

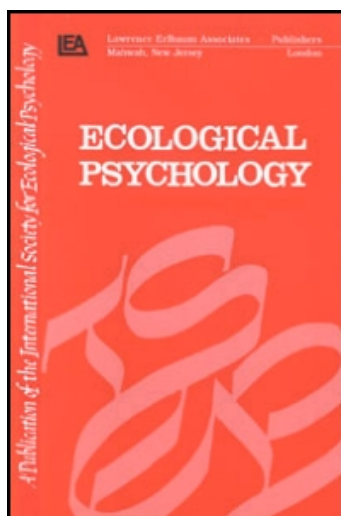
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The Separation of Action and Perception and the Issue of Affordances

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Michaels's (2000) reassessment of the relation between action and perception is endorsed. In alignment with Milner and Goodale (1995), she proposed a separation between action (i.e., control of movement) and perception (i.e., the explicit knowledge of environmental properties, including animal-referential ones), the separation being based on the reliance on different optical variables. However, how should the concept of affordances be incorporated into this scheme? We present data showing that affordances, both when perceived and acted on, are not susceptible to optical illusions. Because action and perception are distinguished on the basis of information used, but are also proposed to interact, it is hypothesized that, dependent on the task goal, "information for action" may be used in perception, and "information for perception" may be used in action. Participants may become more attuned to information for action when perception serves to acquire explicit knowledge about what the environment affords for action.

Vision serves to regulate the organism's encounters with the environment. Obviously, there are different types of encounters. For instance, you may look at a cup of coffee to grasp it or look at the cup to see if you should ask for a refill. Milner and Goodale's (1995; Goodale & Haffenden, 1998; Goodale & Humphrey, 1998) argument can be summarized by stating that for these different encounters vision may be distinct. On the basis of neurological and behavioral evidence, Milner and Goodale argued that the dorsal stream of the visual cortex, which is proposed to support visual control of movement (i.e., action), is separate from, but interacts with, the ventral stream, proposed to support perception. Michaels (2000) argued that this putative separation is foremost an empirical issue, and an evaluation of the evidence so far led her to conclude that the separation between action and perception is justified. She was led (and not misled, we argue) to this conclusion by a study of hers in which she examined the information-based control of timing a punch to hit falling balls (Michaels, Zeinstra, & Oudejans, 2001).

We were led to a similar conclusion when examining the timing of hand closure in one-hand catching (Bennett, van der Kamp, Savelsbergh, & Davis, 1999; van der Kamp, 1999). Following Lee (1976), numerous authors have assumed that for interceptive-timing tasks information about time to contact is needed. This information is specified by the relative rate of change of optical size, possibly in combination with the relative rate of change of target vergence (e.g., Rushton & Wann, 1999; Savelsbergh, Whiting, & Bootsma, 1991). In a series of experiments, the assumption that optical variables specifying time to contact controlled the timing of hand closure in one-hand catching was tested (Bennett et al., 1999; Bennett, van der Kamp, Savelsbergh, & Davis, 2000; van der Kamp, 1999; van der Kamp, Bennett, Savelsbergh, & Davis, 1999; van der Kamp, Savelsbergh, & Smeets, 1997). We found that the timing of hand closure was affected by ball size in monocular conditions only (cf. Michaels et al., 2001), by ball velocity in both monocular and binocular viewing conditions, and by an increase in interocular separation. Therefore, we concluded that the timing of hand closure was controlled by some combination of the rates of change of optical size and target vergence, not by their relative rates of change as is found in perceptual judgment tasks (e.g., Gray & Regan, 1998).

Interceptive timing, unlike perceptual judgments, is not controlled by optical variables specifying time to contact. Hence, an information-based distinction between action and perception is suggested, a position quite similar to that of Goodale and Milner (1995).¹ However, ecological psychologists who accept the information-based separation between action also need to deal with the issue of affordances: "Are affordances perceived or acted on ... [that is] ... whether

¹In their earlier contributions, the emphasis was on the different transformations of information carried out by the ventral and dorsal system (e.g., Milner & Goodale, 1995), whereas in the more recent articles it has been the different types of information that are stressed (e.g., Marotta, Behrmann, & Goodale, 1997).

affordances should be viewed as ventral-stream or dorsal-stream activity” (Michaels, 2000, p. 253). Or, alternatively, should affordances be viewed as a reflection of the interaction between the two streams? We report two experiments and attempt to provide a provisional answer to the issue of affordances.

A telestereoscope consists of two pairs of parallel mirrors positioned perpendicular to each other. It effectively increases the interocular separation between a participant’s eyes, resulting in an increase of the angle of target vergence. We built a telestereoscopic device to examine the role of binocular information in the control of timing the one-handed catch (Bennett et al., 1999; van der Kamp et al., 1999). To our astonishment, looking through the telestereoscope made the objects appear not only smaller but also farther away. When catching a tossed ball, however, the hand was closed too early, which is consistent with the increase in the angle of target vergence. Participants, therefore, were not only required to catch balls but also made verbal judgments on reachability and provided a verbal report on what they perceived during the telestereoscopic viewing condition compared to normal viewing. Here we report on these two different verbal reports only (for a more elaborate analysis see van der Kamp et al., 1999; van der Kamp, Savelsbergh, & Bennett, 1998). For the reachability judgments the experimenter slowly moved an illuminated ball to the participant in a darkened room. The participants ($N = 19$) had to indicate verbally when the ball became reachable, which was defined as the distance that would enable it to be reached with an outstretched arm. The directed-choice question related to distance was “Do you perceive the ball as closer, farther, or at the same distance under telestereoscopic viewing as compared to normal viewing?” The average distance judged as reachable was larger for telestereoscopic viewing ($M = 93$ cm) than for normal viewing ($M = 69$ cm), indicating that the participants judged the ball as closer when wearing the telestereoscope. This is consistent with the observation that all participants closed their hands earlier when catching under telestereoscopic viewing. However, the directed-choice question indicated otherwise: Only 2 participants reported the ball to appear closer. Eight participants reported that they saw the ball farther away under telestereoscopic viewing, whereas the remaining 9 participants did not see any difference. It is important that both the reachability and the directed-choice question require perceptual judgments, that is, telling about “explicit knowledge or awareness of environmental properties, including animal-referential ones” (cf. Michaels, 2000, p. 241). So how should these findings be interpreted? The reachability judgment is consistent with the use of the angle of target vergence, whereas the distance comparison is not. Because 12 participants reported that they saw the ball as smaller under telestereoscopic viewing, they may have reasoned along the lines of the size–distance paradox, reasoning that because the ball appears smaller it has to be farther away (cf. Mon-Williams & Tresilian, 1999). Hence, the difference between the two perceptual judgments may be information based. When telling about what the environment affords for action, participants may be more attuned to information that also serves to control movement (and

vice versa). Does this imply (more) dorsal-stream involvement when telling about action than when telling about environmental properties in general?

The tentative answer to the latter question might be affirmative; at least, such is suggested by preliminary results from an experiment in which we examined whether an object affords one- or two-hand grasping (van der Kamp & Savelsbergh, 2000). Participants ($N = 6$) were randomly presented 20 disks (3 cm in height) with diameters ranging from 12.0 to 22.0 cm with steps of 0.5 cm. The disks were presented four times in three conditions: (a) only the disks were presented, (b) the disks were presented within a circle of 5 large disks (23 cm), and (c) the disks were presented within a circle of 11 small disks (11 cm). The circles of large and small disks create the Titchener illusion: The center disk appears smaller in the presence of the large outer disks and vice versa. It has been shown that perception, but not action, is affected by this illusion (Aglioti, Goodale, & DeSouza, 1993; Goodale & Haffenden, 1998). However, in these studies, perceptual judgments were not related to action. Hence, in one series we asked participants whether they would have picked up the disks with one or two hands (does the disk afford one-hand or two-hand grasping?), and in the other series we required participants to actually grasp and lift the disk. Figure 1 shows the average number of two-handed grasps in relation to the diameter of the center disk and the circle disks. It was anticipated that in the case of the large (small) outer disks, the center disk would appear smaller (larger), and hence the number of two-handed grasps would decrease (increase). Neither for action nor for perception was the commonly observed effect of the Titchener illusion found. (Exceptions were for the 19.5-cm disk in perception and for the 15.5- and 19.5-cm disks in action.)

Again, how should these results be interpreted? It could be argued that no separation between action and perception exists. However, given the present state of affairs, such an interpretation will not do (cf. Michaels, 2000; Milner & Goodale, 1995). A second interpretation would be that information about affordances, whether acted on or perceived, is exclusively supported by dorsal-stream activity. This cannot be ruled out, but it makes the perception of affordances an exception within Milner and Goodale's framework. A third alternative follows from Milner and Goodale's assumption that the dorsal and ventral visual streams always interact—an argument that has often been neglected. In other words, perception is primarily but not exclusively supported by ventral-stream activity, whereas action is primarily but not exclusively supported by dorsal-stream activity. An information-based distinction between action and perception, therefore, implies that, depending on the goal of the task, information for action may be used in perception, and information for perception may be used in action. We hypothesize that the reliance on information for action depends on what perception, the explicit knowledge, is about. Information for action becomes more important (as reflected by dorsal-stream activity?) when perception serves to tell about what the environment affords for action and less so when perception serves to acquire explicit knowledge of environmental properties in general, hence the insensitivity to the

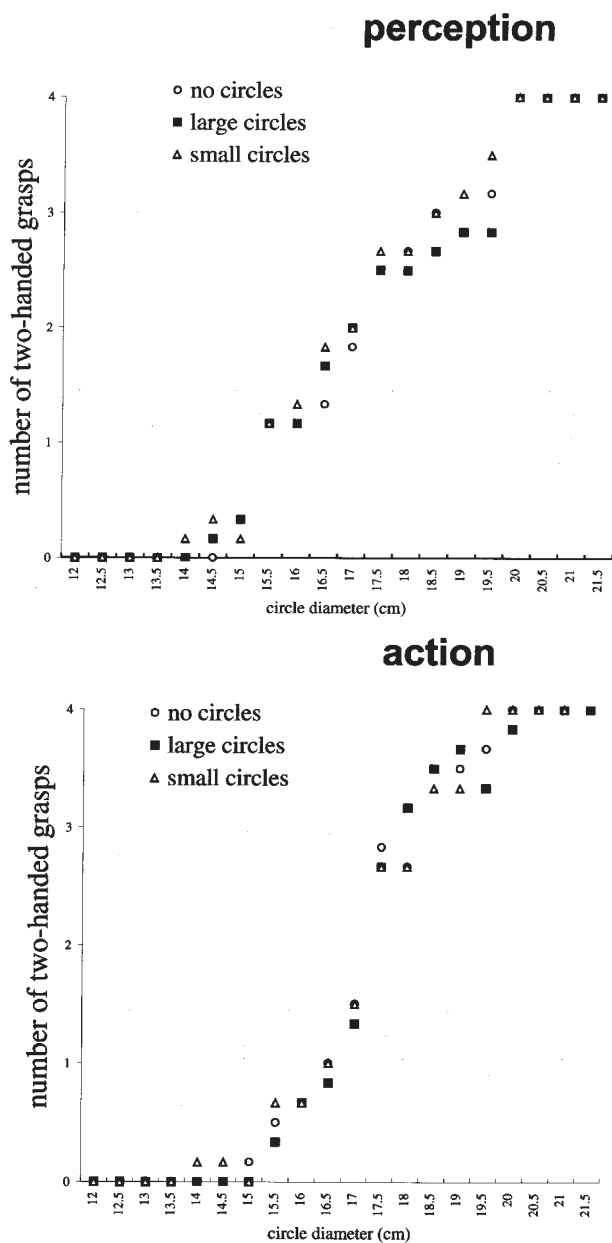


FIGURE 1 The effect of the Titchener illusion on the transition from one- to two-handed grasping in perception (top) and action (bottom).

optical illusions created by the telestereoscope or the Titchener circles in the perception of affordances.

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