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well "feel" green. Borrowing from **O&N**'s introduction (sect. 1.2): What is the mapping function from a complex structure of sensorimotor contingencies onto the experience of one color or another?

It seems to be important to **O&N** that "there is no simple, unanalyzable core of the experience" (sect. 6.4). If this is so, it only follows that there are no simple, unanalyzable qualia; qualia are complex entities. It does not follow that qualia don't exist (even if there are philosophers who characterize qualia as simple). We are still left with the problem of explaining how elements that have no experiential quality can give rise to an experience when put together.

O&N seem to suggest that all there is to the quality of an experience is the structure of the sensorimotor contingencies – experiences differ because they are based on the execution of different sensorimotor contingencies. These contingencies, the knowledge about them, and their execution are part of the functional properties of our brains. The "explanatory gap" arises because all these information-processing activities could work as well without us experiencing anything at all. If sensorimotor contingencies are to explain conscious experience, the existence of conscious experience should follow with logical necessity from the existence of the appropriate sensorimotor contingencies (together with the necessary boundary conditions, for example, a world in which they can be executed, cf. Chalmers 1996a). To illustrate: We could build the appropriate sensorimotor contingencies into a robot (e.g., one that can drive a Porsche, among other things), and this should allow us to deduce that the machine has a rich inner life (e.g., is able to feel what it is like to drive a Porsche). I'd rather stay agnostic on this, even for a very graceful robot.

It seems that **O&N** would be more confident. In their discussion of blindsight (sect. 7.2) they define experience in terms of being able to describe and react appropriately to what one sees. This is a common materialist reply to the hard problem: The denial of phenomenal experience as an explanandum – everything that needs explaining is behaviour (Dennett 1991). In this case it all comes down to the empirical question, which theory is better suited to explain the observed behavior. Then, however, there is no room for the "fundamental question" raised in the introduction: How does anything going on in our brains and their causal interactions with the world give rise to experience? With regard to this question, the approach of O&N does not achieve more than any other theory of vision: It simply evades it.

Sins of omission and commission

Gerard O'Brien and Jon Opie

Department of Philosophy, University of Adelaide, Adelaide, South Australia 5005. **gerard.obrien@adelaide.edu.au jon.opie@adelaide.edu.au**
http://www.arts.adelaide.edu.au/Philosophy/gobrien.htm
http://www.arts.adelaide.edu.au/Philosophy/jopie.htm

Abstract: O'Regan & Noë (O&N) fail to address adequately the two most historically important reasons for seeking to explain visual experience in terms of internal representations. They are silent about the apparently inferential nature of perception, and mistaken about the significance of the phenomenology accompanying dreams, hallucinations, and mental imagery.

Despite the plethora of theories that have surfaced over the years, there are really only two ways of explaining visual experience. The first accords with the commonsense intuition that when we open our eyes and look around, we have direct access to the world. In this view, visual experience supervenes on the interaction between our visual apparatus and the visually detectable properties of the environment. The second approach rejects commonsense, and holds that our perceptual access to the world is always indirect. What we see is not the actual world; what we see (or, better, what we see *with*) are mental representations constructed by our brains. According to this "constructivist" conception, visual experience supervenes on the brain alone.

Although the history of vision science has seen many oscillations between these two poles, constructivism currently dominates the discipline. **O'Regan & Noë**'s (**O&N**'s) sensorimotor account of vision, on the other hand, favours commonsense over mainstream thinking. The great drawback with constructivist theories of vision, they observe, is that such theories are burdened with the problem of explaining how neural representations give rise to visual experiences – a problem that has stubbornly resisted all attempts at resolution. By contrast, their sensorimotor account, precisely because it rejects the idea that the brain constructs visual experiences, steps right over this explanatory gap. Visual experiences occur when our visual apparatus, replete with the structure of its sensorimotor contingencies, actively engages with the world. Such experiences are not states in the head, they are "ways of acting" (sect. 6.3).

O&N are right about the extra explanatory burden that is carried by constructivist theories of perception. And they are no doubt right to be dissatisfied with current attempts to explain the qualitative character of visual experience in representational terms. Nonetheless, before abandoning constructivism it would be wise to consider why, for nearly thirty years now, vision scientists have almost universally adopted this counter-intuitive approach. The reasons are numerous, but two deserve special mention because of their historical significance.

First, our perceptual responses are underdetermined by the information our visual apparatus garners from its interaction with the world. The conclusion many theorists find inescapable is that, appearances to the contrary notwithstanding, visual perception must be an inferential process – one that constructs representations of the environment by combining stimulus data with information internal to the perceiver. (This form of argument is too familiar to require detailed rehearsal here. For a classic rendering see Fodor and Pylyshyn 1981, and for a more recent statement see Palmer 1999b, p. 55. Palmer notes that the structure of the environment cannot be unambiguously determined by stimulus data, even if we factor in the dynamics of organism-environment coupling, because "time is also a dimension of the environment.")

Second, there are several kinds of visual experience which occur when organism and environment are not actively coupled. The standard examples are the visual experiences that accompany dreams, hallucinations, and mental imagery. Such experiences provide compelling evidence that neural activity is sometimes sufficient for visual awareness. Furthermore, many theorists think it reasonable to surmise that dreams and hallucinations indicate something important about the nature of visual experience more generally, namely, that even "veridical" experiences are constructed by the brain, and thus implicate internal representations.

O&N are silent about the first of these reasons for preferring constructivism, a serious omission given the fundamental role this form of argument has played in shaping cognitive science. They do, however, address dreams and mental imagery, albeit briefly (sect. 4.4). According to O&N, the worry is that "since dreams and mental images are apparently pictorial in nature, this seems to show that we *are,* after all, capable of creating an internal iconic image." But this, they think, is as misguided "as the supposition that to see red, there must be red neurons in the brain," and conclude that "the supposed fact that things appear pictorial to us in no way requires there to be pictures in the head."

O&N's response here is lame, because they misconstrue the problem that dreams, hallucinations, and mental imagery pose for their account. These mental phenomena are problematic *not* because they seem to depend on internal *icons;* they are problematic because they can occur in the absence of any interaction between the visual apparatus and the world. The precise form of visual representations – whether, for example, they are more like pictures or linguistic tokens – is indeed a much debated issue (see Block 1981). But this is a debate *within* the constructivist camp,

not between advocates of constructivism and their critics. What O&N must demonstrate is that they can account for the phenomenology associated with dreams, hallucinations, and mental imagery without postulating internal representations *of any kind.* At the very least they must explain how visual experiences can arise in situations where the very activity that is supposed to account for experience is missing.

To sum up: **O&N** are guilty of two sins, one of omission and one of commission. They are *silent* about the apparently inferential nature of perception, and *mistaken* about the problem that dreams, hallucinations, and mental imagery create for their sensorimotor account of vision. Since O&N fail to address adequately the two most important arguments for constructivism, it is reasonable to conclude that the challenge for visual science remains that of explaining how neural representations give rise to visual experiences.

Perceptual theories that emphasize action are necessary but not sufficient

John R. Pani

Department of Psychological and Brain Sciences, University of Louisville, Louisville, KY 40292. **jrpani@louisville.edu**
http://www.louisville.edu/~jrpani01

Abstract: Theories that make action central to perception are plausible, though largely untried, for space perception. However, explaining object recognition, and high-level perception generally, will require reference to representations of the world in some form. Nonetheless, action is central to cognition, and explaining high-level perception will be aided by integrating an understanding of action with other aspects of perception.

Theoretical advances in psychology nearly always follow new empirical demonstrations. If the sensorimotor theory of perception proves to be an advance, it will be because it provides a successful account of the phenomena of change blindness. On this point, it seems to me that where the theory concerns space perception, it has much to recommend it. Change blindness, however, appears relevant also to object and scene recognition (e.g., Archambault et al. 1999; Hollingworth & Henderson 2000; Pani 2000), and here the sensorimotor theory seems to be on uncertain ground. Nonetheless, it is important to develop theories in which the possibilities for action are embedded in our understanding and use of concepts.

Low-level perception. O'Regan & Noë (**O&N**) suggest that perception consists largely of mastering sensorimotor contingencies through a variety of different forms of action. This conception reinforces a number of important statements about perception. One of these is J. J. Gibson's (e.g., 1979/1986) argument that perception does not include static percepts, such as a percept of the shape of an object. Instead, perception involves tuning the sensory systems to sets of relations and transformations that occur continuously, often due to observer action or locomotion. The individual becomes attuned to the information that specifies an object of constant shape, and static percepts of shape are unnecessary. In extending this view to higher perceptual and cognitive functions, Neisser (e.g., 1976) argued that the anticipation of perceptual information within systems of action was the essential ingredient for bridging perception and cognition.

The authors add two elements to this account. First, the world serves as an outside memory for action. Second, our perception of the world is not a reflection of the content of mental representations, but rather, is due to the structure of the world itself and our ability to act intelligently with respect to it. That is, perceptual knowledge exists only in sensorimotor action.

To account for change blindness, the authors discount the notion that untutored intuitions about the richness of momentary perceptions are a sound basis for theory. They suggest that each moment of perception includes relatively sparse information, and that it is through the combined efforts of well-adapted actions that the richness of perception is constituted. Successful action is successful perception, and no representation of the world is necessary.

For perception of geometric properties of the world, this seems a reasonable approach, but significant theoretical challenges remain. People not only perceive and act in a complex world, they understand that they do, as evidenced by their concepts, language, and behavior. For example, we understand that innumerable saccades and shifts of attention extended across time and space all sample information from one scene. How do we know this (see Neisser 1976)? The more severe we are in saying that there is no information outside of the focus of attention, and the more severe we are in rejecting the contribution of mental representations (e.g., in working memory), the more challenging these issues become. It will be nontrivial to work out the details of such an account, and it may be necessary to allow more information into momentary perceptions and working memory. To revive a debate that took place with regard to auditory attention (e.g., Norman 1969), change blindness may be due in part to limitations on memory (see Hollingworth 2001; Pani 2000; Simons 2000b).

High-level perception. It was a truism insisted upon by the behaviorists years ago that knowledge is expressed in behavior. No sensible cognitive theory ultimately isolates its components from the necessity to generate actions, and theories about action are not necessarily theories without representations.

At the same time, no theory of human perception (as a whole) can avoid the fact that perception includes object recognition, and that recognition involves categorization. Categories are pivot-points that determine choices between potentially large sets of diverse actions, and they affect action at every level from eye movements on upward (see Lichtenstein & Brewer 1980). The broad shift of behavior that comes from realizing, for example, that a store is closed or that an animal is stuffed demonstrates that the individual *knows what these facts mean.* And the stored information about what something means can be considered to be a representation, whether or not the function of that information is to generate behavior. Even if a theory of object recognition is devoted to explaining human action, claiming that the theory has no representations may be little more than an aesthetic decision regarding labels.

Categories, thinking, and concepts. Having expressed some skepticism about the stronger claims of the sensorimotor theory, I would like also to express some enthusiasm about the enterprise. As theories of concepts based on the possibilities of action are developed, new sets of explanations become possible. Some cognitive phenomena will be associated particularly closely with this type of explanation. For example, people's typical indifference to how well mental images depict information probably is due to the fact that the images are part of a larger effort for which pictorial fidelity of any single image is unnecessary to the outcome (see Pani 1996). Similarly, the time-honored problem of the consciousness of meanings (as opposed to sensations and images) probably will have to be explained as an instance of a complex state of preparation within sets of possible actions (Brown 1958; Humphrey 1951; Pani 1996). For example, try a bit of introspection. Answer the question: Can a man marry his widow's sister? As you came to your answer, what was the nature of the conscious event? I suspect that describing the experience as a changed set of anticipations with respect to possible actions related to the man in question (e.g., whether to introduce yourself) is much more promising than a description that refers to images or internal speech.