Conduction apraxia

Cynthia Ochipa, Leslie J Gonzalez Rothi, Kenneth M Heilman

Department of
Veterans Affairs
Medical Center,
Tampa, Florida, USA
C Ochipa

Department of
Veterans Affairs
Medical Center,
Gainesville, Florida,
USA

L J G Rothi
K M Heilman

Center for
Neuropsychological
Studies and
Department of
Neurology, University
of Florida College of
Medicine, Florida,
USA

L G Rothi
K M Heilman

Correspondence to:
Dr Cynthia Ochipa,
Audiology and Speech
Pathology Service (126),
James A Haley Veterans
Hospital, 13000 N 30th St,
Tampa, Florida 33612,
USA.

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Abstract

A left hemisphere damaged patient with ideomotor apraxia is described, whose performance on pantomime to verbal command was superior to pantomime imitation. His reception of these same gestures (gesture naming) was spared. This syndrome has been named conduction apraxia. To account for this selective impaired performance on gesture imitation, a separation of the representations for gesture production and reception is proposed and a non-lexical gesture processing route for gesture imitation is suggested.

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Liepmann and Maas¹ proposed that the left hemisphere contained "movement formulas" for the programming of skilled movements. Heilman, *et al*² proposed that these movement formulas or space-time movement representations were stored in the left inferior parietal lobule and lesions that ablate the parietal lobe should be behaviourally dissociable from more anterior lesions that leave these engrams intact but disconnect them from motor areas. Studies of gesture comprehension and dis-

crimination have shown that apraxic patients with parietal lobe lesions (supramarginal or angular gyrus) not only gesture and pantomime poorly to command and to imitation but also have gesture comprehension deficits. Apraxic patients with anterior lesions (anterior to or deep to the supramarginal gyrus) are impaired in producing skilled movement but are not impaired in comprehending or discriminating gestures.^{2,3} Failure to comprehend gestures in the absence of apraxia (pantomime agnosia) has also been described. This disorder was associated with lesions of the visual association areas. Rothi *et al*⁴ posited that these lesions deprived the space-time movement representations stored in the parietal lobe of visual input (fig 1, lesion A).

In the apraxic conditions described, gesture imitation performance is either comparable with or somewhat better than gesture to verbal command. For example, patients with ideomotor apraxia make the most errors on pantomime to command, whereas imitation performance improves or remains equally impaired.^{5,6} We describe a left hemisphere damaged patient with ideomotor apraxia whose imitation of transitive gestures was much worse than his performance when pantomiming in response to verbal command. His poorer performance on gesture imitation could not be explained on the basis of a disconnection or dissociation of visual areas from the space-time movement representations because gesture comprehension was preserved. The behavioural dissociation between gesture to command and gesture imitation we found in this case provides support for a model of gestural processing in which the representations used for praxis production and those important for gesture recognition are independent. Whereas these representations are normally linked, in this case they may have been disconnected or dissociated.

Case report

A 69 year old, previously healthy, right handed man was admitted to the hospital after having been found lying on the floor of his home for an undetermined amount of time in a confused state. Neurological examination showed a right foot drop but no other motor abnormalities. Sensory examination showed decreased sensation to all modalities on the right hemibody. Aphasia and a right visual field defect were also noted. Computed tomography conducted at the time of admission showed an infarct involving the left

Figure 1 Liepmann's conceptualisation of praxis processing. Lesion A is proposed to account for pantomime agnosia.⁴ *It has been posited that the movement formulas are coded in a three dimensional supramodal code. These representations must be transcoded into an innervatory pattern that in turn is fed to the motor cortex. The supplementary motor area is thought to play a part in the transcoding of the space-time representations into the innervatory patterns.^{10,14}

Figure 2 Computed tomography consistent with an infarct in the distribution of the left middle cerebral artery involving the inferior parietal and superior temporal lobes.

inferior parietal and posterior superior temporal lobe (fig 2).

SPEECH AND LANGUAGE EVALUATION

The patient's speech and language were formally evaluated nine days after onset with the western aphasia battery.⁷ Results were consistent with conduction aphasia in that spontaneous speech was fluent in the context of relatively spared auditory comprehension and poor naming and repetition abilities. Verbal output was characterised by frequent literal and verbal paraphasic errors and occasional neologisms. Auditory comprehension was good for yes or no questions, auditory word recognition, and one and two step commands.

Comprehension of multistage, syntactically complex commands was poor. Reading and writing abilities were severely impaired.

PRAXIS EVALUATION

Evaluation of praxis was conducted three weeks after onset with a modified version of the Florida apraxia screening test (table).⁸ Pantomime in response to verbal command, pantomime imitation, actual tool or object use, and gestural comprehension were assessed. The gestural comprehension subtest was given before the production subtests. Gesture comprehension was tested by having the subject identify a gesture performed by the examiner. For each item on the production subtests, he was required to produce a pantomime in response to verbal command. Immediately after his performance, the examiner performed the correct gesture, and he was requested to imitate the examiner's production. He was then given the actual tool or object and was asked to demonstrate its use. The patient's performance was videotaped and scored by a panel of three trained judges with the system for the qualitative analysis of errors described by Rothi *et al.*⁹ (See appendix for a description of the possible apraxic error types.) As well as judging the types of errors, imitation was also judged as to whether it was inferior, superior, or equivalent to pantomime to command. For comparison purposes, the praxis performance of an additional five left hemisphere damaged apraxic patients was scored with the protocol described. All subjects in this group were right handed and had had a single, unilateral stroke of the left hemisphere. Hereafter they are referred to as the comparison group.

Results

The patient exhibited a severe ideomotor apraxia to both verbal command and imitation. Table 1 gives the praxis test results. Gesture comprehension was spared (14/14 correct). Although performance on pantomime to verbal command was poor (1/14 correct), performance was much worse in the imitation condition on eight out of 14 items

Results of praxis testing: left hand

Pantomime content	Pantomime to command	Praxis task	
		Pantomime imitation	Actual tool or object use
Scissors	BPO	BPO, M (decline)	+
Key	S	S, O, M (decline)	S
Watch	A, EC	A, EC (same)	+
Toothbrush	EC	EC (decline)	EC
Pencil	M	M, BPO (decline)	+
Phone	A, EC, M	A, EC, M (decline)	+
Screwdriver	M	M (same)	+
Comb	BPO	BPO (same)	+
Toothpaste	EC	EC, M (decline)	+
Knife	M	M, IC (decline)	+
Glass	IC	+ (improved)	+
Spoon	+	A (decline)	A
Fork	M	IC, EC (same)	IC, EC
Doorknob	IC	IC (same)	+

BPO = body part as object; M = movement; S = sequencing; O = occurrence; A = amplitude; IC = internal configuration; EC = external configuration; + = correct. See appendix for error type description.

Figure 3 Modification of Liepmann's model to account for selective impairment of gesture imitation (lesion A) and selective sparing of gesture imitation (route B).

(57%). For example, when asked to demonstrate the use of a key, he made a sequencing error. When provided with a model for imitation, his performance deteriorated such that the incorrect gesture was classified as consisting of sequencing, occurrence, and movement errors. On several test items, additional error types were not seen in the imitation condition, but rather the same error type was noted to be worse in degree than in the pantomime to command condition. On only one occasion was improvement noted with imitation. Considerable improvement was noted, however, in actual tool or object use (10/14 correct).

The imitation performance of all five of the patients in the comparison group was judged to be worse than pantomime to verbal command on only two occasions (3%) for the comparison group *v* 57% for our patient). Imitation performance on the remaining items either improved (38%) or was equivalent to the pantomime to command task (59%).

Discussion

Our patient showed a severe ideomotor apraxia in response to both verbal command and imitation. He did not show, however, the gestural comprehension deficit that has been reported with other patients who have inferior parietal lobe lesions. This suggests that other areas in the left or possibly the right hemisphere may mediate his gesture comprehension. These areas normally may have been used to comprehend gesture or were able to compensate for damaged areas.

Unlike other apraxic patients reported in the medical literature^{5,6} and the comparison patients reported here, his performance on gesture imitation, when compared with his performance to verbal command, deteriorated rather than improved. This particular pattern of practic deficits, which has not been previously described, calls for a modification of previous models of praxis processing systems.

With a parallel drawn from models of language processing, Rothi *et al*¹⁰ suggest that the term "action lexicon" corresponds to the visuokinesthetic motor engrams or Liepmann's "movement formulas." Similar to the lexicon of the linguistic system, the action lexicon provides a processing advantage to gestures for which the user has had prior experience (learned skilled motor acts). The model of praxis processing presented in fig 1 suggests that imitation failure would occur with disorders of action lexicon access or egress and therefore occur concomitant with either failures of gesture reception or production or from the cumulative effect of both reception and production difficulties. The patient's increased difficulty with imitation of known gestures, however, cannot be accounted for solely by a production deficit because imitation was worse than performance to verbal command. It can also not be accounted for by a failure to gain access to the action lexicon, a receptive defect, or the cumulative effect of receptive and production deficits because the patient had no difficulty with gesture comprehension. The finding that pantomime to command was superior to pantomime imitation in this patient with intact gesture comprehension, supports the postulate that there may be a division of the action lexicon into an action input lexicon and an action output lexicon (fig 3), similar to that found in models of word recognition and production.¹¹ Intact gesture comprehension in the context of particular difficulty with imitation suggests dysfunction at some point after access to or processing by the action input lexicon. Because pantomime to command requires access to the action output lexicon, defective pantomime to command may result from impairment at or after access to the action output lexicon. Particular difficulty with pantomime imitation may be accounted for by increased production difficulty resulting from additional problems arising before access to the action output lexicon (fig 3, lesion A).

Again, drawing a parallel from the language system, Strub and Gardner¹² suggest that the verbal repetition deficit in conduction aphasia occurs after phonemic analysis of auditory input and before the actual encoding of phonemes for production. Our patient's apraxic deficit may be similar in that we believe that there is a disruption at the stage between visual analysis of gestures and the motor encoding of known gestures for production. We therefore propose that "conduction apraxia" may be a suitable descriptive term for this disorder. This conduction apraxic patient's behaviour is almost opposite to that of patients with pantomime agnosia⁴ whose gestural comprehension is impaired while pantomime production and imitation are spared. Rothi *et al*¹⁰ suggest that this constellation of symptoms cannot be accounted for by the action input lexicon to action output lexicon route shown in fig 3, which implies that pantomime imitation always requires the same input processing as gesture

comprehension. Rothi *et al*¹⁰ comment that sparing of pantomime imitation in these cases suggests a direct connection between visual analysis of gesture and the innervatory patterns for movement implementation. That is, these patients may be using what Rothi *et al*¹⁰ term a “non-lexical” action processing route for imitation (fig 3, route B). Such a route may also be used by normal subjects who are able to imitate meaningless novel gestures. Mehler¹³ described two cases who were unable to imitate intransitive, non-symbolic hand or arm movements in the context of normal pantomime to command and gesture comprehension. Mehler¹³ did not, however, report testing the imitation of known transitive gestures. Rothi *et al*¹⁰ suggest that it may be this “non-lexical” system that was selectively impaired in the cases described by Mehler¹³ whose deficits were limited to the imitation of non-familiar limb movements, those for which there were no “lexical addresses.” Rothi *et al*¹⁰ also suggest that the existence of a non-lexical action processor may account for the improvement seen in those apraxic patients who are less impaired on pantomime imitation. That is, these may be the patients who selectively spare the non-lexical route. By contrast, those patients who do not improve in the imitation condition may be those who impair both the lexical and non-lexical routes of praxis imitation.

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Appendix²: types of errors

CONTENT

P = perseverative: The subject produces a response that includes all or part of a previously produced pantomime.

R = related: The pantomime is an accurately produced pantomime associated in content to the target. For example, the subject might pantomime playing a trombone for a target of a bugle.

N = non-related: The pantomime is an accurately produced pantomime not associated in content to the target. For example, the subject might pantomime playing a trombone for a target shaving.

TEMPORAL

S = sequencing: Some pantomimes require multiple positionings that are performed in a characteristic sequence. Sequencing errors involve any perturbation of this sequence including addition, deletion, or transposition of movement elements as long as the overall movement structure remains recognisable.

T = timing: Any alterations from the typical timing or speed of a pantomime and may include abnormally increased, decreased, or irregular rate of production.

O = occurrence: Pantomimes may involve either single (for example, unlocking a door with a key) or repetitive (for example, screwing in a screw with a screwdriver) movement cycles. This error type reflects any multiplication of single cycles or reduction of a repetitive cycle to a single event.

D = delay: Delay in the initiation of a movement.

SPATIAL

A = amplitude: Any amplification, reduction, or irregularity of the characteristic amplitude of a target pantomime.

IC = internal configuration: When pantomiming, the fingers and hand must be in a specific spatial relation to one another to reflect recognition and respect for the imagined tool. This error type reflects any abnormality of the required finger or hand posture and its relation to the target tool. For example, when asked to pretend to brush teeth, the subject's hand may close tightly into a fist with no space allowed for the imaged toothbrush handle.

BPO = body part as object: The subject uses his or her finger, hand, or arm as the imagined tool of the pantomime. For example, when asked to smoke a cigarette, the subject might puff on his index finger.

ECO = external configuration orientation: When pantomiming, the fingers/hand/arm and the imagined tool must be in a specific relation to the “object” receiving the action. Errors of this type involve difficulties orienting to the “object” or in placing the “object” in space. For example, the subject might pantomime brushing teeth by holding his hand next to his mouth without reflecting the distance necessary to accommodate an imagined toothbrush. Another example would be when asked to hammer a nail, the subject might hammer in a differing location in space reflecting difficulty placing the imagined nail in a stable orientation.

M = movement: When acting on an object with a tool, a movement characteristic of the action and necessary for accomplishing the goal is required. Any disturbance of the characteristic movement reflects a movement error. For example, a subject, when asked to pantomime using a screwdriver, may orientate the imagined screwdriver correctly to the imagined screw but instead of stabilising the shoulder and wrist and twisting at the elbow, the subject stabilises the elbow and twists at the wrist or shoulder.

OTHER

NR = no response.

UR = unrecognisable response: A response that is not recognisable and shares no temporal or spatial features of the target.

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