

# DOUBLE DISSOCIATION BETWEEN MEANINGFUL AND MEANINGLESS GESTURE REPRODUCTION IN APRAXIA

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## INTRODUCTION

A model of the normal processing of gestures to account for the complexity of the different patterns of apraxia has been proposed by Rothi et al. (1991; 1997) and recently refined by Cubelli et al. (2000). This model, in analogy with the dual-route models of reading (e.g., Coltheart et al., 1993) encompasses three processing components<sup>1</sup>:

(i) A “lexical route” which supports recognition (action “input lexicon”), identification (action semantic system) and production (action “output lexicon”) of familiar gestures;

(ii) A visuo-motor conversion mechanism which turns visual information into motor programmes, upholding the reproduction of all seen gestures;

(iii) A short-term memory workspace, on which both the lexical and the non-lexical route converge, storing the motor programmes to be executed.

According to the functional architecture of this model, the reproduction of visually presented known gestures can be accomplished either by means of the lexical route or through the visuo-motor conversion system. A deficit in the reproduction of familiar gestures could then derive solely from the impairment of the gestural buffer. Such a deficit should cut across both meaningful and meaningless gestures alike, and should be yoked to an analogous disturbance of elicited, non-imitative gesture production. The malfunctioning of the visuo-motor conversion mechanism would give rise to a selective deficit of the imitation limited to meaningless gestures. On the other hand, the deficit of the lexical route would hamper spontaneous production of learned actions though imitation of both meaningful and meaningless gestures would be made possible via the visuo-conversion mechanism. In summary, whereas the model can easily account for the selective deficit in the imitation of meaningless gestures, it may run into difficulties should isolated impairment of meaningful gesture reproduction be observed, which is the pattern reported in this paper.

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<sup>1</sup> The current version of the model does not include a direct route linking the perceptual representation of an actually seen object to the stored action programmes, as predicted by Rumiati and Humphreys (1998). This issue is still controversial. For example, recent findings (Creem and Proffitt, 2001) suggest that a semantic mediation is necessary for the appropriate use of an object.

## PARTICIPANTS

Three right-handed brain-damaged people were selected from a consecutive series of patients assessed for apraxia and considered for the study. BS is a 48 year old male with 13 years of education, EE is a 59 year old male with 5 years of education, MF is a 40 year old female with 11 years of education. They had suffered a left ischaemic stroke resulting in temporo-parietal, subcortical (internal capsule and thalamus), and fronto-temporo-parietal lesions, respectively. They all performed above the cut-off score on Raven's Coloured Progressive Matrices (Raven, 1965).

Twenty healthy participants served as matched controls: mean age 54.4 (range 40-59); mean education 6 years (range 3-13).

## PROCEDURES

A battery of 13 tests was devised to assess the different stages of gestural processing depicted in the model. The same transitive and intransitive gestures were used across all tasks. Transitive gestures comprised either the actual use of an object or the corresponding pantomime, whereas intransitive gestures included symbolic actions carried out without the support of an object (e.g., the military salute). The tasks included in the battery were:

Two recognition tests, one investigating the discrimination of transitive gestures (*"Is the gesture performed by the examiner correct or wrong?"*), the other of intransitive gestures (*"Is the gesture performed by the examiner familiar or novel to you?"*).

Two gesture-object matching tasks, taxing the identification of transitive gestures (*"Which object did the examiner pretend to use?"*), and that of intransitive gestures (*"With which drawing does the gesture performed by the examiner match?"*), respectively.

Six tasks assessed the gesture production on command. Four investigated transitive gestures, three of which required miming and one the actual use of objects. Mimes were elicited through different modalities: verbal (the name of the object), visual and tactile (the real object). The two remaining tests involved intransitive gestures, which were elicited by the correspondent name spoken by the examiner (*"Show me the military salute"*) or by pictures representing the context usually associated with them (e.g., a recruit meeting a general).

Finally, three tasks investigated the imitation of pantomimes (e.g., hammering), intransitive gestures (e.g., military salute) and meaningless gestures (e.g., fist under the chin), respectively.

## RESULTS

In the recognition and identification tasks, all three patients performed well within the normal range, suggesting that the action-input lexicon and the action semantic system were spared. The scores obtained by the three patients and the

controls in the tasks assessing the production on command and imitation are reported in Table I.

BS and, to a lesser extent, EE showed a selective deficit in the imitation of meaningless gestures. MF presented with the opposite pattern, showing impairment in the meaningful gesture production, both on command and on imitation, combined with a normal performance in the imitation of meaningless gestures. Although in need of replication, the contrasting profile of BS and EE versus that presented by MF indicates a double dissociation. It is worth noticing that an item was scored as error when it was failed on the second attempt, therefore knowing that the performance was wrong did not always prompt her to seek alternative routes to fulfil the requirement of the task.

### CONCLUSION

BS and EE's performance is consistent with the pattern predicted by the model should the conversion mechanism be selectively impaired. This pattern of spared and impaired praxic abilities has been previously reported (Goldenberg and Hagmann, 1997) and corresponds to the clinical picture labelled "conduction apraxia" by Ochipa et al. (1994).

MF presented with the reversed pattern. She performed poorly in all tests of gesture production but was flawless in meaningless gesture imitation. The model runs in some more difficulty in accounting for her pattern of spared and impaired abilities and the interpretation of her profile necessarily ad hoc. Both the conversion mechanism and the gestural buffer ought to be spared given her impeccable performance in imitating meaningless gestures. MF's problems in producing elicited gestures should therefore be attributed to a deficit within the lexical route. Action input lexicon and action semantic system are spared as indicated by the absence of discrimination and comprehension disturbances. The deficit lies at the level of the output lexicon or in accessing it. The spared non-

TABLE I

*Patients and Controls' performance on gesture production (in all tests score ranges from 0 to a maximum of 15). Cut-off scores were determined as the worst score achieved by the controls minus two further points (asterisks indicate pathological score).*

	Elicited Gestures						Imitative Gestures		
	Transitive			Actual use	Intransitive		Panto-mimes	Intransitive	Meaningless
	Pantomimes				Verbal input	Visual input			
	Verbal input	Visual input	Tactile input						
<i>Controls</i>									
Range	13-15	13-15	13-15	15	15	11-15	15	15	15
Cut-off	11	11	11	13	13	9	13	13	13
<i>Patients</i>									
BS	13	12	11	14	13	12	14	14	4*
EE	14	14	14	15	14	14	15	13	11*
MF	6*	8*	10*	10*	3*	1*	10*	11*	15

lexical route should permit imitation of all seen gestures, yet her performance with meaningful gestures was pathological.

To imitate as well as to repeat or copy are all complex tasks (Goldstein, 1948) which call for different processing operations according to the degree of familiarity of the stimulus to be reproduced. Margolin (1984) postulated that both a reading and a pictorial strategy could play a role in copying strings of letters. Similarly, gestures could be reproduced by means of either a lexical or a configuration imitation procedure. Should a shown gesture be recognised as familiar and identified, its reproduction would be constrained by the selection of the correspondent motor programmes within the action output lexicon. Gestures that carry no meaning for the examinee would be processed via the visuo-motor conversion mechanism.

The consequent prediction is that deficits in producing elicited gestures would be coupled with some difficulty in imitating meaningful gestures, unless a deficit of the action input lexicon (pantomime agnosia, Rothi et al., 1986) be associated. This hypothesis would be taken to task by the observation of a patient showing a dissociating performance between imitation of meaningful gesture and production of elicited gestures but without pantomime agnosia. Such observation would compel one to posit that the postulated lexical and configuration procedures are under strategic control which should then be refined experimentally.

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