# The essence of gesture is invisible

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**There are six reasons for the invisibility of much of gesture:**

1. The meaning of gesture
2. Abstract symbolic representation
3. Mental imagery
4. The intention of the subject
5. The predicted control of speed and position in gesture
6. The phenomenon of persistence

## 1. The meaning of gesture:

The pattern of brain responses related to observing the movement of others is far from being fixed and immutable. **It depends largely on the nature of the actions observed**. For example, a movement with a known meaning will not create the same response as a symbolic movement without meaning (Decety et al. 1997; Rumiati et al., 2005). Learning can take place only if the subject has precise knowledge of the result of his actions (Simonet, 1990, for a review).

## 2. Abstract symbolic representation:

The symbolic representation of abstract features is constructed by two factors:

a) The observation of gesture.
b) The intensive practice of gesture.

a) **The observation of gesture:**

The observation of a visual model allows the learner to draw on a symbolic representation of abstract features of the task (Bandura, 1969, 1977, 1986). Considerable research has therefore been undertaken to determine, both in children and in adults, the role of the observational learning of factors related to *attention* (McCullagh, 1986), *motivation* (Landers and Landers, 1973; Gould and Weiss, 1981), *characteristics of the model* (Landers, 1975; Ishikura and Inomata, 1995; Sambrook, 1998), *verbalization* (Weiss, 1983; Weiss and Klint, 1987) or *mental imagery* (Lejeune and al. 1994; Fery and Morizot, 2000).

The image is defined as "an evocation of the inner qualities of a perceptual object in the absence of that object" (Blanc-Garin, 1974, p. 539).

This link between image and sensation could suggest that the image is a mere residue of perception or, in other words, the image is built isomorphically to the observed image. This idea is to a large extent incorrect. The image is therefore defined here not as a mere residual perceptual trace, but as a "true deferred imitation" (Piaget and Inhelder, 1963, p. 70). *The image is not a reflection but an operation.*

When the subject observes a visual model, there is a whole occipito-temporo-parietal network involved:

1. Information first undergoes basic processing in the occipital visual areas.

2. A second transformation then takes place in the superior temporal sulcus (STS).

This structure is involved in decoding biological motion (Perrett et al., 1985, 1989; Oram and Perret, 1994; for a review, Allison et al., 2000). Furthermore, neuronal activities recorded in the STS are largely modulated by the *perspective of the observer*. If this perspective shifts, the cellular response changes (Perrett et al., 1989, 1991). For example: if you're in a car and you draw a figure on the windshield, an outside observer will see this figure as a mirror image (a "b" will appear as a "d"). If the observer wants to reproduce your drawing "in place", he must, first, rebuild your route according to its original perspective.

b) **Intensive practice of gesture:**

In cognitive psychology, it is conventional to distinguish two main modes of movement control:

I. *A closed-loop control (retrospective)*: In this first mode, driving a trace stored in long-term memory determines the start of the movement which is then adjusted in real time through sensorimotor feedback. It thus applies to movements whose duration is long enough to accommodate these changes (greater than 100 ms).

II. *An open loop control (proactive)*: in contrast, open loop control applies to very fast movements. It suggests that the movement is fully programmed in advance and therefore performed without reference to sensory cues.

The mode of movement control is essentially retroactive at the beginning of learning (P. Zesiger 1995). During this stage, children use the sensory feedback (visual and kinesthetic) from their own hand movements. Through learning and automation, proactive monitoring of the movements will become dominant.

## 3. Mental imagery:

A visual model can have positive effects on performance when combined with mental imagery tasks (Christmas, 1980; Hall and Erffmeyer, 1983; Ziegler, 1987; Gray 1990; Lamirand and Rainey, 1994; Bucher 1993; Lejeune et al. 1996; McKenzie and Howe, 1997; Frey and Morizot, 2000).

Internalized representations evoked during imagery tasks are not visual but are essentially motor representations (Famose, 1976). In this context, mental repetition loses its status and becomes true sensory imitation (Piaget and Inhelder, 1963) or internalized achievement (Jeannerod 1994, 2001). This internalization of the action may lead to the specific solicitation of sensorimotor networks and act as practice or repetition without movement.

Three studies show the effect of imagery on learning:

1. A study by Li-Wei et al. (Li-Wei et al., 1992), conducted as part of learning forehand in table tennis, in children aged 7 to 10 years.

2. A recent study also on learning tennis (Fery and Morizot, 2000).

3. A study on learning table tennis (Lejeune et al., 1994).

These studies show the existence of an improvement when the demonstration was followed by a task of mental rehearsal.

4. **Intention of the subject:**

The neural substrate for imitative mechanisms is significantly different for the tasks of emulating an effect or of reproducing a movement (Koski et al., 2002).

Activations are different when the subject is instructed to watch the movement:

1. To observe.

2. To imitate.

3. To recognize the movement during a subsequent performance (Decety et al., 1997; Buccino et al. 2004b; Rumiati et al., 2005).

Fogassa and colleagues showed that the response of parietal cell mirrors was modulated by the purpose of the action (Fogassa et al., 2005). Thus, for example, when the experimenter grasped an object to bring it to his mouth or put it in a box, the pattern of neural response was significantly different.

Consistent with this result, an imaging technique (fMRI) has recently shown in humans that mirror neurons in the frontal region responded differently when the same movement was observed in two different contexts (e.g. grabbing a cup in order to drink from it, or in order to change its position; lacoboni et al., 2005).

## 5. The predicted control of speed and position in gesture:

For decades, it has been accepted that most motor skills obeyed *ballistic logic*. This logic can be summarized as follows: once started, the motor program runs in "open loop" and it is impossible to amend its development. This hypothesis has been invalidated by a host of behavioral studies over the last two decades (for a review, Paillard, 1996; Prablanc et al. 2003; Desmurget and Grafton, 2000, 2003; Todorov, 2004).

The first research to establish the existence of a rapid control of gesture during its execution concerned visual feedback loops. (Paillard, 1980, 1996) noticed that capture of the foveal target was usually performed before or, in the case of large eccentricities, just after the start of the hand movement (Prablanc et al. 1979; Prablanc and Martin, 1992; Desmurget et al., 2001, 2004).

This implies that the initial phase of rapid transit to the target member is performed under the control of peripheral vision, while the slow terminal phase is completed in central vision. Paillard suggested that the peripheral retina could play a specific role in early control of the directional component of gesture.

In rapid pointing movements, the movement of the hand is initially prepared on the basis of retinal information devices. However, this information does not allow as precise an encoding of target position as foveal information (Prablanc et al., 1979, Abrams et al. 1990; Bock, 1993; Desmurget et al., 2005b). Work by Prablanc et al. showed that the original inaccuracy was corrected during the course of an arm movement, regardless of whether the subject can see his hand or not (Prablanc et al. 1986; Desmurget et al., 2005b).

The speed and position of the probable effector can not only be estimated immediately, but also predicted in advance (Desmurget and Grafton, 2000). This capability enables adjustment of the current response to environmental stress for even the fastest movements.

In recent work, Piselli et al. (Piselli et al., 2000) have shown that these adjustments are largely automatic and independent of voluntary mechanisms. This result, recently reproduced by

Cressman et al. (Cressman et al., 2006), is not surprising if one considers the nature of analysis required to stop the action underway: it is necessary to perceive the movement (for example, a jump), to identify it consciously, to decide to block the response, and then to send an inhibitory control. We can conclude that the work mentioned above by Piselli et al. (Piselli et al., 2000) indicates that stopping the action takes more time to adjust it.

## 6. The phenomenon of persistence:

Two currents of motor learning:

1. *Centripetal logic*: the exploration of a wide range of responses is essential to the formation of motor skills (Schmidt, 1975, 1976; Wulf and Shmidt, 1988, 1994; Wulf and Lee, 1993; for a review, Schmidt and Lee, 1999). We start from a multiplicity of experiences intertwined to develop, through abstraction, a general and generalizable rule.
2. *Centrifugal logic*: A stabilized practice, based only on the expression of a particular gesture, optimizes the extraction of the relevant skill (Lai et al., 2000; Wright and Shea, 2001; Whitacre and Shea, 2000, 2002; Shea et al. 2001; for a review, Shea and Wulf, 2005). We start from a particular instance of "average” ability then go by progressive differentiation to a wide range of adaptive behaviors.

Centripetal approaches encourage adaptation functions, as opposed to centrifugal approaches which tend rather to annihilate the flexibilities of the system in order to ultimately facilitate the formation of rigid and compelling invariants (Summers, 1975; Shapiro, 1977; Ripoll, 1982; Weineck 1986; Dronkert and Verwey, 1996). Several studies illustrate the results of the inadequate practice of centrifugal logic. Studies by Zatsiorsky show how “The practice of exclusive and prolonged identical gymnastics movements is a serious impediment, even among high-level gymnasts, to the acquisition of new gestures" (quoted in Ripoll, 1982, p. 140). Other studies on learning the sprint suggest that the application of constant and identical drives results in the establishment of a genuine *sign stereotype* whose main characteristic is to make "more difficult, even impossible, a new speed development " (Weineck, 1986, p. 86).