwing required improved control of arm movements for accuracy, and throwing for hunting became linked to pointing, a key early gesture. Then pointing could have become associated with vocal grunts. Moreover, movements of the arm could distinguish predator from prey. Language most likely had its origins in the neural basis of motor control. Evolution cannot invent something quite new but can only tinker with what is already there. As has been argued, the neurological basis of motor control has very similar features to the syntax of language. Just consider how the same muscles – "words" – can be activated in an astonishing variety of movements – "sentences" (Lieberman 2000).

But what were the changes in the brain that enabled all this great advance to occur? Human manipulative skills are not much greater than apes', but the difference lies in how these are used. Apes can trace writing but they do not use motor skills in the same way as humans, and this is genetically determined because it is an intrinsic property of the brain. The key difference lies not just in the increase in brain size, but in the way the brain is organized in relation to motor control. There has to be both analysis and reflection as to what to do, and then the ability to do it; and this involves new cognitive processes. This is associated with the significant enlargement of the associative areas of the frontal neocortex.

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Letters "a" and "r" appearing before authors' initials refer to target article and response, respectively.

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