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Perception and Action Are Inseparable

Jeroen B. J. Smeets and Eli Brenner

Vakgroep Fysiologie
Erasmus Universiteit Rotterdam
Rotterdam, The Netherlands

In her article, Michaels (2000) defined action as "a temporally bounded, observable, goal-directed movement (or non-movement) that entails intention, the detection of information, and a lawful relation between that information and the movement" (p. 251). She defined perception as "the detection of information" (p. 244). This forces one to conclude that it is impossible to study action separately from perception. We argue that perceptual judgments are communicated by movements and that it is impossible to distinguish movements reporting perceptual judgments from other movements, so we conclude that the reverse also is true: It is impossible to study perception separately from action.

Before trying to distinguish between perception and action, one must of course define them accurately. Michaels (2000) started by defining perception (ecologically) as "the detection of information" (p. 244). She pointed out that a clear definition of action is missing in the work of Goodale and Milner (1992) and comes with a (new) definition of action: "a temporally bounded, observable, goal-directed movement (or non-movement) that entails intention, the detection of information, and a lawful relation between that information and the movement" (p. 251). This definition binds action to perception, as it states that there can be no action without detection of information (which is perception). Can there be perception without action? The problem with this question is the measurement of perception. There is no way to do so other than by activating muscles to speak, press a button, move a mouse, and so

Correspondence should be addressed to Jeroen B. J. Smeets, Vakgroep Fysiologie, Helmholtz School, Erasmus Universiteit Rotterdam, Postbus 1738, NL–3000 DR, Rotterdam, The Netherlands. E-mail: smeets@fys.fgg.eur.nl

on. If one would accept that these movements are actions one could conclude that there is no measurable perception without action.

Various authors have claimed that movements that report perceptual judgment are fundamentally different from "real actions." Michaels's (2000) definition of action tries to capture the intuitive idea that pressing a button to report a perceptual judgment is not a real action. To write this article, I press long sequences of buttons on my keyboard. Is typing an action? It is definitely intentional (I want to write the article), it entails the detection of information (I monitor and correct errors), and there is a lawful relation between the information and the movement (when I see a *w* missing, my left index finger moves to the position of the *w* on the upper left side of my keyboard). All three criteria of an action are met: Typing is an action.

One might argue that having to move toward the upper left side of the keyboard when a *w* is missing is an arbitrary rather than a lawful relation, because the position of the *w* depends on the country one is in (QWERTY or AZERTY keyboard).What constitutes a lawful relation? A clear (very strict) example of a lawful relation between the information and the movement is an *isomorphism* (Bridgeman & Huemer, 1998). If one requires an isomorphism, typing cannot be considered an action anymore but is a perceptual report. At a lower level, however, typing still consists of actions. After having chosen the right key, the movement toward it is based on an isomorphism. Thus perceptual reports are conveyed by actions.

An example of this entanglement between perception and action is the experiment of Aglioti, DeSouza, and Goodale (1995) mentioned in Michaels (2000). In Aglioti et al.'s experiment participants viewed two disks and had to grasp the left one if it was the largest (or smallest). The direction in which participants started to move (i.e., their choice) was not isomorphic with the perceptual information on size, and the authors consequently considered it to reflect a perceptual judgment. The opening of a participant's hand and the forces used to grasp the disk are isomorphic with the size of the disk and can thus be considered as (aspects of an) action. Thus, different aspects of a single grasping movement can be considered either perception or action. The key to the distinction is the isomorphism (or some other lawful relation).

The fundamental difficulty with lawful relations is that they are not fixed. The relation between the missing *w* and where my finger has to move depends on the kind of keyboard I am using. For grasping a disk, the exact relations both between its size and the forces used to lift it, and between its size and the opening of the hand, depend on various factors (such as the material the disk is made of and movement speed; Smeets & Brenner, 1999). Moreover, the opening of the hand would be independent of disk size if one's task were to push the largest disk away rather than to pick it up. So one could claim that the task determines what is lawful. Probably, this is a way to circumvent *intention*, a term that is used in Michaels's (2000) definition of action but is itself not defined.

Our conclusion is that perception and action are the right categories neither to discuss information processing in the brain (for alternative categories, see

Ungerleider & Haxby, 1994) nor to solve issues in (ecological) psychology. We think that differences between tasks or aspects of tasks in, for example, the influence of illusions (e.g., Aglioti et al., 1995) are related to differences in the information used. The effect of size-contrast illusions on perceptual judgments depends strongly on the exact format of the display (Franz, Gegenfurtner, Bülthoff, & Fahle, 2000; Pavani, Boscagli, Benvenuti, Rabuffetti, & Farnè, 1999). Such illusions can also affect one size-related aspect of an action (e.g., the forces to lift it) without influencing another size-related aspect of the same action (Jackson & Shaw, 2000; Smeets & Brenner, 1996). Differences between tasks also clearly influence the way one picks up information. How one moves one's eyes when one looks at a picture depends on what perceptual judgment one is asked to make (Yarbus, 1967, p. 174). How one's head and eyes are coordinated (the example mentioned in the Michaels, 2000) depends on the task: It is important not only whether the hand moves but also what the hand is doing (Smeets, Hayhoe, & Ballard, 1996). So the distinction is not between perception and action but between the information used for various aspects of a task, independent of whether the task is considered "perception" or "action."

Why, then, does an illusion influence one aspect of a task while another aspect of the same task remains uninfluenced? The answer is that various aspects of a task are based on different sources of information. We can illustrate this with an experiment we conducted a few years ago, in which we asked participants to hit running spiders (Smeets & Brenner, 1995). A moving background influenced perceived speed but not perceived position. When hitting moving targets, the background influenced the hand's maximum speed but not its initial direction. Both these two aspects of a hitting movement are mathematically isomorphic with the speed of the target. According to Bridgeman and Huemer (1998), both aspects are thus part of an action. Therefore, the differential effects of the illusion on these variables cannot be explained by a distinction between perception and action. We argued that these findings could be explained by assuming that the hand's initial direction is based on information on the (perceived) position of the target, independent of its speed, whereas the maximum speed of the hand is based on the (perceived) speed of the target. Using this assumption, we could also explain the differences in the shape of the trajectories toward targets moving at different speeds (Smeets & Brenner, 1995).

In this example two sources of information are involved: the speed and the (changing) position of the spider. In the real world, it is physically impossible to change speed without changing positions in a corresponding way. An illusion, however, can do this trick. Look, for instance, at some motion (e.g., a waterfall) for a minute or so and then look at a stationary object (e.g., a tree). The result is that you see the tree moving upward, without changing its position. Illusions of speed will influence any aspect of interception that depends on velocity but not one that depends on (change in) position (Smeets & Brenner, 1995). Similarly, illusions of size will influence aspects of grasping that depend on size, such as grip force, but not

aspects that depend on positions, such as grip aperture (Smeets & Brenner, 1999). In this way, one can describe the information used for each aspect of a task. We see no advantage in trying to define two separate categories (perception and action) to classify all aspects of human behavior.

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