

## **Gesture following deafferentation: A phenomenologically informed experimental study<sup>1</sup>**

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**Abstract.** Empirical studies of gesture in a subject who has lost proprioception and the sense of touch from the neck down show that specific aspects of gesture remain normal despite abnormal motor processes for instrumental movement. The experiments suggest that gesture, as a linguistic phenomenon, is not reducible to instrumental movement. They also support and extend claims made by Merleau-Ponty concerning the relationship between language and cognition. Gesture, as language, contributes to the accomplishment of thought.

### **Introduction**

In thinking of the relationship between embodied movement and language Merleau-Ponty suggested that the body converts a certain motor essence into vocal form (1962, p. 181). This conversion does not depend on conscious control or explicit monitoring. In this regard the shaping of linguistic form in gesture or in voice is very like movement itself. Thus, Merleau-Ponty remarks:

What we have said earlier about the ‘representation of movement’ must be repeated concerning the verbal image: I do not need to visualize external space and my own body in order to move one within the other. It is enough that they exist for me, and that they form a certain field of action spread around me. In the same way I do not need to visualize the word in order to know and pronounce it. It is enough that I possess its articulatory and acoustic style as one of the modulations, one of the possible uses of my body (1962, p. 180).

In this paper we explore the relationship between movement and a related linguistic modulation of the body, gesture, by examining the unusual case of

IW. IW has profound difficulties with movement due to a pathology that deprives him of proprioception and the sense of touch below the neck. He provides an exception to Merleau-Ponty's observation that one does not have to visualize external space and one's own body in order to move. As we will see, IW has to do exactly that – visualize external space and his own body in order to control his movements. Yet, observation of IW's gestural behavior suggests that in certain respects his gestures remain normal. This difference in IW between gesture and other kinds of movement motivates an intriguing set of questions. To what extent is gesture normally not only like movement, but a conversion or modulation of motor behavior? LeBaron and Streeck (2000) have analyzed the performances of unimpaired speakers in which instrumental actions are transformed, over time, into symbolic, gestural movements. Are such transformations accessible to IW, whose motor control is structured on radically different principles, including visualization? Or to what extent does gesture, in some aspect, transcend motor behavior and come to be defined and controlled by communicative contexts?

### **Problems with movement: the case of IW**

We begin with a brief description of IW's condition. IW suffered an illness of unknown etiology when he was nineteen-years-old, and has lived with the consequences for over twenty years. The illness caused an immune reaction that destroyed the cell bodies of the large myelinated sensory nerve fibers that run from the body limbs to spinal cord. These are the nerves responsible for delivering tactile and proprioceptive information to sub-cortical regions of the brain. The result was loss of the sense of touch and proprioception (movement and position sense) below the neck, and loss of all motor control that depends on proprioceptive feedback. The sensory nerves concerned with pain, temperature and such ill-defined modalities as muscle fatigue were unaffected. Likewise his motor nerve fibers were left intact. Despite this, IW could not control his movement. Although he was not paralyzed, he was unable to walk, or to write, or to feed himself, because without peripheral feedback from his body and limbs he lacked normal automatic control over his own movement. It was, and still is the case that IW cannot locate the position of his limbs in darkness. Matters were complicated by the fact that when this happened to him no one was able to say exactly what the problem was. There was no diagnosis, and no known prognosis. Seeing the extent of his deficit, however, his original neurologist told him that he would be wheelchair bound for the rest of his life (Cole 1995).

In spite of this, IW persisted in attempting to control his movement using conscious visual attention, and he succeeded by his own fortitude in the course of two-to-three years of therapy to regain control over his posture and movement. Today he walks, writes, feeds himself, has been twice married, has been gainfully employed as a civil servant, and is currently a photographer and disability consultant auditing the built environment for accessibility for hearing, visually and physically disabled people. When we say that he has regained control over his posture and movement, we do not mean that he has recovered from the neuropathy that destroyed his sensory nerves. Rather his control of movement is based primarily on visual attention and cognitive effort (although some aspects of walking have become close to automatic due to consciously guided practice). In the dark, controlled movement is impossible since he has no visual access to current position of his limbs and cannot tell where they are in relation to one another.

One way to explain IW's problems with movement, and his unique solution to those problems, is to employ a distinction between *body image* and *body schema* (Gallagher and Cole 1996). Although these concepts are often confused in the psychological literature, a clear distinction can be made in the following way. A *body image* consists of a system of perceptions, attitudes, and beliefs pertaining to one's body, originating in a self-referential consciousness directed toward one's body. A *body schema* is a system of processes that constantly regulate posture and movement. It consists of motor capacities that are in part governed by sensory feedback but that function without body awareness or the necessity of perceptually monitoring the body. Used in the plural, *body schemas* refer to a collection of motor programs that may individually be defined by a specific movement or posture, for example, the movement of hand to mouth.

Although it is possible to make a *conceptual* distinction between body image and body schema, and to find real cases in which body image and body schema can be distinguished *in actuality*, it is also true that in the normal case body image and body schema are quite integrated in their functioning, reflecting the normal integration of perceptual and motor functions. Exceptions to this normal integration are important for establishing a real difference between body image and body schema. The case of IW is one of the exceptions that help to clarify this distinction.

A double dissociation between two phenomena establishes an empirical (and not just conceptual) difference between them. Such a dissociation exists between body image and body schema. On one side of this dissociation, we find cases that reflect a perfectly intact body schema, and at the same time a major problem with body image. For example, in cases of unilateral neglect, a pa-

thology that often results from brain damage following stroke, the patient will totally ignore one side of her own body, most often the left side (following damage to the right hemisphere). The patient's body image simply stops at dead center; anything to the left of center is excluded from her body image. In cases where there is no paralysis, she might be asked to raise her left arm, and in response she raises her right arm, claiming it to be her left one, or she becomes entirely confused about it, or confabulates about the status of her left limbs. In some cases the patient never initiates use of the left side of the body and it appears to be paralyzed when it is not. In other cases, however, despite neglect of the left side, patients do use the left limbs to dress, walk, eat, and so forth.

A patient like this is described by Denny-Brown. The patient, an elderly woman who was both modest and fastidious about her clothing, suffered a right parietal lobe lesion. She subsequently, while dressing, carefully adjusted her clothing on her right side but ignored her left side leaving parts of her body undressed (Denny-Brown, Meyer, and Horenstein 1952; similar patients have been described by Ogden 1996 and Pribram 1999). Dressing involves complex spatial and motor skills. Despite the fact that garments constantly change spatial orientation in the course of the procedure, one usually performs the required movements in a close to automatic way, employing motor programs that belong to the body schema. In this patient, as in non-neglect subjects, motor activity on the left is sufficiently governed by an intact body schema. So even without conscious recognition of a certain aspect of the body (that is, absent a complete body image), a sophisticated motor use of that aspect is still possible. Here we have one half of a double dissociation: an intact body schema, but a very damaged body image.<sup>2</sup>

The other half of the double dissociation requires a case in which there is an intact body image, but the absence of a body schema. This is exactly how IW can be described. His lack of proprioceptive feedback means that movements that are normally spontaneous or automatic simply do not exist for him. He has to think through every move. When he reaches to lift a glass, he has to consider the shape made by his fingers, the strength of his grip, and the movement of his arm, and he has to keep the target in sight until he grasps it. No matter how many times he practices a movement, it never becomes completely automatic for him, although, with practice his movements can become smoother and easier to make – but always in need of conscious effort, and almost always in need of visual guidance.

An important qualification is required, however. It is not quite right to say that IW's body image is perfectly intact. His body image completely lacks the information normally provided by proprioception and touch. When in dark-

ness, or with eyes closed, IW does not know where his limbs are. On the other hand, with his eyes open and the lights on, IW is capable of using visual aspects of his body image to control his movements in quite precise ways. So in some respects his body image is impoverished. In other respects, however, it is put to service above and beyond the call of duty for a normal body image. IW employs the workable aspects of his perceptually informed body image to make up for a loss of body schema.

In the normal subject, movement tends to take care of itself. When I walk across the room, I may be thinking of where I am going or what I am going to do, but I am not attending to my feet, or thinking about putting one foot in front of another. As Merleau-Ponty indicates, I do not need to visualize external space and my own body in order to move one within the other. Thanks to various body schemas, some of which are innate, others acquired, my body moves itself in appropriate ways without my conscious effort. IW is without a body schema system and he has to think about putting one foot in front of another. In contrast to Merleau-Ponty's characterization, IW does in fact need to visualize external space and his own body in order to move one within the other. He has to calculate the geometry of reaching for a glass. He often has to concentrate on his posture. Standing in the wind, he has to predict the force of it in order to maintain his balance.<sup>3</sup>

### **A motor theory of gesture**

IW has not only relearned movement and an alternative form of motor control, he has also re-established the ability to gesture – something he had lost for a time subsequent to his illness. Furthermore, by all appearances, IW's gestures, for example, during conversation, are close to normal. Merleau-Ponty's remarks concerning the conversion of motor essence into linguistic form suggest that what we say of movement we may also say of gesture. In the normal case I do not need to visualize or monitor my own body in order to move. In the same way I do not need to visualize the gesture in order to know how to make it. Since IW proves an exception in regard to movement it is natural to assume that he would also be an exception in regard to gesture. If so, his case would seem to support what we will call a motor theory of gesture.

According to this theory gesturing is primarily a matter of movement, falling within the domain of sensory-motor behavior. Gesture is the same sort of movement as instrumental or locomotive movement.<sup>4</sup> This would imply that in the normal case gestural movement, like instrumental and locomotive

movement, comes under the control of the body schema system. On this view, IW, an exceptional case with respect to sensory-motor control, would control gesture as he controls his movement. Accordingly, IW's gestures, like his instrumental and locomotive movements, would fall under his conscious control. For example, according to this view, he would consciously monitor his speech and his gesticulation to keep them in synchrony.

A hypothesis consistent with the motor theory of gesture has been independently advanced by Jürgen Streeck (1996) and Sotaro Kita (2000). On their view gestures are virtual actions (actions without actual objects), and involve the same neural pathways as those involved in real actions. Thus Kita suggests that actions in a virtual environment are equivalent to (or analogically equivalent to) instrumental actions. A gesture is something like a reenactment that reproduces the original instrumental action in a virtual (imaginary) space. LeBaron and Streeck (2000) assert that when the hands are used in both gesture and instrumental action, the same motor system is involved.

Moreover, the speaker's hands know how to do things other than gesticulation, and it seems unlikely that the skills that the hands bring to bear on their symbolic tasks are entirely separate from those that they have acquired while handling things. Rather, the patterns that are at hand when there is a need to gesture appear to be made from the same fabric as those that are required in instrumental action. And this producer's knowledge, too, is socially and culturally shared. (Le Baron and Streeck 2000, p. 137)

So gesture is the original action once again, but in an analog form, and this time in the virtual environment. Accordingly, gesture is something like a motor supplement to linguistic practice; not an intrinsic part of language, but something added to speech to help it along.

### **Experiments on gesture**

Paul Ricoeur suggests knowledge of gesture is in the gesture (1992, p. 62). Following a distinction made in Anscombe (1979), he considers knowledge here to mean a form of practical knowing-how rather than knowing-that. As Merleau-Ponty points out, the same can be said of motility in general: knowing how to move is usually built into movement itself. One way to put the issue that is before us is to ask whether the know-how of gesture is, as the motor theory of gesture suggests, of the same sort as the know-how of instrumental or locomotive movement. If both gesture and movement belong to the category of action, are they two distinct kinds of action, or is gesture simply a sub-category of instrumental movement? Is the know-how of gesture reduc-

ible to the know-how of movement? We suspect that the motor theory of gesture may not provide the whole story, and we think that the case of IW may help to answer these questions in a way that establishes a clear differentiation between *expressive* movement and other kinds of movement (e.g., reflex, locomotive, and instrumental).

Given IW's difficulties with movement, and the extraordinary way in which he controls his movement, it would be natural to presume that IW has similar problems with gestural movement. If he has difficulties picking up a glass, would he not also have difficulties gesturing the idea of picking up the glass? If IW has to consciously control every movement would he not, as the motor theory suggests, also have to consciously control his gestures. But since normal gestures are not consciously controlled in that way, we should expect IW's gestures to fall outside the normal range, at least in terms of timing and shape. To all appearances, however, IW's gestures seem close to normal.

McNeill (1992) has developed an exhaustive analysis of gestures that involves the classification of different types, a microanalysis of how gestures are formed, and a precise computerized technique for measuring the timing (on the order of hundredths of seconds) of gestures relative to speech. With IW we conducted several experiments on gesture at McNeill's lab at the University of Chicago (Cole et al. 1998; Gallagher, McNeill and Cole 2001). In these experiments we systematically observed IW's gestures under various conditions. For our purposes here we focus on one of the conditions.

To test his gestures we videoed IW in a situation that allowed him free use of his hands, and we asked him to narrate the plot of a cartoon he had just seen. During the narration task, when vision of his hands was available, IW made numerous meaningful gestures well synchronized with his co-expressive speech, confirming that he had the ability to produce gestures. His gestural performance looked essentially identical to non-neuropathic performance, and further computerized analysis of the video confirmed this.

To discover whether IW controlled his gestures using visual feedback, a blind was placed before him in such a way as to block his view of his hands. Asked again to rehearse the cartoon story, however, IW did not gesture at all; his hands remained clasped in his lap. When asked, he explained this lack of gesture as a decision made because he was not sure of the space his hands were in and whether it would be safe to move them. Since IW has no sense of touch, he cannot tell whether his hands are hitting something unless he sees them or feels pain or a change in temperature. The fact that IW decided not to gesture in an uncertain environment suggests that IW has a conscious veto power over his gestures. He can decide not to gesture in certain situations – specifically when he does not know when it is safe to do so. But in this regard, IW is per-

fectly normal. A subject placed close to a hot stove and asked to explain something, would likely veto gesturing to avoid being burned. When we assured IW that it was safe to move his hands and, without cueing either form or timing, requested him to gesture, and again placed him in the blind situation, he did gesture, and his gestures turned out to be normal on measurements of timing and shape.

Once IW allowed his gestures to get under way, they seemed to have a mind of their own. That is, they did not seem to be under IW's attentional control, and they were consistent with normal measurements in terms of timing and shape, relative to IW's speech acts. An especially striking illustration of this came later in the experiment when IW, no longer recounting the cartoon story, continued to converse while his hands remained under the blind. His hands began to form gestures but did so outside of awareness. During the first 20 seconds of the conversation he performed a string of gestures (14 in all) and then said, revealingly “. . . and I'm starting to use my hands now . . .” while continuing to gesture. His gestures were utterly non-exceptional in timing and shape during the critical 20 seconds when they were outside of awareness.

The spatial organization of his gestures is especially important. Instrumental movement – reaching to pick up a glass, for example – usually requires topokinetic precision. To pick up a glass or to catch a ball I need to be able to move to a target position in the surrounding space. My grasp, in this type of situation, also requires a morphokinetic precision. That is, my hand has to shape itself to meet the object I am about to pick up. In contrast, there are usually very few topokinetic constraints placed on gesture, although gesture often requires morphokinetic accuracy. That is, it needs to be shaped in the right way to communicate meaning. Under the blind condition IW would not be able to perform instrumental movements requiring sustained spatial accuracy. His sense of topokinetic space is highly degraded without visual guidance. Yet he can make movements in space with some limited degree of topokinetic accuracy. In the gestural context this is useful for differentiating meanings, for example, to the right for one meaning, to the left for a contrasting meaning. Examples of this occurred during the 20-second out-of-awareness gesture stream described above.

Is the difference between morphokinetic and topokinetic movement sufficient to explain IW's ability to perform gestures? That is, is he better at gestures simply because they do not need to be topokinetically accurate? IW's performance in the blind condition suggests that there is more than this involved. Try this experiment. Sit at a table with your hand placed underneath it, out of view. Make a fist and then extend your index finger. Curl it back into the fist and then extend it again. The mechanisms that allow you to tell when

your finger is extended or not, or even that you've made a fist, simply do not work for IW. If you can imagine not knowing whether your finger is extended or curled, then you can start to imagine the difficulty involved in attaining even morphokinetic accuracy without proprioceptive feedback. Yet, IW's gestures reflected the meaning he was attempting to convey with a significant degree of morphokinetic precision, suggesting that meaning plays a part in how those gestures are shaped and how his hands move in gesture. IW's gestures were also precisely synchronized with the verb phrases he used to describe various events. His gestures are normal both with respect to morphokinesis and with respect to timing.

Gesture is not as highly dependent on topokinetic precision as reaching to pick up a glass, for example. If it were, gesturing might be impossible for IW in the blind condition. It is also likely that over the course of a conversation the lack of topokinetic control in that situation would begin to interfere with the morphokinetic aspects of gesture. IW does show small misalignments in gestural space, reflecting his lack of topokinetic control without vision. Nonetheless, he can structure space morphokinetically. Under the blind, he did manage to perform a two-handed asymmetric gesture with the two hands working together to create a spatial arrangement in which each locus was established in relation to the other (he was describing a cartoon in which a trolley chased Sylvester the cat: his right hand was the trolley, the left was Sylvester, and the right 'chased' the left across the gesture space in alternating left-hand, right-hand strokes).

To what extent can the motor theory of gesture explain this experimental data? It is possible that IW's gestures are to some extent under his conscious control, in the same way as his instrumental and locomotive movements are. In support of this interpretation, we can mention two things. First, IW reports that he consciously decided to practice gesturing after his illness. For IW it was important for his sense of self-esteem and emotional embodiment that he gestured in a close to normal fashion. His embodied existence felt incomplete without the emotional and paralinguistic movements which gesture provides. To have a body that was purely instrumental or locomotor was felt by IW to be inadequate. It is also possible that the prosodic aspects of speech helped him develop the timing of his gestural movements. Second, he reports that he still consciously initiates gesture.

That these reports necessarily support a motor theory of gesture, however, can be challenged by the following considerations. First, as indicated, IW's gestures disappeared during the first few months following the onset of his illness, when he was still trying to gain control over his movements. There may be a variety of ways to explain this. IW was extremely cautious about

moving at all. He didn't know precisely what to expect at first since a minor movement might end up in an unexpected position. In such circumstances, it is not unlikely that one would exercise one's veto power over gesture. Also, to some extent, gesture depends upon a stable posture. It might be the case that IW had to re-establish control over posture before gesture could be brought back. Ian reports that he practiced gesture in order to recover it. What does this mean precisely? Does it mean that (1) he did not know how to make a gesture and he had to reinvent it? That is, he knew what a gesture was but could not accomplish it unless he planned out the whole thing – in that case, reinventing the motor elements of the gesture. Or (2) he knew how to make a gesture but had to practice doing it because of motor and postural instability. That is, for example, when he made a gesture he consciously had to practice adjusting his posture to maintain balance. This second option might *seem* very much like reinventing and practicing gesture (and being conscious of the gestural movement) – but in some sense it would be practicing precisely a different kind of motor control. It is difficult to discriminate phenomenologically between these possibilities in retrospect.

Second, the report that he consciously initiates gesture may reflect a normal veto control over starting to gesture in cases when he is uncertain of his surroundings. The important question in this regard is whether he consciously controls his ongoing gestures. Certain of the experimental results, however, suggest something different. Specifically, the experiments bear on the hypothesis advanced by Streeck and Kita. This hypothesis predicts that IW would have the same difficulty with gesture as he has with instrumental action. If IW can perform gestures normally and fluently under conditions in which instrumental action would be difficult or impossible for him, namely, without visual feedback, a clear and real distinction between gesture and instrumental action is established. The experiments support precisely this distinction.

### **A communicative theory of gesture**

A different interpretation is based on the fact that IW's gesturing is close to normal with respect to morphokinetic factors and timing. The timing of IW's gestures is normal, that is, they are normally integrated with his speech acts, something that is unlikely to be the case if gestures were under conscious control. This suggests that IW's gesturing is not consciously monitored, but is much more integrated with linguistic behavior, and controlled by factors that go beyond ordinary sensory-motor control. This second interpretation leads to a communicative theory of gesture and the idea that there is some non-

motor mechanism for the control of gestures. In other words, gestures are primarily part of communicative action rather than a form of motor behavior.

The experiments show a clear difference between instrumental and locomotive motor action, on the one hand, and the expressive movement involved in gesture, on the other. In the most general terms, IW's instrumental and locomotive movements appear slightly abnormal and *are* abnormal to the extent that they are consciously/cognitively controlled. In addition, even for those aspects of his movement that have become automatic, certain constraints and limiting factors continue to be different from normal. In walking, for example, IW cannot bend his knees when his step is weight-bearing. In contrast, IW's gestures appear normal and, analyzed in terms of timing and self-organization, are normal. There are some accuracy constraints on individual finger position present during both instrumental and gestural movement. Few spontaneous gestures seem to depend on precise finger control, however. Perhaps because of this feature of gesture and its rather general level of detail, IW's gestures can remain in the normal range.

IW's deafferentation does not involve brain damage. His speech and his use of spoken language are normal – IW is articulate and well spoken. But IW's arms and hands are deafferented. He does not feel them, and in the dark, without visual contact, he does not know where they are, and in that situation he is unable to perform instrumental movements. He can reach to remembered positions in 3D space in the dark. But this is a static, consciously remembered, and impoverished movement compared with gesture. IW can also reach out with some accuracy to pick up a glass he can see even if his hands are not visible; he can shape his hand roughly to the shape of the glass but without seeing his hand he is unable to close his hand around the glass. Nonetheless, under the blind, his speech-embedded gesticulation appears to be morphokinetically normal.

Gestural control both normally and in IW may be based on links centrally made between a cognitive-linguistic system and hand movement. These links may be analogous to those that exist between the visuo-oculomotor system and arm movements. For example, in experiments involving eye-tracking, the latency of onset of smooth pursuit of a moving target by the eyes is shorter, and the velocity of smooth eye-tracking higher (before saccadic movements), when the visual target is moved by the subject's hand, than if the target is moved by an external device. This is the case both for control subjects and for IW and another deafferented subject. This suggests a connection or coordination at the level of motor commands for hand and eye movement, which is non-conscious and independent of proprioception (Vercher et al. 1996).

In another experiment the relative extent to which IW was able to use dif-

ferent signals from his visuo-oculomotor system to improve accuracy of arm movements was shown (Blouin et al. 1996). IW was asked to track a visual target eccentrically to the left with his eyes and then move his unseen arm to the same place. He was able to do this better if the eyes were moved to the target in a short saccade than if he moved his eyes slowly or, with eyes still, attempted to judge the eccentricity by movement of the target across his visual field. This suggests that he can calibrate arm movement from eye movement command, though, again, not at a conscious level. Though IW attended to the task intensely during these experiments (and his performance fell off when he was tired), this does not imply that the coordination between motor programs is consciously made.

These examples demonstrate that IW is able to use motor command in one domain to improve motor performance in another. In the first experiment arm movement improved eye tracking whilst in the second eye movement improved the accuracy of arm reach. Such visuo-oculomotor experiments provide evidence of a cross-modal and non-conscious interaction between motor programmes in IW.

We want to suggest that the linkage between language and gestural movement may have an analogous nature. Language generation might constrain or enable the control of gestural movement in a similar manner. As IW speaks and gestures brain regions responsible for the generation of language may be contributing to control of gestural movement by enabling access to motor programmes that underpin his gesture stream. Good evidence from neurophysiology and neuropsychology suggest the establishment of such relations between language centers and motor areas in the human brain (Iverson and Thelen 1999). These relations are explicated in terms of a common brain mechanism responsible for timing of sequential movement and linguistic performance (Ojemann 1984), and the activation of supplementary motor cortex and premotor regions along with the cerebellum and Broca's area in the production of language and movement. There is evidence that Broca's area, a well-know language area of the brain, plays an important role in the generation of coherent sequencing of movement (Iverson and Thelen 1999).

On this interpretation, gesture is not a motor supplement to speech. Nor is it subordinate to speech, but is semantically and pragmatically coordinated with it. As McNeill (1985, p. 351) indicates, gestures

are movements that . . . occur only during speech, are synchronized with linguistic units, are parallel in semantic and pragmatic functions to the synchronized linguistic units, perform text functions like speech, dissolve like speech in aphasia, and develop together with

speech in children. Because of these similarities, a strong case can be made for regarding gestures and speech as part of a common psychological structure.<sup>5</sup>

The conversion of a certain motor essence into gesture, suggested by Merleau-Ponty, is not a conversion that allows for gesture simply to remain part of movement. IW shows us that gesture is in a different class of actions than instrumental or locomotive actions.

The self-organizing intentionality of instrumental and locomotive movements normally depends on the implicit workings of body schemas. For IW, as we have seen, self-organizing motility breaks down. Yet, the self-organizing intentionality of language remains intact, and gesture, temporarily disrupted by IW's illness, has been re-established to a higher degree than his capacity for instrumental or locomotive movement. On the communicative theory of gesture the reason gesture can be re-established with such proficiency is that gesture, as a movement concerned with the construction of *significance* rather than with *doing* something, is organized primarily by the linguistic-communicative context.

The important distinction here is between (1) instrumental action (the kinds of motor action with which IW has problems) and (2) communicative action, or action with meaning mapped onto it. Streeck and Kita, developing a motor theory of gesture, claim that gesture is an extension of the same class of movements as reaching, grasping, and so forth. In this case gestural communication would be mediated through the mapping of meaning onto instrumental action. The experiments with IW suggest the alternative hypothesis, namely that gesture is not a form of instrumental action but a form of communicative action, not a reproduction of an original motor behavior, but a different kind of action. According to the communicative theory, gesture is not an action that takes place within a virtual or narrative space. Inside the narrative space one wants to find narrative content, not a hand that is doing something, even in gesticulation. Rather, gesture is an action that helps to create the narrative space that is shared in the communicative situation, and as such, it comes under the control of linguistic/communicative systems rather than the instrumental motor system.

IW's gestures, under non-feedback conditions, where he is incapable of accurate instrumental actions in a seamless and complex progression, suggest that communicative actions involve a direct mapping of meaning onto space and motion. IW's gestures can be decoupled from visual monitoring and can be performed without sensory feedback of any kind, and therefore without the contributions of either body schema or body image. Yet they remain relatively accurate in timing and form. This suggests that gestural movements must be

controlled by a system that is at least in part separate from the system that controls the same muscles in instrumental actions. Gestures may share the final motor pathway to the spinal level, but it is possible that the control of that pathway is different at a higher level of the neuroaxis. The evidence for this goes beyond issues pertaining to the accuracy of timing and form, to the fact that gestural programmes appear to unfold with speech in a way that is not reflectively controlled, and thus, in a way not seen in IW's instrumental acts.

### **Intrasubjective and embodied aspects of gesture**

IW's ability to co-create language and gesture patterns of normal complexity in timing and form suggests that gesture is something other than an instrumental action. Gesture is elaborated in a way that is linked up with language creation. The synergy between speech and gesture is an interaction that enriches communication. Perhaps it is even more than that.

People who are congenitally blind gesture, despite the fact that they never have a visual model. Indeed, they produce gestures that cannot be differentiated from those made by sighted speakers. One might think that they gesture for the sake of their interlocutor. Iverson and Goldin-Meadow (1998) report, however, that congenitally blind subjects even use gestures to communicate with other blind subjects. If no one is able to see their gestures, why do they make them? The experiment with IW takes this one step further. Under the blind, and without proprioception, IW has no explicit, conscious knowledge of the specifics of his gestural production. In this case, what does he gain from his gestures?

Merleau-Ponty tells us that language does not simply externalize or communicate a pre-formed thought; rather, language accomplishes thought. Is it possible that gesture itself, as language rather than movement, assists in the accomplishment of thought? Studies of IW and people who are congenitally blind provide good evidence for that idea. The experiments with IW further suggest that this contribution to cognition is not the result of the movement itself. Ian in the blind condition does not receive feedback from either movement itself or from the motor output to move, of which he appears in the crucial period to be unaware. His cognitive gain from gesture without visual feedback, we suggest, may be due to pre-motor preparatory processes involved in the generation of the gestural movement rather than from the gestural movement itself (for these distinctions, see Haggard and Magno 1999).

Gestures as language may serve communication with others, but it may also accomplish something within the communicating subject, namely, an intra-communication with oneself, rather than simply an inter-communication with the other person. These two aspects of gesture, its intrasubjective and intersubjective functions, may be difficult to pry apart.

In any particular case, the system that guides the movement of gesture and language includes the particular semantic and pragmatic contexts of communication. The difference between reaching out to pick up a glass (instrumental action normally controlled by a body schema) and formulating a gesture to signify the action of picking up a glass will depend to some extent on the fact that the gesture serves entirely different functions than the actual grasping – cognitive and communicative functions that require the generation and expression of meaning. The gesture may for just that reason differ in its mechanical recipe from the instrumental action. The meaning and the communicative situation call forth the gesture; the feedback for that gesture will not be proprioceptive but linguistic. IW, who, in a blind condition, is unable to locate his hands proprioceptively, nonetheless says something with his hands, because they are moving in synchrony with this vocal expression, and are parallel with his semantic and pragmatic intentions.

On the one hand, although gesture involves movement it is irreducible to movement. Like Merleau-Ponty, we want to define gesture as a spontaneous movement that is not consciously thought out beforehand, and that transcends its purely motor aspects. Gestures are not just movements and can never be fully explained in purely kinesic terms. They are not just arms waving in the air, but *symbols that exhibit meanings* in their own right (McNeill 1992, p. 105). The thing that makes gesture more than movement, of course, is the fact that gesture is language, or, as McNeill suggests, *gesture and language are one system* (1992, p. 2). On the other hand, gesture is nonetheless movement. Gesture and language remain embodied. They require, as a necessary condition, some form of motor feedback.

Thus, a fuller explanation of gesture is to be found in a theory that integrates, in very specific ways, the insights gained in both motor and communicative approaches. One requirement for topokinetic aspects of gesture is that there be some knowledge in the system concerning the location of the hands relative to each other and relative to the rest of the body. Topokinetic properties of gestures depend on position feedback that is not linguistic. In the normal case proprioception provides the feedback necessary for locating our hands, even with our eyes closed. In IW vision normally provides the feedback that he requires to know where his body parts are. Lacking proprioception and vision, IW is unable to locate his hands except by memory – he thinks

they are wherever he last saw them. With subsequent movement he loses track of them. One can see this under the experimental blind condition. The topokinetic aspects of the gesture start to go off and eventually IW's hands are lost to him. This then starts to interfere with the morphokinetic aspects of gesture.

Thus, the case of IW helps to define a precise integration of motor and communicative theories of gesture, and to outline what we can call an *embodied or integrative theory of gesture*. Specifically, by distinguishing several different aspects of gesturing, it is possible to identify precisely the different roles played by motor processes and communicative processes:

- **Initiation:** in some cases, conscious control exercises veto power over gestural movement.
- **Launching and timing:** communicative control tied to the pragmatics of the situation.
- **Morphokinesis:** communicative control tied to semantics.
- **Topokinesis:** motor control, dependent primarily on proprioception (and body-schematic processes) in the normal case.

So, on the one hand, with respect to launching, timing, and morphokinesis, the communicative theory wins out. Linguistic or communicative processes that are irreducible to pure movement govern gesture. On the other hand, however, gesture is not something that transcends the body in any complete sense. It is generally constrained by the requirements of motor control. Specifically, gestures do not stay on track without feedback to the motor system that allows that system to know where the hands are in relation to each other and to the body.

When IW lost proprioceptive feedback he was unable to update or to access the central motor programs responsible for controlled movement. In the absence of proprioceptive feedback, however, central motor programs may continue to exist.<sup>6</sup> As we suggested above, consistent with experiments on eye-tracking and arm movement (Blouin et al. 1996; Vercher et al. 1996), it may be possible that language circumvents, in some degree (although not entirely), the purely motoric/proprioceptive aspects of feedback and access to motor programs. It is possible that the semantic and communicative (pragmatic) aspects of gesture provide sufficient feedback to sustain control of gestural movement. Nonetheless, to the extent that gesture depends on a link to motor programs it is still constrained at the mechanical or bottom end. In addition, in IW there are specific engineering problems pertaining to postural readiness and the changed mechanics of movement and that are reflected as constraints

on gesture. Here some version of the motor theory is inescapable. Gesture is not purely a linguistic or communicative phenomenon; it requires motor control, and is thus embodied in a very basic way.

Although speech and gesture depend on movement, as a necessary condition, they nonetheless *transcend* motility and move us into a semantic space that is also a pragmatic, intersubjective, intercorporeal space. Language, insofar as it involves an open and indefinite power of giving significance transforms and transcends the natural powers of the body (Merleau-Ponty 1962, p. 194).<sup>7</sup> Thus, language is irreducible to either the purely noetic or the purely motoric, even though it shapes thought and depends upon motor ability. Although, as Merleau-Ponty suggests, the body lends itself to gesture (1962, p. 183) gesture is never a mere motor phenomenon; it draws the body into a communicative order defined by its own pragmatic rules.

Language not only transcends the body, it also returns to the body in the sense that it makes the body move in certain ways. The relation between embodiment and language is a self-reciprocating, self-organizing one in this sense. The body generates expression and is thereby involved in the production of language; language operates by calling forth the gestural expression of the body. It is, of course, another person like myself who moves, motivates, and mediates this process. To say that language moves my body is already to say that other people move me.

## Notes

1. Authors are listed in alphabetical order and have equally contributed to authorship.
2. Similar conclusions about intact body schemas can be reached based on tests of hand grip conducted with unilateral neglect patients. Despite neglect of the left hand, for instance, a subject made to pick up an object with the left hand shows completely normal handgrip for the task (Milner 1998). That is, the hand reaches and shapes itself in the appropriate fashion for picking up the particular object – the details of such motor action being quite different for different objects, a puck rather than a cup, for instance. Thus, even in cases of conscious denial of ownership of the hand, where the hand is not included in the subject's body image, motor programs are sufficiently intact to accomplish the action.
3. IW can walk with 50% concentration now, whereas originally it was 100%. In other words he has gained some automaticity in locomotion, but still needs concentration and visual attention to guide his movements. The mechanical and postural constraints on his walking are different from normal, because he needs to keep his feet in his peripheral vision. His head, for example, is forward, and this changes weight distribution on his feet and other aspects of posture.
4. Robin Allot (1992) outlines a motor theory of language. He writes: "At every level of language, from the elementary speech sounds, through the word-forms on to the syntac-

- tic rules and structures, language was isomorphic with the neural systems which already existed for the control of movement.”
5. Merleau-Ponty puts it this way: “The spoken word is a genuine gesture, and it contains its meaning in the same way as the gesture contains its” (1962, p. 183). Or again, “The spoken word is a gesture, and its meaning, a world” (p. 184).
  6. This is difficult to ascertain, however. In the absence of proprioceptive feedback central motor programs may continue to exist, but be initially inaccessible, or be relearned and then consolidated to become more automatic. The fact that the mechanical constraints of movement are also different in IW complicates the issue. See Gallagher and Cole (1995) for further discussion.
  7. Gesture transcends movement and the body. We mean this in the same sense as Merleau-Ponty indicated: “The use a man is to make of his body is transcendent in relation to that body as a mere biological entity. . . . Behaviour creates meanings which are transcendent in relation to the anatomical apparatus, and yet immanent to the behaviour as such, since it communicates itself and is understood” (1962, p. 189). And again, “the human body is defined in terms of its property of appropriating, in an indefinite series of discontinuous acts, significant cores which transcend and transfigure its natural powers. This act of transcendence is first encountered in the acquisition of a pattern of behavior, then in the mute communication of gesture . . .” (p. 193).

## References

- Allot, R. 1992. The motor theory of language: origin and function. In: J. Wind et al. (eds). *Language Origin: A Multidisciplinary Approach*. Dordrecht: Kluwer.
- Anscombe, G.E.M. 1979. *Intention*. London: Basil Blackwell.
- Blouin, J., Gauthier, G.M., Vercher J.-L. and Cole, J. 1996. The relative contribution of retinal and extraretinal signals in determining the accuracy of reaching movements in normal subjects and a deafferented patient. *Experimental Brain Research* 109: 148–153.
- Cole, J. 1995. *Pride and a Daily Marathon*. Cambridge, MA: MIT Press (originally London: Duckworth, 1991).
- Cole, J., Gallagher, S., McNeill, D., Duncan S., Furuyama, N. and McCullough, K.-E. 1998. Gestures after total deafferentation of the bodily and spatial senses. In: Santi et al. (eds). *Oralité et gestualité: Communication Multi-modale, Interaction*, pp. 65–69. Paris: L. Harmattan.
- Cole, J. and J. Paillard. 1996. Living without touch and peripheral information about body position and movement: studies upon deafferented subjects. In: J. Bermúdez, A. Marcel and N. Eilan (eds). *The Body and the Self*, pp. 245–266. Cambridge, MA: MIT/Bradford Press.
- Denny-Brown, D., Meyer, J.S. and Horenstein, S. 1952. The significance of perceptual rivalry resulting from parietal lesion. *Brain* 75: 433–471.
- Gallagher, S. and Cole, J. 1995. Body schema and body image in a deafferented subject. *Journal of Mind and Behavior* 16: 369–390.
- Gallagher, S., Cole, J. and McNeill, D. 2001. The language-thought-hand system. In C. Cave, I. Guaitella and S. Santi (eds). *Oralité et gestualité: Interactions et comportements multimodaux dans la communication*, pp. 420–424. Paris: L’Harmattan.

- Iverson, J.M. and Goldin-Meadow, S. 1998. Why people gesture when they speak. *Nature* 396 (19 November 1998): 228.
- Iverson, J.M. and Thelen, E. 1999. Hand, mouth and brain: The dynamic emergence of speech and gesture. *Journal of Consciousness Studies* 6 (11–12): 19–40.
- Kita, S. 2000. How representational gestures help speaking. In: D. McNeill (ed). *Language and Gesture*, pp. 162–185. Cambridge: Cambridge University Press.
- LeBaron, C. and Streeck, J. (2000). Gestures, knowledge, and the world. In: D. McNeill (ed). *Language and Gesture*, pp. 118–138. Cambridge: Cambridge University Press.
- Marcel, A.J. 1992. The personal level in cognitive rehabilitation. In: N. von Steinbüchel, E. Poppel and D. von Cramon (eds). *Neuropsychological Rehabilitation*, pp. 155–168. Berlin: Springer.
- Milner, D. 1998. Unconscious visual processing for action: Neuropsychological evidence. Paper presented at Towards a Science of Consciousness, Third Conference, Tucson, April 27, 1998.
- Merleau-Ponty, M. 1962. *Phenomenology of Perception*, tr. C. Smith. London: Routledge and Kegan Paul.
- McNeill, D. 1985. So you think gestures are non-verbal? *Psychological Review* 92: 350–371.
- McNeill, D. 1992. *Hand and Mind: What Gestures Reveal about Thought*. Chicago: University of Chicago Press.
- Ogden, J.A. 1996. *Fractured Minds: A Case-Study Approach to Clinical Neuropsychology*. Oxford: Oxford University Press.
- Ojemann, G.A. 1984. Common cortical and thalamic mechanisms for language and motor functions. *American Journal of Physiology* 246 (Regulatory Integrative and Comparative Physiology 15): R901–R903.
- Pribram, K.H. 1999. Brain and the composition of conscious experience. *Journal of Consciousness Studies* 6 (5): 19–42.
- Ricoeur, P. 1992. *Oneself as Another*, tr. K. Blamey. Chicago: University of Chicago Press.
- Streeck, J. 1996. How to do things with things: Objects trovés and symbolization. *Human Studies* 19: 365–384.
- Vercher, J-L., Gauthier, G.M., Guedon, O., Blouin, J., Cole J. and Lamarre, Y. 1996. Self-moved target eye tracking in control and deafferented subjects: Roles of arm command and proprioception in arm-eye coordination. *Journal of Neurophysiology* 76 (2): 1133–44.

