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Hemispheric specialization in nonverbal gesticulation investigated in patients with callosal disconnection

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Abstract

We present a research study of nonverbal gesticulation in split-brain patients. These patients have the two hemispheres operatively disconnected (callosotomy) and thereby allow the separate investigation of the role of right and left hemisphere in gesticulation. The assumption of hemispheric specialization in gesticulation has been raised by several neuropsychological investigations that show specific hand preferences for certain gesture types, as well as by two previous case studies of gesticulation in split-brain patients. The current study focuses on the contribution of the right and left hemispheres to pantomime and its relation to other types of speech-related gestures.

Introduction

Callosal disconnection entails that the left hemisphere can only control the contralateral right hand and vice versa. Hence, in patients with complete callosotomy, the hemisphere that generates a gesture can be determined by the hand which is used to perform the gesture. Using this direct link between the hand choice and a hemisphere, this study aims to determine hemispheric specialization of different types of gesticulations. Previously, three split-brain patients have been investigated (McNeill 1992, Lausberg et al. 2000) and their gesticulation pattern produced evidence for the hemispheric specialization of gesticulation. These findings concur with results of hand preference studies on gesticulation that revealed specific hand preferences for certain gesture types, such as physiographs, batons, or deictics (Kimura 1973 a, b, Sousa-Poza et al. 1979, Lavergne & Kimura 1987, Foundas et al. 1995). This also implies that hemisphere-specific gesticulation is associated with different neuropsychological functions such as language, motor... Thereby, gestures can give insight into the process of verbalizing spatial and motoric imagery in speech production (McNeill 1992, Kita 2000). On this background, our study concentrates on the investigation of pantomime and its relation to other types of speech-related gestures.

Method

In the current study, we tested 3 patients with complete callosotomy, and as control groups patients with partial callosotomy (n=5) and healthy subjects (n=11). The surgical diagnosis of complete and partial callosotomy was verified by NeuroImaging (MRI). The three groups did not differ significantly concerning the distribution of gender and of native languages (English and French). However, a mild difference in mean age could not be excluded.

As a basis for the interpretation of the gestural behavior, the subjects' handedness, their sensorimotor status, and the callosal disconnection syndrome were investigated. Specifically, the degree of ipsilateral motor control was examined, i.e. the compensatory development of direct motor pathways from the right hemisphere to the right hand and from the left hemisphere to the left hand, which can be found in some split-brain patients. Pantomime of tool use (demonstration of how to use scissors, a ball, a screwdriver, etc.) was examined in two standardized tests, first as response to visual presentation of the tools, then with handling the tool (but not really using it). In the second experiment, free gestures were elicited by a task in which the participants had to narrate an animated cartoon with moving geometric objects. The experiment was repeated as a pantomime task in which the participants had to demonstrate without words the content of the animated cartoon. The pantomime experiments were videotaped and evaluated by two independent raters who were trained beforehand in a specifically developed movement coding system.

Results

General neuropsychological findings

All patients are within the low IQ-range (according to the Wechsler Adult Intelligence Scales) except for one patient who just reaches the minimum score for the average IQ range. Healthy controls are distributed almost equally over the three IQ-groups: low, average, and high IQ. All subjects are right-handed except for one healthy control who is ambidexter (according to the Montreal Handedness Questionary). There are no severe primary motor or sensory deficits such as paresis, coordination deficits, or numbness, that could effect gesticulation.

Examination of callosal transfer

However, sensorimotor tests that require callosal transfer clearly revealed a functional callosal disconnection in the patients with complete callosotomy. In order to examine the callosal transfer between the right and the left hands, the investigator touched a finger of the blind-folded participant, e.g. ring finger of the left hand, who then had to raise the corresponding finger on the other hand. The patients with complete callosotomy showed an error rate of 75 %, which is clearly higher than that of the patients with partial callosotomy (13 %) and the healthy controls (3 %). When the analogous task was repeated on the wrist, the elbow, and the shoulder, the patients with complete callosotomy showed 65 %, 57 %, and 19 % errors, respecti-

vely. In contrast, the error rates for the patients with partial callosotomy were 9 %, 3 %, and 2 %, respectively, and for healthy controls 1 %, 0,5 %, and 0,5 %, respectively.

Pantomime

Patients with complete callosotomy showed apraxia of the left hand for pantomime when the tool was visually presented, but not when they could handle the tool. These results as well as the findings in the experiment with narration and pantomime of animated cartoons will be presented in detail on the conference.

Discussion

The experiments for sensorimotor callosal transfer provide evidence that the three patients with complete callosotomy do not compensate callosal disconnection by means of ipsilateral motor pathways for hands and fingers. Their error rate increases continuously from proximal, i.e. shoulders (19 % errors), to distal, i.e. fingers (75 % errors), indicating the decrease of ipsilateral motor control from the proximal to the distal parts of the arm. The patients with complete callosotomy were only able to control their wrist movements in 35 % of the tasks. Even stronger was the evidence for lack of ipsilateral control of finger movements. It is unlikely that split-brain patients will spontaneously, e.g. in an interview, use their deficient ipsilateral motor pathways to express themselves. Thus, when a patient with complete callosotomy uses distal parts of the arm for a gesture, we can conclude that the gesture is generated by the contralateral hemisphere. These findings are confirmed by the left hand apraxia for pantomime on visual tool presentation which also reveals the lack of motor control of the left hand by the left motor-dominant hemisphere.

The split-brain patients showed left hand apraxia in pantomime when the tool was visually presented, but not when they could grasp the tool. This dissociation concurs with findings of De Renzi (1988) in patients with impairment of pantomime of tool use who made distinctly fewer errors when asked to handle the actual tools. Goldenberg & Hagmann (1998) raised the hypothesis that the capability to pantomime is based on both the retrieval of tool instruction of use from semantic memory and the inference of function from the tool structure. The latter could explain the dissociation found in our patients because tactual tool exploration facilitates the inference of function as compared to the merely visual scanning of objects. With regard to theories underlining that gestures are abstracted from material action (LeBaron & Streeck 2000) our data suggest that the first step in the development from actual object handling toward free gesture could be the internalization of the tactual object qualities.

Further results of the analysis of pantomime and co-speech gestures in the narration of the animated cartoons will be presented and discussed on the conference.

References

De Renzi E, Faglioni P, Sorgato P. 1982, "Modality-specific and supramodal mechanisms of apraxia", Brain, 105, 301-312.

Foundas AL, Macauley BL, Raymer AM, Mahler LM, Heilman KM, Rothi, LJG. 1995, "Gesture laterality in aphasic and apraxic stroke patients", *Brain and Cognition*, 29, 204-213.

Goldenberg G, Hagmann S 1988, "Tool use and mechanical problem solving in apraxia," *Neuropsychologia*, 581-589.

Kimura D. 1973a, "Manual activity during speaking - I Right-handers", *Neuropsychologia*, 11, 45-50.

Kimura D. 1973b, "Manual activity during speaking - II. Left-handers", *Neuropsychologia*, 11, 51-55

Kita S. 2000, "How representational gestures help speaking", in McNeill D. (ed.), *Language and Gesture*. Cambridge, Cambridge University Press, 162-185.

Lavergne J, Kimura D 1987, "Hand movement asymmetry during speech: No effect of speaking topic", *Neuropsychologia*, 25, 689-693.

Lausberg H, Davis M, Rothenhäusler A. 2000, "Hemispheric specialization in spontaneous gesticulation in a patient with callosal disconnection", *Neuropsychologia*, 38, 1654-1663.

LeBaron C, Streeck J. 2000, "Gestures, knowledge, and the world" in McNeill D. (ed.), *Language and Gesture*. Cambridge, Cambridge University Press, 118-138.

McNeill D. 1992, *Hand and mind. What gestures reveal about thought*. Chicago, University of Chicago.

Salmaso D, Longoni AM. 1985, "Problems in the assessment of hand preference", *Cortex*, 533-549.

Sousa-Poza JF, Rohrberg R, Mercure A. 1979, "Effects of type of information (abstract-concrete) and field dependence on asymmetry of hand movements during speech", *Perceptual and Motor Skills*, 48, 1323-1330.