Two visual systems but only one theory of perception

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Abstract: The parallel drawn by Norman between the dorsal and ventral systems and direct and indirect approaches is based on two misrepresentations of the direct approach – that it is concerned only with the unconscious control of action, and that it cannot explain learning. We propose a way of understanding the visual system differences from within the direct approach.

Norman has suggested that the functioning of the dorsal system can be understood from a direct/ecological perspective and that of the ventral system from an indirect/constructivist perspective. We believe that this reconciliation falls short in two important respects. First, it is our contention that no kind of perception is best understood as indirect. In other words, perception via the ventral system is as direct as that via the dorsal system. If this is true, then the differences between the two visual systems must be a consequence of something else. Our second point then, is that these differences can be understood as a division of function within the direct approach.

Norman suggests that direct theories successfully explain only unconscious perception which guides manipulative action. We disagree. Clearly, some information pickup (in the Gibsonian sense) is unconscious, but this does not mean that all information pickup is unconscious. For example, orienting towards and tracking a swooping bird, watching it land, and then trying to identify what kind of bird it is as it sits behind swaying vegetation, are all the kinds of things Gibson had in mind when he stressed the direct and active nature of perception. This is a sequence of perceptual acts which do not involve object manipulations and which result in completely conscious percepts. In addition, constructivist approaches invariably propose that we are only aware of some of the representations we activate in a long sequence of processing (the last ones in the chain, typically), so awareness is a dubious distinction between the approaches, in any case.

The other important misrepresentation of the direct approach is the claim that information pickup is largely an unlearned process. It must be noted that far from viewing learning as a peripheral aspect of perception, the direct theorist places learning at the centre of any explanation of human behavior. For example, whether or not a gap can be jumped over depends on how big the jumper is, the strength of their legs, whether they are riding a bicycle, and various other factors. Obviously, the perception of what the gap affords must be learned, if only because that changes as the perceiver grows.

In a footnote, Norman grants the dorsal system procedural memory, but no "representational memory." This is fine for the direct theorist, but only because she considers all memories as procedural rather than representational (a position which echoes the proceduralist stand of memory theorists, such as Crowder 1993). The direct approach to learning is to suggest that it involves "tuning in to" properties of the world – acquiring sensitivities to situations or relationships in the world. There are brain changes associated with these new sensitivities, but these changes don't "represent" the external situations, they merely give the perceiver a new sensitivity. This is less liable to be misinterpreted if we use a simpler, nonneural, example. Lifting lots of heavy weights causes changes to muscular tissue. These changes give the weight-lifter new abilities – they can now lift previously unliftable weights. They stand in a new relationship to certain (heavy) objects in the world (they have a new "sensitivity," in one sense). Importantly, there is no sense in which the changes in the musculature "encode" the events that lead to them. Note the similarity between this example and the learning of connectionist models; changes in muscle fibres and connection weights are, to our minds, the same general kind of change. One hallmark of this view is that it is clear what is happening when learning occurs, unlike the state of affairs following the "encoding of a new representation."

We are in general agreement with Milner and Goodale (1995) (and, to some extent, with Norman) that the major difference between the ventral and dorsal visual pathways is one of function. However, we state that functional distinction in slightly different terms. According to Norman, the representation-less dorsal stream is implicated in reaching behavior, whereas the ventral stream mediates object recognition through long-term representations. Presumably, this distinction is based on the belief that an object's size is a property of the object (which can therefore be detected directly), but its identity is a relational property (it is a member of some class of objects). Of course, in order to grasp an object, its size must be known relative to the observer, and so this is a relational property too, but it is a different kind of relationship. Since both these kinds of relationships are properties of the world, a direct theory has no problem proposing that the recognition and grasping of objects are both a function of sensitivity to relational properties. The dorsal stream appears to be sensitive to person-relative properties of the world (egocentric relationships), and the ventral stream appears to be sensitive to object-relative properties of the world (allocentric relationships). For example, even if it could be unequivocally shown that when a person reaches for a disc embedded in an illusory context they do so accurately, but when judgements are made of the disc using the ventral system they are influenced by the illusion, this would be perfectly explicable from an entirely direct perspective. Such an explanation would only need to propose that the dorsal system is sensitive to the "absolute" diameter of the disc but the ventral system is only sensitive to its relative diameter. It is sensitivity to relative size that generates the illusion. In our view, understanding of the functioning of the ventral stream will come from more careful consideration of the allocentric relationships in the world to which human perceivers become sensitive. That understanding, however, will be best considered in terms of the direct relationship between the human perceiver and the world which is perceived.

Conceptual space as a connection between the constructivist and the ecological approaches in a robot vision system

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Abstract: The *conceptual space* (Gärdenfors 2000) is discussed as a representation structure that connects the *constructivist* and the *ecological* vision subsystems in an operating autonomous robot based on computer vision.

The two vision subsystems discussed by Norman, based on the *constructivist* and the *ecological* approaches, have an immediate counterpart in the design of robotic architectures based on computer vision. On the one side, the *ecological* approach is adopted to design robot behaviors that reactively connect the information acquired by cameras and other sensors to robot actions, as in the case of obstacle avoidance, path following, and orienting the robot towards a goal (see Arkin 1998).

On the other side, the *constructivist* approach is adopted to design the object recognition system of the robot, that is, the high-level vision algorithms that let the robot identify and recognize the objects on which it needs to act in its working environment. In general, a robot object recognition system generates 2D/3D observer-independent reconstruction of the objects in the perceived