Manual Approach During Hand Gesture Imitation

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**Background:** Patients’ tendency to draw near or into the target when copying figures, a phenomenon termed closing-in, has been previously described. That the closing-in could occur when copying hand gestures has also been noted.

**Objectives:** To study a patient with corticobasal degeneration to quantify his manual approach behavior and to test a possible working memory hypothesis.

**Methods:** The subject of this study is a patient with severe ideomotor apraxia from probable corticobasal degeneration. Fluorine 18–labeled deoxyglucose–positron emission tomographic findings revealed a hypometabolism involving the bilateral parietotemporal and the right frontal lobes. When asked to copy an examiner’s (J.C.K.) hand gesture, the patient approached, touched, or grasped the examiner’s hand, a behavior mostly consistent with the closing-in behavior previously proposed. To investigate the frequency and severity of closing-in, the patient was asked to copy 20 meaningless hand gestures (10 simple and 10 complex). Copying the 20 hand gestures was performed with either the left or the right hand while the patient was seated opposite the examiner (across condition) or on the same side of the examiner (lateral condition).

**Results:** Of the 80 trials, closing-in occurred in 43 (53.8%) (35 with approaching, 6 with touching, and 2 with grasping). The closing-in was more frequent and more severe when gesturing with the left than the right hand, but it did not differ between the lateral and across conditions and between simple and complex gestures.

**Conclusions:** Corticobasal degeneration might be associated with aberrant manual approach behavior. Although our results do not support the working memory hypothesis, frontal dysfunction might have led to a loss of voluntary control of ontologically primitive propensity to move the forelimb in the direction to which one attends.

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ANY STUDIES have reported phenomena in which the patient’s hand unintentionally approaches or grasps environmental objects or parts of the examiner’s body. These approach phenomena include grasp reflex,1-4 magnetic apraxia,5 utilization behavior,6 and compulsive manipulation of objects associated with an alien hand.7-10 Recently, we examined and tested a patient with severe ideomotor apraxia associated with probable corticobasal degeneration (CBD). When asked to copy the examiner’s (J.C.K.) hand gesture, the patient approached, touched, or grasped the examiner’s hand, behaviors consistent with the “closing-in” sign of Mayer Gross.11 In this study, we wanted to quantify this approach behavior and test a working memory hypothesis that might account for closing-in.

**REPORT OF A CASE**

Our patient was a 68-year-old right-handed man who was a former bus driver. The patient had no formal education but was literate in Korean. He had been healthy until 4 years ago, when he developed clumsiness in the left hand and an unsteady gait. Three years ago, he became amnesic, misplacing items in the house and forgetting details of recent events. Two years ago, he developed bradykinesia and a decreased left arm swing while walking. Around that time, he also showed occasional twitching (myoclonic jerks) in the left arm and hand. One year before our examination, he developed dressing apraxia. For the past few months, the patient’s wife occasionally noted that, while eating with the right hand, the patient’s left hand involuntarily hit the right hand or the dishes. Also, twitching of the left hand increased in severity and extended to the right hand.

The results of a cranial nerve examination were significant only for hypometric saccades; his extraocular movements were full. His strength was normal in all limbs, but a pronator drift was noted in the left arm. Two-point discrimination was decreased bilaterally, and graphesthesiia was decreased in the left hand. His tendon reflexes were more active on the left than the right side. There was moderate rigidity in all limbs, more marked on the left side. Bradykinesia was noted with decreased facial expression. Tremor was not observed, but intermittent myoclonus was present in both arms, being more prominent...
His gait was normal in stance and stride, with no festination, but his left arm swing was decreased. Grasp reflexes were elicited bilaterally, with repeated tactile stimulation of the palm. Snout, sucking, and glabellar reflexes were not present.

He scored 18 of a possible 30 on the Mini-Mental State Examination. On gesture production to verbal command or to imitation, both hands showed severe ideomotor apraxia, more marked on the left side; the left hand movements were unrecognizable, and the right hand gestures had severe spatial and content errors. When asked to imitate nonsense hand gestures with the right hand, the patient’s hand unintentionally approached or touched the examiner’s hand. With an instruction not to touch the examiner’s hand, the approaching behavior stopped temporarily but reappeared after several trials. These unusual behaviors prompted us to perform an experiment, described later. The results of other neuropsychological tests were as follows: decreased digit span, forward 4 (27th percentile) and backward 2 (13th percentile); fluent speech with intact comprehension and repetition but decreased naming (Boston Naming Test score, 31 of 60 [seventh percentile]); reading was intact, but writing showed apraxic agraphia; Rey-Osterrieth Complex Figure copy score, 3 of 36 (<16th percentile); Hopkins Verbal Learning Test—free recalls over 3 trials, 6 of 36 (<16th percentile), and with 20-minute delayed recall, 0 of 12 (<16th percentile); decreased fluency on a controlled oral word association test (phonemic word fluency with 3 letters, 0 [<16th percentile]; and semantic word fluency with animal and supermarket items, 22 [16th percentile]); markedly impaired at motor set shifting (fist-edge-palm) bilaterally; and perseveration on the Luria triple loop test. To elicit utilization behavior, the patient was presented with various objects, such as tissue, cups, and pens, within his reach, but the patient did not use them.

His vitamin B₁₂ serum level, thyroid function test results, and serologic results for syphilis were normal. A brain magnetic resonance imaging scan revealed diffuse atrophy with few white matter ischemic changes; the right lateral ventricle was larger than the left lateral ventricle. Brain fluorine 18–labeled deoxyglucose–positron emission tomographic findings revealed a hypometabolism involving both parietotemporal areas and the right frontal lobe, but the most severe abnormality was located in the right parietal area (Figure 1).

HAND GESTURE COPYING TASK

After obtaining informed consent, a hand gesture copying task was performed. We used 20 meaningless hand gestures, as illustrated in Figures 2 and 3. To divide them into 10 simple and 10 complex gestures, we asked 6 healthy graduate students to rate the complexity of each gesture on a 5-point scale (1 indicates very easy; 2, easy; 3, moderate; 4, difficult; and 5, very difficult). According to the mean score of each gesture, the 10 gestures ranked in the top 10 (mean ± SD of the complexity rating, 3.42 ± 0.89) were considered complex and the remaining 10 (mean ± SD of the complexity rating, 1.40 ± 0.51) were considered simple (paired t test, P < .001).
Copying the 20 hand gestures was performed with either the left or the right hand while the patient was seated opposite the examiner (across condition) or on the same side of the examiner (side-by-side or lateral condition). Therefore, there were 4 different test conditions (right vs left hand, across vs lateral) in which the patient imitated the 20 gestures, a total of 80 trials. The sequence of the 4 conditions was as follows: across—right hand, lateral—right hand, across—left hand, and lateral—left hand. For each condition, the 20 gestures were presented in random order. All procedures were videotaped by a digital videocamera held 1 m above the examining table.

In the lateral and the across conditions, the patient's right hand imitated the examiner's right hand and the patient's left hand imitated the examiner's left hand. In the lateral condition, the patient was seated on the left side of the examiner in the left hand copying condition and on the right side of the examiner in the right hand copying condition. In each trial, before the stimulus was presented, the patient was asked to put his right or left hand on the table with the palm facing the ceiling and all the fingers extended (neutral hand gesture). The initial positions of the patient's and the examiner's hands were adjusted such that (1) the intersection of the wrist crease and the tendon of palmaris longus (called the wrist point) was aligned with each individual's midaxillary line; (2) in each individual, the distance between the wrist point and the midsternum was approximately 300 mm; and (3) the distance between the patient's wrist point and the examiner's wrist point was approximately 350 mm in the across and the lateral conditions. Before the experiment, the patient was instructed to perform the praxis in the designated place, but during the experiment, this instruction was not repeated. After each trial, the patient's hand was relocated to the original position. Before stimuli were presented, the examiner's hand was covered with white A4 size paper to prevent the patient from seeing the examiner's hand. Twenty seconds were allowed for each gesture after removing the white paper from the examiner's hand.

Figure 2. A and B, results of copying hand gestures (left hand). The patient's left hand imitated the examiner's (J.C.K.) left hand (the patient was wearing the multicolored shirt). The procedure was videotaped, and the still picture with maximum “closing-in” was selected for presentation. The hand gesture in the left upper corner of each lateral picture represents the target gesture. The number in the left lower corner of each picture represents the severity rating of closing-in (0 indicates no approach; 1, approach but no touch; 2, touch or overlap the examiner's hand; and 3, grasp the examiner's hand). Pictures were ordered from the simplest to the most complex gestures (see the “Hand Gesture Copying Task” section for further explanation). Simple indicates simple gestures; complex, complex gestures; lateral, the patient was seated on the same side of the examiner (lateral condition); and across, the patient was seated on the opposite side of the examiner (across condition).
SCORING

Two psychometricians (B.H.L. and J.C.) blinded to the clinical information rated the patient’s response on the videotape. First, the raters assessed the accuracy of hand gestures as either correct or incorrect. Hand gestures were considered accurate when the configuration and the orientation were correct. Second, the raters quantified the severity of closing-in as follows: 0, no approach; 1, approach but no touch; 2, touch or overlap the examiner’s hand; and 3, grasp the examiner’s hand. Interrater reliability was obtained for the accuracy of gesture copying and the severity of closing-in.

RESULTS

INTERRATER RELIABILITY AND ACCURACY OF PRAXIS

The interrater reliability for the accuracy rating of hand gestures was 0.88 \((P<.001)\) by \(\kappa\) correlation; and for the severity rating of closing-in, 0.85 \((P<.001)\) by Spearman rank correlation.

The accuracy of gesture copying is presented in the Table and in Figures 2 and 3. In the lateral condition, the patient performed correctly on 12 (7 with the right and 5 with the left hand) of the 20 (10 left and 10 right) simple gesture trials and on 3 (1 right and 2 left) of the 20 complex gesture trials (Table). In the across condition, correct responses were observed on 16 (9 right and 7 left) of the 20 simple and on 1 (0 right and 1 left) of the 20 complex gesture trials. Overall, copying simple gestures was more accurate than copying complex gestures \((P<.001, \text{ McNemar test})\).

FREQUENCY AND SEVERITY OF CLOSING-IN

The results of the frequency and severity of closing-in are presented in the Table and in Figures 2 and 3. Closing-in occurred in 43 (53.8\%) of the 80 trials. Of the 43 trials with closing-in, 35 (81.4\%) had closing-in of the first degree (approach but no touch), 6 (14.0\%) of the second degree (touch...
or overlap the examiner’s hand), and 2 (4.6%) of the third degree (grasp the examiner’s hand). Closing-in was more frequent when the gesture copying was performed with the left (frequency, 27 of 40 gestures) vs the right (frequency, 16 of 40 gestures) hand \((P=.02, \text{McNemar test})\). The severity scores of closing-in were also greater on gesture copying with the left (mean ± SD, 0.88 ± 0.79) than with the right (mean ± SD, 0.45 ± 0.60) hand \((P=.01, \text{Wilcoxon signed rank test})\). There were no significant differences, however, in the frequency and severity of closing-in between the across and lateral conditions and between the simple and complex items. Specifically, in the lateral and the across conditions, the frequencies of closing-in were 23 of 40 and 20 of 40, respectively \((P=.63, \text{McNemar test})\); the mean ± SD severity scores of closing-in were 0.75 ± 0.81 and 0.58 ± 0.64, respectively \((P=.24, \text{Wilcoxon signed rank test})\). With the simple and complex hand gestures, the frequencies of closing-in were 26 of 40 and 17 of 40, respectively \((P=.06, \text{McNemar test})\); the mean ± SD severity scores of closing-in were 0.75 ± 0.63 and 0.58 ± 0.81, respectively \((P=.28, \text{Wilcoxon signed rank test})\).

Our patient had several asymmetrical (left worse than right) abnormal signs of the forelimbs, including rigidity, bradykinesia, apraxia, myoclonus, and agraphesthesia. Our patient also had cognitive deficits. A brain magnetic resonance imaging scan revealed asymmetrical (right worse than left) atrophy of the cerebral hemisphere, and fluorine 18–labeled deoxyglucose–positron emission tomographic findings showed frontal and temporoparietal hypometabolism that was also more severe in the right hemisphere. These findings are compatible with the diagnosis of CBD.

When copying meaningless hand gestures, the patient’s hand approached the examiner’s hand. Our patient’s approach behavior differs from grasp reflex\(^2\)\(^-\)\(^4\) and instinctive grasp reaction,\(^1\)\(^,\)\(^12\) which are elicited only by tactile stimuli of the palm and are not associated with praxis. Behaviors characterized by manipulation of objects within one’s reach have been described in patients with anarchic hand syndrome\(^7\)\(^-\)\(^10\) or utilization behav-
ior. Neither medical history taking nor a bedside examination, however, showed such behaviors in our patient. Our patient’s approach behavior may resemble the magnetic apraxia described by Denny-Brown. The original patient of Denny-Brown grasped bedclothes or objects and had difficulties in relaxation. The use of the hand was awkward and clumsy even when there was nothing in contact with the palm. Before grasping, the whole limbs tended to stiffen. For example, when the patient attempted to write, the hand stiffened and seemed to stick to the paper. Denny-Brown suggested that magnetic apraxia was driven by the intact parietal lobe that was disinhibited by frontal lobe dysfunction. Our patient’s behavior may differ from magnetic apraxia in that his approach behavior was restricted to praxis performance and there was no stiffness or inability to relax.

There have been a few reports that described approach behavior in patients with CBD. In the original report of CBD, Rebeiz et al\textsuperscript{13} noted that 2 of the 3 patients had an aberrant manual approach (ie, one of their hands would approach the other hand). Recently, Jacobs et al\textsuperscript{14} described a patient with CBD whose hands, feet, and mouth were drawn toward the examiner’s hands when the examiner’s hands passed close to these areas. These magnetic responses, however, may differ from our patient’s approach behavior because the magnetic response of our patient occurred exclusively when copying hand gestures.

Our patient’s behavior is most compatible with the closing-in phenomenon described by Mayer Gross,\textsuperscript{11} who observed a tendency to come close to the target when drawing.\textsuperscript{15} He also stated that the closing-in occurred when copying hand gestures. To our knowledge, however, studies of closing-in when copying hand gestures have not been performed thereafter.

On bedside examination, we had the impression that our patient had severe manual approach because even touching and grasping occurred frequently and consistently. In the experiment, however, touching or grasping occurred only in 8 (10%) of the 80 trials. This difference might be due to the experimental methods: before the experiment, the patient was instructed to...
perform praxis in the designated place, and after each trial, the patient’s hand was relocated to the original place by the examiner. Regarding the mechanism of closing-in, Mayer Gross\(^1\) postulated that the behavior results from “the fear of empty space.” Two years later, Muncie\(^2\) suggested that closing-in results from “the inability to make an abstract copy from a concrete model.” More recently, by observing the closing-in phenomenon in patients with degenerative dementia and in 2- to 6-year-old healthy children, Gainotti\(^3\) insisted that closing-in is similar to other phylogenetically more primitive behaviors (grasping, sucking, echolalia, or echopraxia) that normally are inhibited by higher cortical areas.

We posited that this approach behavior or closing-in might occur as a strategy to overcome visual-perceptual or working memory deficits. When copying hand gestures, a patient has to compare his or her own hand with the examiner’s hand. As the distance between the patient’s and the examiner’s hands increases, the demands on working memory might become greater. A failure to correctly imitate hand gestures may be caused by a compromise in visual-kinesthetic working memory. Therefore, patients with visual-kinesthetic working memory deficits might move toward the examiner’s hand to reduce the demands on working memory. Based on this hypothesis, we expected that approach behavior would be more frequent or severe with complex than with simple gestures and in the across than in the lateral condition because more complex gestures and the across condition require greater demands on visual-kinesthetic working memory. Contrary to our expectations and the observations of Mayer Gross,\(^4\) the frequency and severity of closing-in did not vary in terms of the location of the examiner and the complexity of the gesture. Therefore, our results do not support the working memory hypothesis.

There may be alternative explanations for the manual approach that our patient demonstrated. While the patient might have touched or grasped the examiner’s hand in an attempt to enhance the copying performance by using the tactile modality in addition to the visual modality, this explanation could not account for the predominant response (approach without touch). We suspect that the manual approach of our patient may be related to directed spatial attention. When a person attends to a visual stimulus, the person’s eyes automatically move to a position that allows the attended image to fall on the fovea. For example, when a person is following a moving object, a cortical area, such as the middle temporal and medial superior temporal areas, computes the spatial trajectory of this object’s movement and provides this information to the oculomotor system. Although normally people can voluntarily alter the direction of their gaze so that they do not foveate the object to which they are attending, with frontal lesions they lose this voluntary control (visual grasp).\(^5\) While less robust than the oculomotor system, humans also have a tendency to move their hands and head to the region of space to which they are attending.\(^6\) Perhaps with the frontal-subcortical dysfunction that is associated with CBD, voluntary control is diminished and this tendency to act in the direction to which one is attending becomes manifest, leading to the manual approach behavior we describe.

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