Do we have Independent Visual Streams for Perception and Action? a Response. *

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Schenk and McIntosh (2009) present the thesis that most visual behaviours, especially those of any significant complexity, are likely to involve collaboration between both visual streams. While very likely true, this statement does not contradict the perception-action model as proposed by Milner and Goodale (1995, 2006). The two-visual system hypothesis implies two functionally specialized systems, and not, as Schenk and McIntosh propose, two behaviourally independent systems.

Milner and Goodale (2006, p. 40) make it clear that the perception-action model can be thought of as a division of labour, rather than parallel, independent systems. This is an important distinction, as any complex behaviour is likely to engage many brain systems comprising a variety of functions. For example, a complex behaviour such as preparing a meal may engage nearly every known functional system in the brain, including perception, action, memory, semantic knowledge, and perhaps even emotion. Only in contrived, intentionally impoverished environments, or brain injuries, can some degree of independence be achieved and studied. This is not a failure of the perception-action model, but an artifact of the wide array of functions required for a human to engage in even the simplest of real-world tasks. Regardless of the multi-function nature of complex behaviour, a reductionist approach to neuroscience and physiology in general has proven singularly valuable in the past.

Patient DF's grasp selection and posting abilities provide an ideal example of the functional limits of a specialized system which has become isolated from it's complement. DF is a woman who developed visual form agnosia as a result of anoxic lesions due to carbon monoxide poisoning (Goodale et al., 1991). As Schenk and McIntosh (2009, p. 8) discuss, while DF is able to accurately grasp and post a simple plaque through a slot, she makes systematic errors with a T-shaped object (Goodale et al., 1994). Equivalently, she is poor at grasping X-shaped objects or grasping objects by holes drilled in them (Carey et al., 1996; Dijkerman et al., 1998; McIntosh et al., 2004). While Schenk and McIntosh (2009) describe this data as an example of the perceptual system being required for action, and thus a lack of independence, this data simply shows the functional limits of the dorsal system. It is a simple task to identify actions which obviously require perceptual abilities (e.g., learning to use a computer keyboard for the first time), however, these simpler tasks provide a precise indication of the limits of the dorsal stream.

Schenk and McIntosh (2009, p. 9) go further to describe DF's reliance on binocular and object based cues for programming reach amplitude and object depth for grasping. When such cues are perturbed or unavailable, her performance is degraded, whereas healthy individuals are able to utilize other, contextual cues (Mon-Williams et al., 2001a,b; Dijkerman and Milner, 1998; Dijkerman et al., 1996, 1999). Schenk and McIntosh (2009) argue that this data implies ventral involvement at all levels of action planning, also arguing that DF, with her quasi-isolated dorsal stream, does not provide an adequate model of visuomotor control. With the same logic, perturbed binocular cues do not represent a model of normal visuomotor performance, or at least a representative one. Patient DF exhibits the ability to use binocular, and simple object-based cues, and so provides a clue to the refined abilities of the dorsal system. Where her performance degrades indicates abilities more specific to the ventral system, which are invoked in healthy individuals when necessary. Again, when considering the perception-action model as a cooperation between two functionally specialized but coordinating systems, the discussed research serves to clarify the model, rather than refute it.

There is, however, plenty of value in questioning the ways in which the two systems interact. Behavioural paradigms and functional neuroimaging has endowed the field with a rich understanding of regional function. However, new methodologies including diffuse tensor imaging and neurofunctional correlations, along with more dynamic models of neural systems promise to bring functional islands together into more complete theories of co-

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ordinated behaviour. In this sense, the data that Schenk and McIntosh (2009) review do not necessarily contradict the perception-action model, but serve to illuminate the unanswered questions of how the two specialized systems interact and complement one-another to produce complex behaviour, a question that needs not just be asked of the dorsal and ventral visuals streams, but of all of the coordinated neural systems that give rise to complex behaviour.

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