

# Perceptual-cognitive control as a special case in equivalent multisensory-sensorimotor interactions

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**Franz Mechsner's primary thesis on the purely perceptual-cognitive nature of movement control entirely neglects, or in fact negates, the influences of action on perception. In the following I wish to follow the logical steps of Mechsner, illustrate what I conceive to be an error in his reasoning and synthesize these arguments in favor of a hypothesis of a system of equivalent elements (senses and effectors) in interaction.**

**Mechsner's initial metaphor of a system defined by a driver and a vehicle illustrates his thesis well: The perceptual-cognitive component (driver) processes environmental information (ice on the road, oily spot...) in the context of the driver's cognitive framework (intention, anticipation...). As a result, the driver manipulates the steering wheel and conveys electric control signals to the wheels. As Mechsner repeatedly points out, physical factors have the function of constraints with regard to the movement process, but control is executed solely by the perceptual-cognitive component. Within his metaphor, the proper functioning of the steering wheel and the correct transmission of the control signals down to the wheels certainly constrain the proper performance of the driving process, but only *mediate* the control of the perceptual-cognitive component. They do not *execute* control. All the experimental studies discussed by Mechsner follow a similar scheme: In a perception-action task, the perceptual component (C1) is manipulated while the dynamics of the action component (C2), the end effectors, is studied. Changes in the dynamics of the action components are interpreted as causally related to the initial manipulation of the perceptual components. Based on this evidence, Mechsner incorrectly concludes that movement control is purely perceptual-cognitive. As evident from his driver-vehicle metaphor, *purely* perceptual cognitive control implies that the direction of control is entirely one-way, that is  $C1 \rightarrow C2$  (from the perceptual component to the action component). The only conclusion he may draw in fact is the existence of a causal link from C1 to C2, however he must not infer the absence of a link from C2 to C1. As a corollary it follows from Mechsner's reasoning that the manipulation of action components has no effect on the perception or its dynamics. Or, to stay within Mechsner's metaphor, changes in the voltage of the electric signal between the steering wheel and the wheels will not affect the driver's perception of the icy road, the oily spot, etc. There is ample evidence for the contrary, that is action does effect perception.**

Early psychological evidence of action related effects is provided during the acquisition of postural and motor control, which influences the development of spatial orientation. Held and Hein (1963) believe that it is not just the acquisition of motor abilities, but active exploration of the environment, that is crucial to the acquisition of spatial orientation. They raised kittens in the dark until they were capable of locomotion and then exposed them to the same visual experiences; however, one kitten actively moved through the environment while the other kitten passively moved in a carrier. Held and Hein (1963) found that the passive kittens showed defects in spatial orientation that could not be put down to motor impairment. Active exploration enables stronger associations to be formed in the development of cognitive structures when a greater number of senses are involved in the acquisition of information. Relatedly, the preselection effect in motor-memory tasks shows the positive effects of action on perception and memory (e.g., Stelmach, G.E., Kelso, J.A.S., & Wallace, S.A. (1975); Kelso, J.A.S. (1977)). Note that the Ebbinghaus illusion paradigm employed by Aglioti, DeSouza and Goodale (1995) is actually not evidence for action-enhanced perceptual effects, but rather support the notion of separate subsystems for vision for perception and vision for action. In particular, these authors showed that despite the large effect the illusion had on perceptual judgments of size, there were only small effects of the illusion on grasp scaling. Biological evidence for the action-perception influence ( $C2 \rightarrow C1$ ) is provided by reafferent input from the motor system, which elicits sensory input from its own receptors (von Holst & Mittelstaedt (1950)). Reafferent input may be useful in motor control to make modifications to the motor act itself, but may also be perceptually disruptive because it can interfere with the sensing of external stimuli or even trigger inappropriate reflexes. This problem can be solved with the transmission of signals from the motor command centers to the appropriate sensory receiving areas that nullify the effect of unwanted reafference. Such signals were termed efference copies by von Holst and Mittelstaedt (1950) and corollary discharges by Sperry (1950) and represent biological examples of action effects on perception. Müsseler, Steininger & Wühr (2001) performed a study, which illustrates the action-perception influence most explicitly. When participants performed a left or right key press and were asked to identify a left or right arrow simultaneously, they performed less well with compatible relationships of key press and arrow than with incompatible relationships. The fact that a *specific* interference has been demonstrated and not only an unspecific reduced attentiveness supports the interpretation of action influencing perception.

To establish a truly inverted task, that is ( $C2 \rightarrow C1$ ), to the bimanual coordination paradigm by Mechsner et al. (2001), that is ( $C1 \rightarrow C2$ ), a rhythmic perceptual paradigm is needed, in which action variables are manipulated. Here the literature on multisensory integration may provide potential experimental paradigms. With regard to design, probably the most equivalent perceptual paradigm has been reported by Jirsa & Kelso (2004): in a perceptual integration task, subjects were to perceive two stimuli of different modalities (visual, auditory or haptic) as synchronous. The stimuli were presented rhythmically and parameterized with a

temporal offset. As a function of the temporal asynchrony of the stimuli, the subjects reported loss of the percept of synchrony at a critical parameter value, as well as related phenomena such as phase wrapping. In this particular study no action variables were manipulated, but it is suggestive, given the above-cited literature on action-perception influence, that the inclusion of an action task will induce different modes of effector coordination, which enhance or suppress the perception of synchrony.

Mechsner's thesis of purely perceptual-cognitive control of action variables is incorrect in its strong formulation. Obviously, the perceptual component executes control over the action components, but also action influences perceptual processing. As an alternative model, an interacting perception-action pair tuned to experimental conditions comes to the mind, e.g. as discussed by Turvey (2004) evoking paradigms of self-organization.

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## References

- Aglioti, S., DeSouza, J., & Goodale, M.A. (1995). Size-contrast illusions deceive the eyes but not the hand. *Current Biology*, 5, 679-685.
- Held, R., & Hein, A. (1963). Movement produced stimulation in the development of visually guided behaviour. *Journal of Comparative and Physiological Psychology*, 56, 872-76.
- Holst, E., & von Mittelstaedt, H. (1950). Das Reafferenzprinzip. *Naturwissenschaften* 37, 464-476
- Jirsa, V.K., & Kelso, J.A.S. (2004). Integration and segregation of perceptual and motor behavior. In: Jirsa, V.K., & Kelso, J.A.S. (eds.). *Coordination Dynamics*. Springer.
- Kelso, J.A.S. (1977). Planning and efferent components in the coding of movement. *Journal of Motor Behavior*, 9, 33-47
- Mechsner, F., Kerzel, D., Knoblich, G., & Prinz, W. (2001). Perceptual basis of bimanual coordination. *Nature*, 414, 69-73.
- Müsseler, J., Steininger, S., & Wühr, P. (2001). Can actions affect perceptual processing? *The Quarterly Journal of Experimental Psychology*, 54A (1), 137-154

**Sperry, R.W. (1950). Neural basis of the spontaneous optokinetic response produced by visual inversion. *J. Comp.Physiol. Psychol.* 43, 482-489**

**Stelmach, G.E., Kelso, J.A.S., & Wallace, S.A. (1975). Preselection in short term motor memory. *Journal of Experimental Psychology: Human Perception and Performance*, 1, 745-755**

**Turvey, M.T. (2004). Impredicativity, Dynamics, and the Perception-Action-Divide. In: Jirsa, V.K., & Kelso, J.A.S. (eds.). *Coordination Dynamics*. Springer.**