

# Perceptual-Motor Dissociation

## Definition

### Perception

Intuitively, perception is the process of becoming aware of physical objects or phenomena through the senses. However, to define it as an observable phenomenon without resorting to a highly subjective concept such as awareness, one must include additional measurable criteria. A less involved and more up to date view is that perception is the mental function by means of which the physical world (including within body processes) is represented, and the process by means of which this function interacts with the physical world, together with the consequence of this interaction. This definition dissolves from the start the perception-action dissociation dilemma: according to it the two concepts are indissociable.

### Motor event

Any movement caused by the muscles.

## Detailed Description

In some sense, the necessity of a tight perception-action coupling has been posited at least since Helmholtz (1867/1962). He proposed that the perceptual stability of our visual world in the presence of continuous eye movements could be due to a closed loop circuitry, whereby the visual-motion signal triggered by the displacement of the retina during an eye movement is cancelled out (up to some error) by the motor signal that induced that specific eye movement. Alternatively, such cancellation can be obtained by subtracting the predicted eye-movement outcome for a given motor command from the actual outcome. In fact, this so called pseudo-closed loop scheme is the founding principle of modern forward models used in computational motor control (Jeannerod 1983, 1997; Wolpert et al. 1995; Warren 2006; Wolpert 2007). A wealth of empirical and modeling studies do indeed support a fine online interplay between perceptual and motor processes during motor planning and execution (e.g. Paillard 1960; Ingle 1982; Requin et al. 1988; Hommel et al. 2001). However, as this literature does not focus on the cognitive aspects of perception and is not controversial, it will only be alluded to in the remainder.

## Opposite Views

Helmholtz's intuition notwithstanding, most of the 20th century perceptual research (with perhaps Gibson's (1950, 1979/1986) notable exception and that of a few followers) was entirely disconnected from the motor research. By the end of the last century, however, two major streams of thought pervaded both fields of research. In 1982, Ungerleider and Mishkin revealed two major sets of nerve projections in the monkey brain, both originating in the primary visual cortex, one projecting ventrally into the temporal lobe and the other projecting dorsally into the posterior parietal cortex (Figure 1). They proposed that these two pathways have complementary functions: the ventral (or 'what') pathway subserves object identification, whereas the dorsal (or 'where') pathway allows spatial localization of these objects. This anatomical dichotomy was extended by Goodale and Milner (1992), who proposed an equivalent functional dichotomy between what they called "vision for perception" and "vision for action". A few years later, O'Regan and Noë (2001) revived Helmholtz's intuition and Gibson's ecological approach, as well as the more philosophical perspective of Maturana and Varela (1987), and documented the opposite view, according to which perception and action are inseparable. In fact, they pushed this view to its extreme, which is that perception cannot exist without action, and vice versa. In defense of this stand Daniel Wolpert has argued that brains' only function is to sustain adaptable and complex movements, pointing out that originally active, brain-equipped creatures (such as sea squirts) that end up settling down for good on rocks, digest their brains once they cease moving (see <http://freethoughtblogs.com/tokenskeptic/2011/12/13/why-we-dont-eat-our-own-brains-professor-daniel-wolpert-on-ted/>). Accordingly, Wolpert's postulate is that all mental processes — sensations, thoughts, emotions — lead to interactions with the environment that eventually translate into muscle activity.

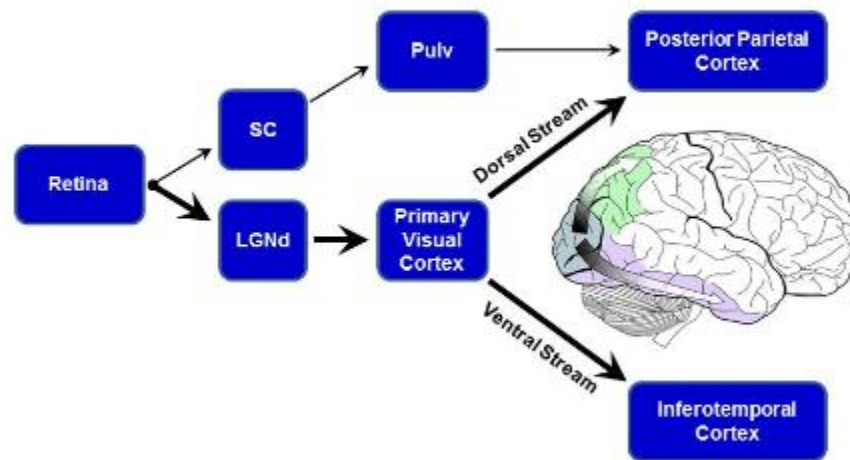


Figure 1. Simplified representation of the two functional pathways for the treatment of visual information according to Ungerleider and Mishkin (1982; following Goodale and Humphrey 1998). Retinal stimulation is transmitted to subcortical structures (SC, Pulv, LGNd) and then cortical structures (PPC, V1). After having reached the visual cortex information flows along one of two streams: the dorsal pathway, which leads to posterior parietal cortex and is thought to subserve the visual control of action, and the ventral pathway, which is thought to subserve perception, and whose integrity is considered necessary for conscious perception. (LGNd, lateral geniculate nucleus pars dorsalis; Pulv, pulvinar; SC, superior colliculus.)

### Arguments in Favor and Against the Dichotomy

Goodale and Milner's dissociative view (Goodale and Milner 1992; Milner and Goodale 1995, 2008; Goodale 2011) was originally based on a type of scientific observation referred to as a 'double dissociation'. Lesions of posterior parietal areas (dorsal stream) lead to a condition known as optic ataxia, which involves disturbances in visually-guided action. Patients set before a mailbox slot are able to report its orientation, but are incapable of correctly inserting a card into it. Lesions of ventral visual areas, in contrast, lead to visual agnosia: these patients are unable to verbally indicate the orientation of the slot, but can correctly insert a card into it. This double dissociation has been challenged based on observations suggesting that (1) optic ataxia is not a general disturbance of visually guided action, (2) visual agnosia is not a disturbance specific to perception, and (3) studies involving such patients were not well controlled (see Pisella et al. 2000, 2006; Rossetti et al. 2003, 2005; Cardoso-Leite and Gorea 2010).

Many other claims favoring a major distinction between perception and action have gone through similar cycles of debate. The dual-pathway theory gained support from various anatomical/imaging, neurophysiological and neuropsychological studies, including studies based on visual illusions, on priming with allegedly 'invisible' stimuli (presumably entailing differential perceptual and motor effects brought about by subsequently presented visible stimuli), and from studies contrasting perceptual and motor response latencies and accuracies. However, the conclusions drawn from such studies have each been rebutted on different grounds. Anatomical/imaging and neurophysiological evidence favoring the dual-pathway theory was offset by evidence that both ventral and dorsal streams process information about the nature of objects and their locations in space (e.g., Konen and Kastner 2008) and that dorsal stream neurons show evident responsiveness to stimulus features supposed to be encoded in the ventral stream, such as shape and color; likewise, some prototypical dorsal-stream features such as motion were shown to be equally well processed in the ventral stream (see Cardoso-Leite and Gorea 2010). The differential perceptual-motor effects caused by visual illusions have been criticized due to the unmatched experimental conditions used to assess them (Franz 2001; Franz and Gegenfurtner

2008). The differential effects of 'invisible' primes have been questioned because 'invisibility' was poorly defined and/or assessed, or because the prime affects the perception of the target stimulus meant to trigger the motor response (Reingold and Merikle 1990; Holender and Duscherer 2004; Cardoso-Leite and Gorea 2010). Finally, results contrasting perceptual and motor response latencies and accuracies were undermined by the observation that such performance differences can be accounted for by a unique processing pathway, if perceptual and motor processes are assumed to require different levels of evidence to trigger a decision (Gibbon and Rutschmann 1969; see Cardoso-Leite and Gorea 2010).

### A False Dilemma?

The ultimate consequence of the dual-pathway theory is that perception can direct action unconsciously; that is, that one can act appropriately on objects that are not seen. This proposition is theoretically debatable, but its test is empirically intractable. On the theoretical side, it makes use of undefined or ill-defined concepts, namely 'perception', 'not seen' and 'consciousness'. While it is unanimously accepted that the retina will transform light into an electrical signal, the stage at which its propagation becomes 'perception' has been under sustained debate since the 19<sup>th</sup> century (see Boring 1942). According to Signal Detection Theory (Green and Swets 1966), a stimulus is reported as 'unseen' either because it is too weak to elicit a neural response or because the subject adopts a high decision criterion; that is, because he or she requires more (neural) evidence of its existence than actually provided by the neural system. The absence of 'consciousness' can be related not only to either of these two causes but also to a variety of ambiguous interpretations of this concept.

On pure common sense grounds, it would be ludicrous to contest the patently obvious dissociation between perception and action. However, the claim that, when tested under strictly matched conditions, subjects' action system may use incoming information that is omitted by the sensory systems may forever remain undecided for at least three reasons. First, because it is impossible to objectify a percept without requiring subjects to perform a perceptual judgment that ultimately involves some sort of action. As a consequence, one cannot prevent an action from interfering with its perceptual cause, and vice versa. For example, asking subjects to react as rapidly as possible in response to a sensory stimulus will lead to perceptual judgment errors (as evidenced by the motor response) that do not occur with a non-speeded motor response. Second, because in the absence of a clear-cut definition of consciousness, the distinction between conscious and unconscious perceptual states will remain elusive, making it hard to determine what sensory information is "omitted" (or not) by the sensory systems. Finally, even if such frontiers between action and perception and between conscious and unconscious states are arbitrarily set, strictly matched conditions for testing perceptual and motor performances cannot be created. For example, the putative "dissociation" between accurately grasping an object and this object's perceptually distorted size by a visual illusion may be accounted for by positing that grasping control is based on the absolute spatial location of the grasping points, whereas perceptual size judgments are based on an estimation of the distance between these grasping points. Also, the finger grip aperture varies during the course of action as it is regulated by an online correction through visual feedback, whereas a perceptual judgment is made once and for all.

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