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Cognition 96 (2005) 215–231
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A specific role for efferent information in self-recognition

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Received 14 February 2003; revised 28 November 2003; accepted 12 August 2004

Abstract

We investigated the specific contribution of efferent information in a self-recognition task. Subjects experienced a passive extension of the right index finger, either as an effect of moving their left hand via a lever ('self-generated action'), or imposed externally by the experimenter ('externally-generated action'). The visual feedback was manipulated so that subjects saw either their own right hand ('view own hand' condition) or someone else's right hand ('view other's hand condition) during the passive extension of the index finger. Both hands were covered with identical gloves, so that discrimination on the basis of morphological differences was not possible. Participants judged whether the right hand they saw was theirs or not. Self-recognition was significantly more accurate when subjects were themselves the authors of the action, even though visual and proprioceptive information always specified the same posture, and despite the fact that subjects judged the effect and not the action per se. When the passive displacement of the participants right index finger was externally generated, and only afferent information was available, self-recognition performance dropped to near-chance levels. Differences in performance across conditions reflect the distinctive contribution of efferent information to self-recognition, and argue against a dominant role of proprioception in self-recognition.

Keywords: Efference; Afference; Self-recognition; Agency; Proprioception; Action

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doi:10.1016/j.cognition.2004.08.002

1. Introduction

Imagine that you are entering into a hall, where a mirror, large enough to reflect many people, is just in front of you. It is not easy to locate the reflection of your own-self among those of others. Most people would make a gesture and try to visually locate it in the reflection. In other words, they would produce a movement and compare it against the visual feedback in order to detect themselves. This example illustrates the interplay between central (i.e. efferent) information related to the motor command, and peripheral (i.e. afferent) information related to the sensory feedback.

Efferent and afferent information jointly constitute the core of our bodily self-awareness (Bermúdez, Marcel, & Eilan, 1998). However, for more than a century (see for example the 'Williams debate' in Petit, 1999), their respective contribution has been debated. Efference has been usually implicated in the unconscious function of internal models of the motor system, responsible for motor learning, motor prediction and motor correction (for a review see Wolpert, 1997). Afference, and especially proprioception, provides us with the specific content of our bodily self-awareness (Gibson, 1979). In effect, proprioception is usually conceptualised as the modality of the self *par excellence*, because no one else can feel my hand moving, the way I feel it from the inside (Bermúdez, 1998). However, afference can be the result of either self-generated actions or externally-generated sensory stimulation. As a result, the meaning of afferent information for perception and behaviour is ambiguous. Recent theories of motor control have shown how an interaction between efferent commands and sensory inflow may reduce this ambiguity. In the case of a self-generated action, intentions and efferent information not only predict the consequent multisensory signals produced by our own movements (Helmholtz, 1995; Sperry, 1950; von Holst & Mittelstaedt, 1950; Wolpert, 1997), but also modulate their perception and underlie the sense of agency (for a review see Tsakiris & Haggard, 2005a).

We distinguish between two related computational problems: the problem of action recognition and the problem of self-recognition. In action recognition, the brain must distinguish between afferent information generated by our own movements, and afferent information that is externally imposed. Self-recognition, in the current context, involves deciding whether a visual stimulus shows one's own body or not. Action recognition may involve unconscious operation of internal predictive models, while self-recognition appears to be a specific cognitive process typically involving conscious experience. As the example with which we started this paper shows, we often use voluntary movements as a means of self-recognition. This fact by itself suggests a hierarchical relation between action–recognition and self-recognition: voluntary action can aid self-recognition only if one can be sure that the resulting body movements were caused by one's own voluntary action. The action–recognition problem has been studied largely in the sensorimotor control literature (Blakemore, Frith, & Wolpert, 2002; Wolpert, 1997). Only a few studies have explicitly investigated the link between action–recognition and self-recognition (van den Bos and Jeannerod, 2003, and for a review see Jeannerod, 2003). We focus here on the contribution of voluntary action to the self-recognition problem.