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Revisiting a study of callosal apraxia: The right hemisphere can imitate the orientation but not the position of the hand

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ABSTRACT

Callosal disconnection can reveal asymmetrical contributions of the two brain hemispheres to praxis. In this paper, we revisit a study of a patient with callosal disconnection (Goldenberg et al., 2001, Neuropsychologia, 39:1432–1443), who perfectly imitated meaningless gestures when imitation was controlled only by the left hemisphere, but was severely impaired when the right hemisphere was in charge of motor control. We decomposed the gestures into a set of geometric variables that were to be reproduced, such as the orientation of the hand and the position of contact between the hand and the face. Whereas orientation of the hand in extrinsic coordinates was replicated correctly by both hemispheres, only the left hemisphere reproduced correctly the position of contact between the hand and the face. This goal-dissociation as well as several partial perseveration errors speak against the hypothesis of a direct route from perception to motor replication of gestures, as interruption of a direct route would probably impair all the features of the gesture. We speculate that incorrect coordination between the reproductions of multiple goals may be the core deficit underlying callosal apraxia.

1. Introduction

Apraxia refers to a disorder of the high-level control of voluntary movement, and is described in terms of the absence of certain deficits rather than in terms of its mechanisms, which are still poorly understood (Petreska, Adriani, Blanke, & Billard, 2007). Specifically, apraxia is defined as "a disorder of skilled movement not caused by weakness, akinesia, deafferentation, abnormal tone or posture, movement disorders such as tremor or chorea, intellectual deterioration, poor comprehension, or uncooperativeness" (Heilman & Rothi, 1993). Since the apraxia's symptoms exclude elementary sensory and motor deficits, apraxia is particularly appropriate for studying the neural processes underlying specific sensori-motor transformations, such as visuo-motor imitation. Case studies of impaired imitation following apraxia, such as the one revisited here, offer a valuable route to deciphering the neural functions and mechanisms of imitation (De Renzi, Faglioni, & Sorgato, 1982; Goldenberg & Hagmann, 1997; Merians et al., 1997; Ochipa, Rothi, & Heilman, 1994; Tessari, Canessa, Ukmar, & Rumiati, 2007). In particular, they have revealed important dissociations between the imitation of meaningless and meaningful gestures, and elements of the hemispheric specialization of praxis (e.g., left hemisphere dominance); see Petreska et al. (2007) for a review.

This paper revisits a case study of imitation of meaningless gestures by a patient whose brain hemispheres were disconnected by a callosal lesion which included the splenium (Goldenberg, Laimgruber, & Hermsdörfer, 2001). This seminal study examined the reproduction of hand postures relative to his face (shown in Fig. 1A).[1] In order to disentangle the contributions of each brain hemisphere, the stimuli to imitate were presented tachistoscopically either in the left or right visual field. In both cases, the patient was requested to imitate alternatively with either the left or right hand (see Fig. 1B). A quantitative analysis of the patient performance revealed that the imitation of hand postures relative to the face was preserved only in the "*right visual field-right hand" condition;* that is, when both perception and motor execution were processed uniquely by the left hemisphere. This observation suggests that the visuo-motor imitation of meaningless gestures requires key competences located in the left hemisphere (see Fig. 1C).

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[1] The study also examined the imitation of finger postures, which will not be considered here as the underlying neural substrates are different from those associated with the imitation of hand postures (Goldenberg & Karnath, 2006).

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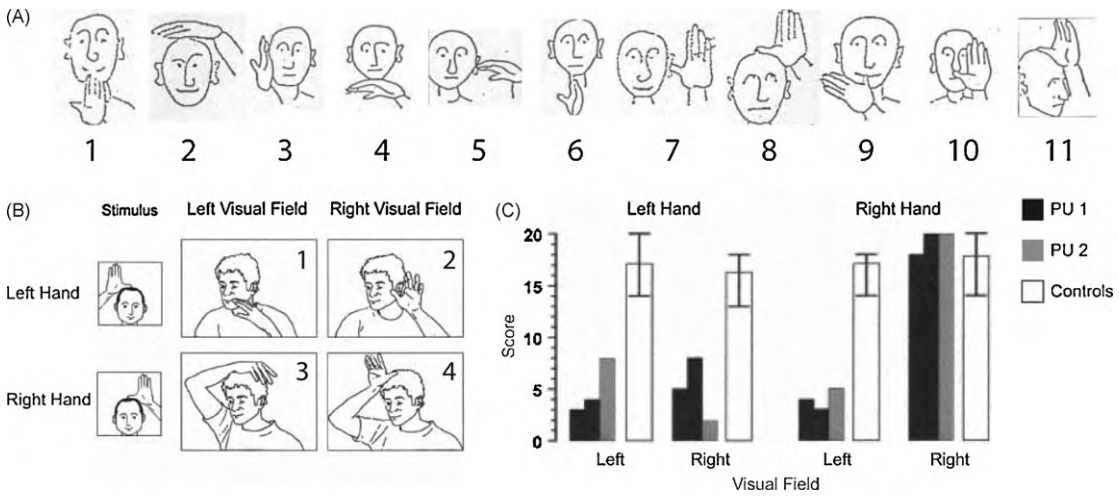

Fig. 1. (A) Visual stimuli used for the tachistocopic examination of imitation of meaningless gestures. (B) Four conditions of testing: the stimulus is presented in the left or right visual field and imitated with either the patient's left or right hand. (C) The patient's score of success in the four conditions (two trials: PU1 and PU2) compared to control data (in white). Note that imitation is preserved only in the "right visual field-right hand" condition. The figures under B and C are adapted from Goldenberg et al. (2001) by permission of Elsevier.

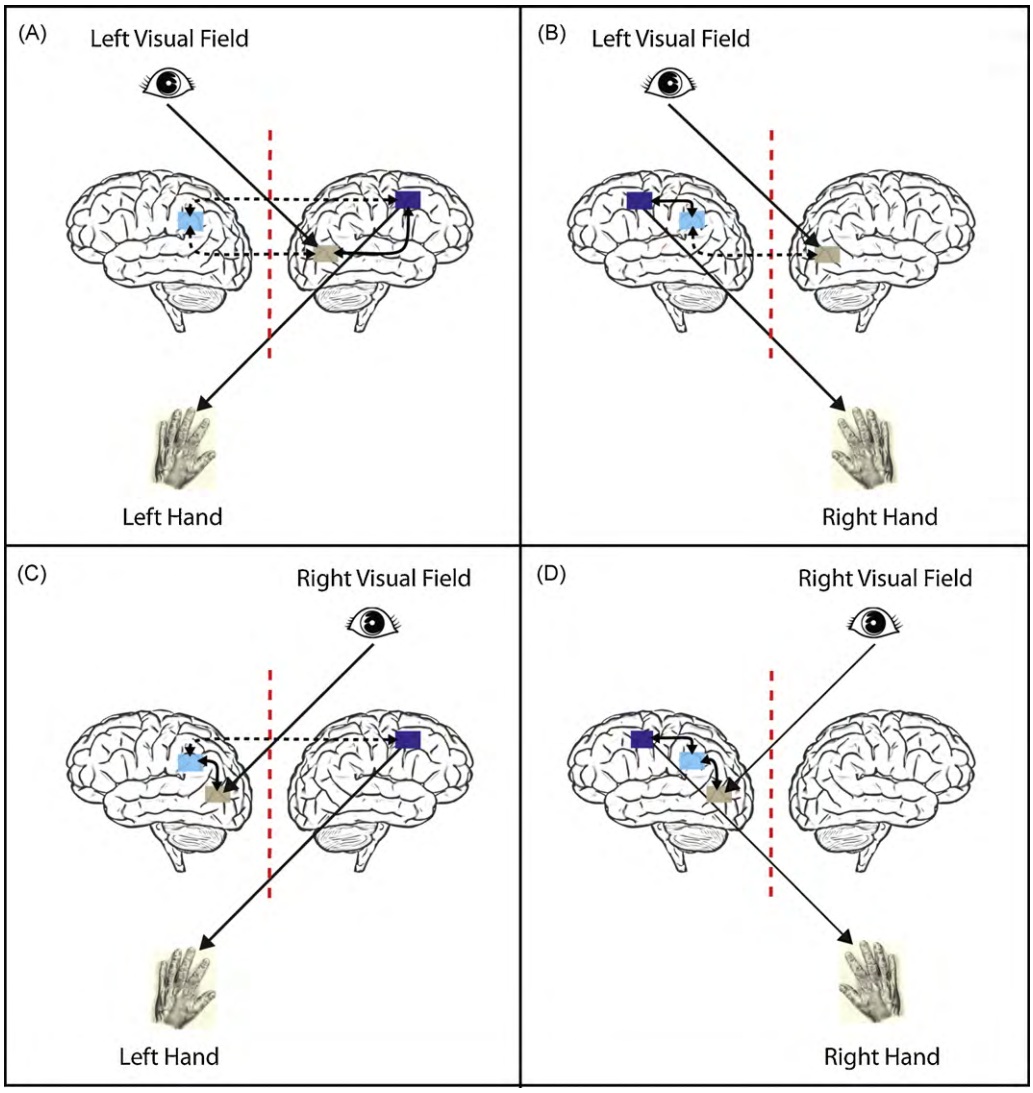

Fig. 2. A neuro-anatomical model of the neural processes underlying imitation of meaningless gestures, shown for the four conditions. First, the stimulus to imitate is processed visually by the contralateral "Extrastriate Body Area", located at the level of the occipito-temporal junction (BA 19/37). Second, the stimulus is translated into its motor counterpart with the participation of the left intraparietal sulcus (BA 40). Finally, the dorsolateral premotor cortex (BA 6) contralateral to the hand implements the motor component of imitation, possibly through motion attractors.