Journal of the International Neuropsychological Society (2002), **8**, 958–962.

DOI: 10.1017/S1355617702870114

BRIEF COMMUNICATION

Postural knowledge of transitive pantomimes and intransitive gestures

MARIA MOZAZ,[1,2,3] LESLIE J. GONZALEZ ROTHI,[1,2] JEFFREY M. ANDERSON,[1,2]
GREGORY P. CRUCIAN,[1,2] AND KENNETH M. HEILMAN[1,2]

[1]Department of Neurology, College of Medicine, University of Florida, Gainesville, Florida
[2]Neurology Service, Malcom Randall Department of Veterans Affairs Medical Center, Gainesville, Florida
[3]Facultad de Psicologia, Universidad del Pals Vasco, San Sebastian, Spain

(Received April 10, 2001; Revised November 15, 2001; Accepted December 17, 2001)

Abstract

Patients with apraxia are more impaired when performing transitive pantomimes than intransitive gestures. This dissociation might be related to the differences in movement complexity. Alternatively, the programs for intransitive gestures might be better defined, more widely distributed, or easier to activate than are those for transitive pantomimes. The purpose of this study was to test the complexity *versus* representational hypotheses. Twenty right-handed normal subjects both performed and discriminated correct from incorrect transitive pantomimes and intransitive gestures. The discrimination was performed by having subjects point at illustrations of hand postures. The subjects performed better when discriminating postures than when performing gestures or pantomimes. On both the production and discrimination tests, subjects performed better with intransitive gestures than transitive pantomimes. Although the finding that even normal subjects had more difficulty performing transitive pantomimes than intransitive gestures might appear to support the complexity hypothesis, that subjects also had more difficulty discriminating transitive than intransitive postures supports the representational activation hypothesis. (*JINS*, 2002, *8*, 958–962.)

Keywords: Apraxia, Motor control, Skilled movements, Transitive, Intransitive

INTRODUCTION

Limb apraxia is defined as an inability to correctly perform learned skilled movements with the forelimbs (Geschwind, 1965, Liepmann, 1920). Although there are at least six clinical limb apraxia syndromes (Heilman & Rothi 1993, Rothi & Heilman, 1997) that are defined by the nature of errors made by the patient, this article focuses on ideomotor apraxia (hereafter referred to as apraxia). When attempting to perform learned skilled movements, patients with ideomotor apraxia make spatial and temporal errors (Poizner et al., 1990, Rothi et al., 1988). The spatial errors include postural (or internal configuration), spatial movement, and spatial orientation. Testing praxis involves selectively varying task demands. When testing for apraxia, subjects are usually asked to pantomime to verbal command (e.g., "Show me how you would use a bread knife to cut a slice of bread") or in response to seeing a tool (e.g., hammer) or the object upon which the tool works (e.g., nail). Subjects might also be asked to imitate a pantomime or gesture performed by the examiner, and to use actual tools and implements. The most sensitive test for apraxia is having patients pantomime to verbal command because this test provides the least cues and is almost entirely dependent on stored learned movement representations (visuokinesthetic movement engrams or praxicons). Seeing or holding a tool, as well as seeing the examiner perform a pantomime, may provide the patient with cues, and if the movement representation is only partially degraded, these cues may obscure the diagnosis. Limb apraxia is, in part, a diagnosis of exclusion (Heilman & Rothi, 1993). In order to be classified as having an apraxia, the inability to perform learned skilled movements should not be caused by more elemental motor disorders, and the inability to perform skilled movements should also not be caused by cognitive deficits such as aphasia or inattention.

Reprint requests to: Kenneth M. Heilman, M.D., Department of Neurology, University of Florida, Box 100236, Gainesville, FL 32610-0236. E-mail: heilman@medicine.ufl.edu

In both stroke and degenerative diseases, apraxia is often associated with aphasia, and impaired auditory comprehension may interfere with praxis testing. In addition, patients with stroke and degenerative diseases often have elemental motor disorders that can also interfere with praxis testing. Therefore, we wanted to develop a test of praxis knowledge that did not rely on the comprehension of verbal commands and does not require pantomime or gesture production.

With the exception of one report (Belanger et al., 1996), many investigators have reported that patients with apraxia are more impaired when performing transitive pantomimes (e.g., using knife to cut bread) than intransitive (e.g., waving goodbye) gestures (Foundas et al., 1999, Haaland & Flaherty, 1984, Rothi et al., 1988, Roy et al., 1991). Transitive pantomimes might be more likely to be impaired than intransitive gestures because the movements associated with transitive pantomimes are more complex. Whereas both transitive pantomimes and intransitive gestures both require coordinated forelimb movements and postures that are directed to a target, transitive pantomimes have an additional requirement; positioning the hand and fingers as well as moving the hand so that it interacts with a tool or implement. For example, when a person performs an intransitive act such as saluting, the person makes a hand posture (hand and wrist straight with thumb adducted), then while flexing the elbow and abducting the arm at the shoulder, the person directs the hand to his or her forehead. In contrast, when pantomiming the use of scissors to cut paper, in addition to making a hand posture to hold the scissors, extending the forearm at the elbow and extending the arm at the shoulder to move the scissors across the paper, the person has to interact with scissors by alternatively flexing and extending the forefinger and thumb. If the complexity hypothesis is correct, we would expect that although normal subjects would be more impaired at performing transitive pantomimes than intransitive gestures, there would be no difference in the recognition of correct *versus* incorrect transitive and intransitive hand postures because the difference in complexity between transitive pantomimes and intransitive gestures is essentially eliminated when one views static hand configurations. In contrast, the finding that normal subjects continue to have more difficulty in recognizing transitive than intransitive postures would raise alternative hypotheses. It is possible that the representations of intransitive gestures are stored differently than those of transitive pantomimes. For example, the representations of intransitive gestures may be more widely distributed and therefore more resistant to local damage or focal degeneration. If this postulate were correct, one may expect that independent of lesion locus one would more frequently observe disorders of intransitive than transitive movement, but more widely distributed networks might also have a greater ability to compensate for focal injury. This distribution hypothesis, however, could not explain why normal subjects make more errors when performing transitive pantomimes than intransitive gestures. Intransitive gestures are more frequently used and observed than transitive pantomimes. Studies have shown that normal subjects have less difficulty recalling the names of objects that have a high frequency than those that have a lower frequency (Brown & McNeill, 1966). Whereas patients with left hemisphere brain dysfunction from focal lesions or degenerative disease might have trouble with word finding, they are also more likely to have trouble with lower than higher frequency words (Nadeau et al., 2000). The relationship between word frequency and naming ability suggests that frequency of use influences the strength of lexical–semantic representations. Because intransitive gestures are more frequently used than are transitive pantomimes, the representations of intransitive gestures may be stronger, and easier to activate and implement than transitive pantomimes. In addition, when most people speak, they automatically gesture, and when people are listening to a speaker, they also recognize the speaker's gestures, including postures. It is rare, however, for people to use transitive pantomimes when speaking or to recognize transitive pantomimes made by other people. According to Hebbian principles of synaptic modulation, cortical memory networks are formed by the coactivation of neuronal networks (Fuster, 2000). Whereas speech and intransitive gestures are frequently temporally linked, speech and transitive pantomimes rarely co-occur. Thus, because intransitive gestures and postures are typically used with communicative intent, their representations are more easily engaged by speech or seeing postures than are the representations of transitive pantomimes. Since normally the memories or representations of intransitive gestures are activated by speech or seeing someone else gesture, it is possible that intransitive representations are more easily and fully activated by speech and seeing gestures than are transitive pantomimes.

According to the above discussion, if the complexity hypothesis is correct, we would expect that, although normal subjects would be more impaired at performing transitive pantomimes than intransitive gestures, there would be no difference in the recognition of correct *versus* incorrect transitive and intransitive hand postures, because the difference in complexity between transitive pantomimes and intransitive gestures is essentially eliminated when one views static hand configurations. If the storage or activation hypotheses are correct, we would expect intransitive gestures would be both easier to perform and to recognize than transitive pantomimes. Therefore, we developed a Postural Knowledge Test to assess the recognition of postures associated with both transitive and intransitive movements. Normal elderly subjects were asked to perform and recognize-discriminate correct from incorrect transitive pantomimes and intransitive gestures.

METHODS

Research Participants

Because we plan to use this test with patients with stroke and degenerative diseases, we tested 20 right-handed (as

Fig. 1. Cartoon of a woman writing notes on a piece of paper while listening to the telephone. While the paper on which she is writing and her arm are visible both the pencil and her distal forelimb including her forearm, wrist and hand are not visible.

determined by the hand with which they selected to gesture or pantomime) elderly, normal, control subjects. There were 10 women and 10 men. Subjects with a history of a neurological disease, including dementia or memory loss, alcohol or drug abuse, severe head trauma, substance abuse, psychiatric disease, or developmental learning disabilities were excluded. To make certain that none of our subjects were suffering with dementia we performed a Mini-Mental State Examination (MMSE; Folstein et al., 1975) on our subjects. The mean score for the MMSE was 28.70 (SD = 1.66). Based on our screening procedure, however, we could not entirely eliminate the possibility that some of our subjects may have had the beginning of a dementing disease such as Alzheimer's. The mean age for our subjects was 75.75 (SD = 5.36). The mean education level was 13.10 (SD = 3.34) years. Preliminary analyses showed no differences in age ($p > .05$), education ($p > .05$) or MMSE scores ($p > .05$) between our women and men. This research project was approved by the Institutional Review Board, and informed consent was obtained.

Apparatus

The Postural Knowledge Test contains 20 test and four training cartoons depicting a person performing an action. Ten of these test cartoons were transitive acts (eating, applying lipstick, ironing, writing, painting, cutting hair, firing a gun, hammering a nail, combing the hair, using a key) and 10 were intransitive (victory, salute, be quiet, hitting, goodbye, snap fingers, okay, pray, applaud, stop). The transitive cartoons portrayed a person acting on an object (e.g., a woman writing) without a person's distal forelimb and tool/implement being visible (see Figure 1). While viewing these transitive action cartoons, the subjects were shown response sheets each containing pictures. For each trial, one picture demonstrates the arm and hand making the correct posture while holding the tool/implement, and the two other cartoons were incorrect foils (see Figure 2). The viewer-centered position of the correct or target cartoon was randomly positioned across trials. The subject was trained to point to the correct hand posture cartoon. The cartoons for the intransitive gesture were similar to those of the transitive pantomimes, only instead of an object upon which a tool works, there was a scene that was associated with the intransitive gesture.

The Gesture–Pantomime Production Test has the same 20 test pantomimes and gestures (10 transitive and 10 intransitive) as does the Postural Knowledge Test. There were also four training trials.

Procedures

The subjects were seated at a table across from the examiners in a quiet room. After the training–demonstration trials, the test trials were administered. In the Gesture–Pantomime Production Test, the subjects were asked to pantomime or gesture with their preferred (right) hand in

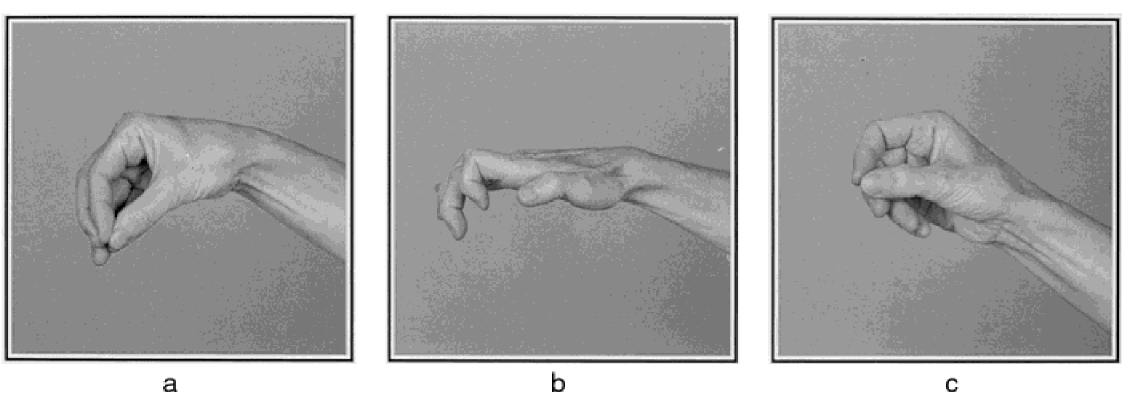

Fig. 2. While viewing this "writing" transitive action cartoon, the subjects are shown a response sheet with three pictures. One picture demonstrates the forearm and hand making the correct posture (c) while the two other cartoons were incorrect foils (a and b).

https://doi.org/10.1017/S1355617702870114 Published online by Cambridge University Press

response to verbal command. While performing these pantomimes the subjects were requested to abstain from using a body part as a tool. The performance of the subject was videotaped and subsequently scored by two trained judges as correct or incorrect. During the Postural Knowledge Test, the transitive and intransitive trials were presented in a randomized order. During the training trials the subjects were given feedback, but during the test trials, no feedback was given.

RESULTS

On the Postural Knowledge Test with transitive pantomimes, men had a score of 8.30 ($SD = 0.95$) and women a score of 8.80 ($SD = 0.63$). On the same Postural Knowledge Test with intransitive gestures, men had a score of 9.50 ($SD = 0.53$) and women had a score of 9.60 ($SD = 0.70$). For both tests men had a score of 17.80 ($SD = 1.03$) and women 18.40 ($SD = 1.17$). On the Postural Knowledge Test, the difference between men and women was not significantly different for the transitive pantomimes ($p = .182$), the intransitive gestures ($p = .722$) or both ($p = .241$). On the Gesture–Pantomime Production Test with transitive pantomimes, men had a score of 4.30 ($SD = 2.06$) and women a score of 5.00 ($SD = 1.83$). On the same Gesture–Pantomime Production Test with intransitive gestures, men had a score of 8.90 ($SD = 1.20$) and women had a score of 9.30 ($SD = 0.82$). For both tests, men had a score of 13.20 ($SD = 2.62$) and women 14.30 ($SD = 2.21$). For the Gesture–Pantomime Production test, the difference between men and women was not significantly different for the transitive pantomimes ($p = .431$), the intransitive gestures ($p = .395$) or both ($p = .324$). Therefore, for subsequent analyses, the scores for men and women were combined (see Figure 3).

On the Gesture–Pantomime Production Test–transitive pantomimes subtest, subjects performed correctly on a mean of 4.65 ($SD = 1.93$) trials and on the intransitive gestures subtest scored a mean of 9.10 ($SD = 1.02$). On the Postural Knowledge Test, subjects obtained a mean of 8.55 ($SD = 0.83$) correct responses on the trials with transitive pantomimes and a mean score of 9.55 ($SD = 0.60$) correct responses with intransitive gestures.

We performed a repeated measures analysis of variance on this data with the major factors being task (Gesture–Pantomime Production *vs.* Postural Knowledge) and gesture or pantomime type (transitive *vs.* intransitive). There was a main effect for task [$F(1,19) = 76.05$, $p < .001$], suggesting that Gesture–Pantomime Production was associated with more errors than was Postural Knowledge, and a main effect for type of gesture [$F(1,19) = 124.10$, $p < .001$], suggesting that subjects make more errors with transitive pantomimes than intransitive gestures. This analysis also revealed a significant interaction between Task × Gesture Type [$F(1,19) = 57.29$, $p < .001$].

Regarding postural knowledge, *post-hoc* analyses with Bonferroni correction revealed that subjects made more rec-

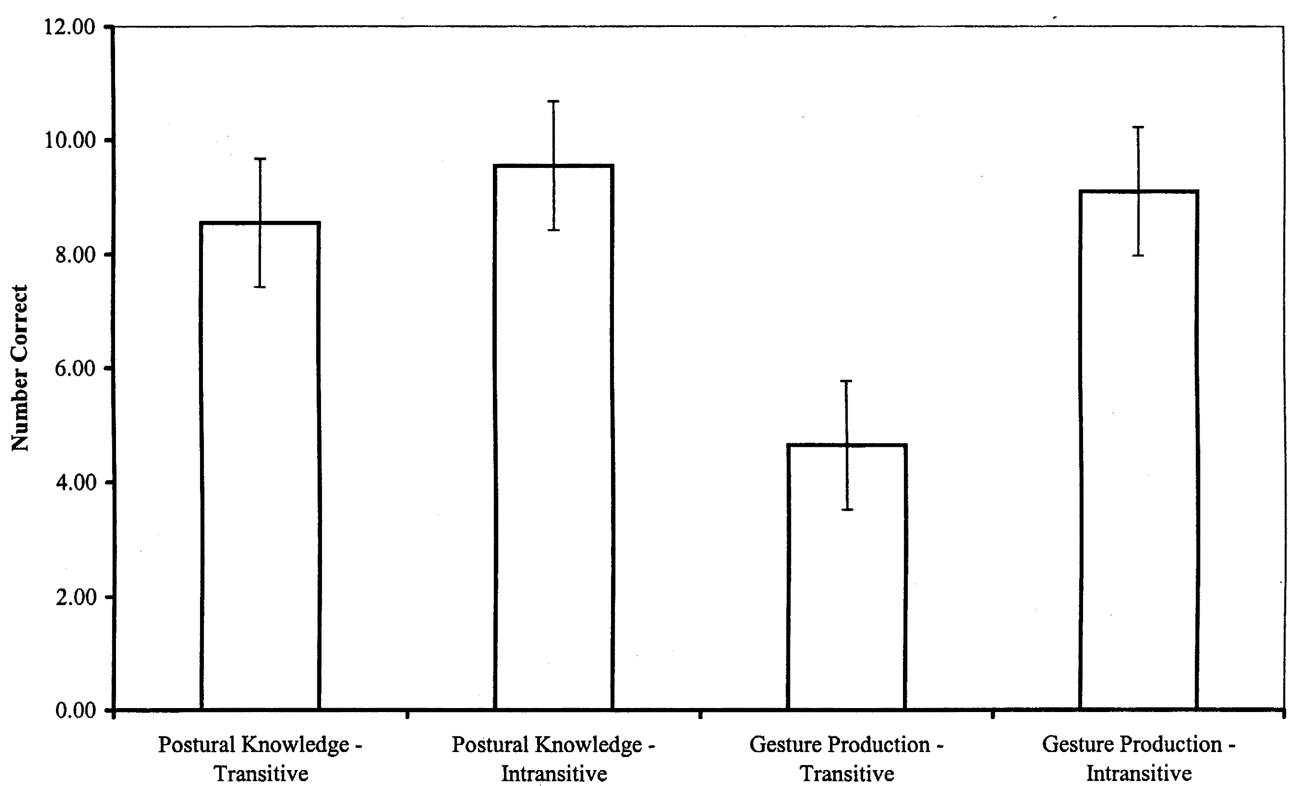

Fig. 3. Praxis knowledge and production.

https://doi.org/10.1017/S1355617702870114 Published online by Cambridge University Press

ognition errors with transitive ($M = 8.55$, $SD = 0.83$) than with intransitive movements ($M = 9.55$, $SD = 0.60$; $p < .001$). *Post-hoc* analyses also revealed that subjects had more difficulty producing transitive pantomimes ($M = 4.65$, $SD = 1.93$) than they had selecting the correct transitive posture ($M = 8.55$, $SD = 0.83$; $p < .001$). However, there was no difference between the production and the recognition of intransitive gestures ($p = .10$).

DISCUSSION

We found that our normal subjects had more difficulty correctly producing pantomimes and gestures than recognizing postures associated with these pantomimes and gestures. In almost all neuropsychological tests, production is more difficult than recognition, and thus our posture recognition test may be less sensitive in detecting apraxia than our production tests.

The observation that brain impaired subjects are more impaired in performing transitive pantomime than intransitive gestures (Foundas et al., 1999, Haaland & Flaherty, 1984, Rothi et al., 1988, Roy et al., 1991) suggests that transitive pantomimes are more difficult to perform than intransitive gestures because the movements associated with transitive pantomimes are more complex. We found that normal subjects also made more errors when producing transitive pantomimes than when producing intransitive gestures, providing further support for this complexity postulate. But when our normal subjects were asked to discriminate between correct and incorrect postures, a task that does not require movement, subjects also had more problems selecting the correct postures for the transitive movements than they did for the intransitive movements. Although it is possible that our results might be artifactual and perhaps related to the foils that were used, our results suggest that the representations of intransitive gestures are stored or activated differently than those of transitive pantomimes. One explanation for the relative sparing of intransitive gestures *versus* transitive pantomimes in patients with focal brain damage is that the representations of intransitive gestures may be more widely distributed and therefore more resistant to local damage. Against this distribution hypothesis, however, is the observations that widely distributed networks, such as semantic–conceptual representations, are more susceptible to deterioration in neurodegenerative disorders such as Alzheimer's disease, and patients with Alzheimer's disease are also more impaired at making transitive than intransitive gestures. In addition, in our study, normal people were used as subjects and lesion vulnerability cannot explain the differences found in normal subjects. Another explanation for the dissociation between transitive pantomimes and intransitive gestures may be related to the means by which these gestural representations are activated. Unlike the pantomimes of transitive acts, intransitive gestures are often used during nonverbal communication. People normally activate these representations when they observe another person's gestures or when they want to transmit a nonverbal message. In contrast, people primarily use transitive postures when actually using tools or objects, and people are rarely called upon to activate these transitive postural representations in response to verbal command or to seeing the posture in the absence of the tool or object. Representations grow stronger and becomes more widely distributed the more one practices (Nudo et al., 1996), and people are less likely to make errors when performing well practiced acts than when performing rarely practiced acts.

ACKNOWLEDGMENTS

Supported in part by the Medical Research Service of the Department of Veterans Affairs and the Eusko Jaurlaritza/Gobierno Vasco, Program 1997-1998/B.1.

REFERENCES

Belanger, S.A., Duffy, R.J., & Coelho, C.A. (1996). The assessment of limb apraxia: An investigation of task effects and their causes. *Brain and Cognition*, *32*, 384–404.

Brown, R. & McNeill, D. (1966). The tip of the tongue phenomenon. *Journal of Verbal Learning and Verbal Behavior*, *5*, 325–337.

Foundas, A.L., Maccauley, B.L., Raymer, A.M., Maher, L.M., Rothi, L.J.G., & Heilman, K.M. (1999). Ideomotor apraxia in Alzheimer's disease and left hemisphere stroke: Limb transitive and intransitive movements. *Neuropsychiatry, Neuropsychology and Behavioral Neurology*, *12*, 161–166.

Folstein, M.F., Folstein, S.E., & McHugh, P.R. (1975). Minimental state. *Journal of Psychiatric Research*, *12*, 189–198.

Fuster, J.M. (2000). Cortical dynamic of memory. *International Journal of Psychophysiology*, *35*, 155–164,

Geschwind, N. (1965). Disconnection syndromes in animals and man. *Brain*, *88*, 237–294, 585–644.

Haaland, K.Y. & Flaherty, D. (1984). The different types of limb apraxia errors made by patients with left and right hemisphere damage. *Brain and Cognition*, *3*, 370–384.

Heilman, K.M. & Rothi, L.J.G. (1993). Apraxia. In K.M. Heilman & E. Valenstein (Eds.), *Clinical neuropsychology* (pp. 141–163). New York: Oxford University Press.

Liepmann, H. (1920). Apraxia. *Erbgn der ges Med.*, *1*, 516–543.

Nadeau, S.E., Gonzalez Rothi, L.J., & Crosson, B. (2000). *Aphasia and language*. New York: Guilford Press.

Nudo, R.J., Milliken, G.W., Jenkins, W.M., & Merzenich, M.M. (1996). Use-dependent alterations of movement representations in primary motor cortex of adult squirrel monkeys. *Journal of Neuroscience*, *16*, 785–807.

Poizner, H., Mack, L., Verfaellie, M., Rothi, L.J.G., & Heilman, K.M. (1990). Three dimensional computer graphic analysis of apraxia. *Brain*, *113*, 85–101.

Roy, E.A., Square-Storer, P., Hogg, S., & Adams, S. (1991). Analysis of task demands in apraxia. *International Journal of Neuroscience*, *56*, 177–186

Rothi, L.J.G., Mack. L., Verfaellie, M., Brown, P., & Heilman, K.M. (1988). Ideomotor apraxia: Error pattern analysis. *Aphasiology*, *2*, 381–387.

Rothi, L.J.G. & Heilman, K.M. (1997). *Apraxia*. London: Taylor & Francis.