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IW—"the man who lost his body"[1]

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Introduction

Mr. Ian Waterman, sometimes referred to as 'IW', suffered at age 19 a sudden, total deafferentation of his body from the neck down—the near total loss of all the touch, proprioception, and limb spatial position senses that tell you, without looking, where your body is and what it is doing. The loss followed a never-diagnosed fever that is believed to have set off an auto-immune reaction. The immediate behavioral effect was immobility, even though IW's motor system was unaffected and there was no paralysis. The problem was not lack of movement *per se* but lack of control. Upon awakening after three days, IW nightmarishly found that he had no control over what his body did—he was unable to sit up, walk, feed himself or manipulate objects; none of the ordinary actions of everyday life, let alone the complex actions required for his vocation. To imagine what deafferentation is like, try this experiment suggested by Shaun Gallagher: sit down at a table (something IW could not have done at first) and place your hands below the surface; open and close one hand, close the other and extend a finger; put the open hand over the closed hand, and so forth. You know at all times what your hands are doing and where they are but IW would not know any of this—he would know that he had willed his hands to move but, without vision, would have no idea of what they are doing or where they are located.

The IW case is a fascinating study of a person who has lost his body schema (to use Shaun Gallagher's terminology), "his body" in the title of the 1998 BBC *Horizon* program that we quote in our title. The neuronpathy destroyed all sensory neurons at roughly the neck level in proportion to their myelination and conduction speed. The initial medical prognosis was that IW would spend the rest of his days confined to a wheelchair. Not one who takes setbacks lightly, IW commenced a rigorous self-designed and administered program of movement practice with the aim of learning to move again, endlessly performing motions over and over in different combinations, different trajectories, different distances and velocities, until he could, by thinking about the motion and using vision as his guide, plan and execute movements flawlessly, so nearly so that observers find nothing unusual about them. Jonathan Cole's book describing IW and his self-administered recovery was called *Pride and a Daily Marathon*, a title that captures in a nutshell the rigor and determination of IW battling the catastrophe that had

[1] The research described in this paper was funded by grants from the NSF STIMULATE, KDI, and HSD programs. We wish to acknowledge much input from collaborators on the IW gesture project: Jonathan Cole, Shaun Gallagher and Bennett Bertenthal. McNeill and Duncan address: Department of Psychology, University of Chicago, 5848 S. University Ave., Chicago, IL 60637, USA. Quaeghebeur address: Center for Philosophical Psychology, Department of Philosophy, University of Antwerp, Prinsstraat 13, 2000 Antwerp, Belgium.

befallen him (see Cole 1995). After more than 30 years, IW has developed an entirely new way of initiating and controlling movement. He has perfected this style to an astonishing degree. His movements depend on having constant visual contact with the environment, including the surrounding space, objects to be manipulated and any other objects in the immediate vicinity. Every movement is planned in advance, the force and direction calculated intuitively, and the movement monitored as it is taking place. Given all these requirements, it is impressive to see IW move without visible flaw at normal speeds. Although his gait seems somewhat lumbering (he calls it controlled falling), his arm and hand movements are truly indistinguishable from normal. However, if vision is denied, IW can no longer control his hands and arms accurately.

Such was the situation in 1997 when, for the first time, the University of Chicago Gesture Lab had a chance to observe IW at first hand. It was through Shaun Gallagher that we had become aware of IW in the first place. Shaun provided a video that had been made some years earlier of IW and another deafferented man during a visit by IW and Jonathan Cole to Pittsburgh. There were ample gesture occurrences on this tape, and so far as we could see IW's gestures appeared completely normal, just as we had observed in the gesturing of unaffected individuals. But of course he had visual contact with his hands at all times. There was accordingly the possibility that, like his practical world-related motions, the gestures were planned and monitored. We shall see that indeed some of IW's gestures are created this way. But others are not, and the exceptions are of great interest for the light they shed on how the human brain orchestrates communicative motions in the absence of feedback.

Shaun also put us in touch with Jonathan Cole and from him we received a copy of *Pride*, which had already been published in England. These preliminary contacts began as early as 1992. We had begun to ponder what IW would do gesturally if we could remove visual contact with his arms and hands. The BBC *Horizon* program provided our opportunity, flying IW, Jonathan and Shaun to the University of Chicago for experiments of our devising while they filmed us. Shaun Gallagher's book (2005), *How the body shapes the mind*, has a full chapter devoted to these experiments. We shall cover here much the same ground but with a more psycholinguistic and gesture-study slant; descriptions fully complementary with Gallagher's.

The study of gesture and its implications

Below we describe these experiments and others performed on another visit, but first we explain briefly the kinds of gestures we focus on, how we study them, and what they reveal of a specific mode of cognition during speech.

The Gesture Continuum

The word 'gesture' covers a range of communicative events. The term is nonetheless convenient and we shall retain it for this chapter, but first we draw some crucial distinctions. The gestures of concern to us are an integral component of language, not a substitute, accompaniment or ornament. Such gestures are synchronous and co-expressive with speech, not redundant, and not signs, salutes, or so-called emblems (see below). They are frequent—about 90% of spoken utterances in descriptive discourse are accompanied by them (Nobe 2000). They occur in similar form across many cultures

(we have observed speakers from more than 20, including 'high-gesture' cultures, such as Naples). The gestures so described were termed 'gesticulations' by Kendon (1988); other gestures in his terminology were 'language-like' and 'pantomime'—all contrasted to 'signs'. Arranged on a continuum, they can be organized as follows (McNeill 1992):

Spontaneous Gesticulation → Language-like → Pantomime → Emblems → Signs

The differences along The Gesture Continuum map onto three dimensions—how necessary speech is to the gesture; how language-like is the gesture; and how conventionalized is its form. These three perhaps can be reduced to an unnamed deeper dimension. Nonetheless, it is useful to see how points on the Continuum differ on the three. So as one goes from gesticulation to sign the relationship of gesture to speech changes:

- The obligatory presence of speech declines.
- Language-like properties increase.
- Socially regulated conventional signs replace self-generated form-meaning pairs.

Language-like gestures have a different timing relationship with speech from gesticulations. For example in, "he goes [-]," a gesture synchronizes with a momentary pause in speech; a vacant grammatical slot. Here gesture substitutes for speech. An emblem is a culturally established morpheme (or semi-morpheme, because it does not usually have combinatoric, 'syntagmatic' values), such as the "OK" sign and others. Emblems can occur with or without speech. Pantomime is gesture without speech, often in sequences and usually comprised of simulated actions. What distinguishes pantomime from gesticulation is that the latter, but not the former, is integrated with speech. Pantomime, if it relates to speaking at all, does so as a 'gap filler' (to use a phrase by Susan Duncan, pers. comm.). Speech-gesticulation combinations are cognitive constructions, and occur where speech and gesture are co-expressive of the same idea.[2] Sign languages are full, socially constituted, non-spoken languages.

Even though 'gesticulation' (hereafter, 'gesture') is only one point on the Continuum, it dominates gesture output in storytelling, living space descriptions, academic discourse (including prepared lectures) and conversations. Such gestures synchronize with speech at points where they and speech embody shared underlying meanings in discourse, possess "communicative dynamism" (Firbas 1971), and are points of maximal discursive force (McNeill & Duncan 2000). Commonly 99% if not all gestures in such contexts count as 'gesticulation'. An example from a student participant in one of our earliest experiments is shown in Figure 1.[3]

Gestures and Speech—Two Simultaneous Modes of Semiosis

Figure 1 illustrates synchronous co-expressive speech and a gesture recorded during a narration. The speaker had just watched a cartoon and was recounting it to a listener from memory. We explained that the task was storytelling and did not mention gesture (the same method was used with IW). The speaker was describing an event in which one

[2] Movement by itself offers no clue to whether a gesture is 'gesticulation' or 'pantomime'; what matters is whether the two modes of semiosis, linguistic form and gesture, simultaneously co-express one idea unit.

[3] Computer art from video by Fey Parrill, Ph.D. Except for Fig. 9, all illustrations are from McNeill (2005), *Gesture and Thought* (University of Chicago Press), and are used with permission.

character (Sylvester) attempted to reach another character (Tweety) by climbing up the inside of a drainpipe; a pipe conveniently topping out next to a window where Tweety was perched. The speaker said, "and he goes up thróugh the pipe this time." Co-expressively with "up" her hand rose and with "thróugh" her fingers spread outward to create an interior space. The upward movement and the opening of the hand were simultaneous and both synchronized precisely with "up thróugh," the linguistic package that carried the related meanings. The prosodic emphasis on "thróugh," highlighting interiority, is matched by the added complexity of the gesture, the spreading and upturning of the fingers. What we mean by co-expressivity here is this joint highlighting of the ideas of rising and interiority, plus their joint contribution to communicative dynamism.[4]

Fig. 1. Gesture combining entity, upward movement and interiority in one symbol.

However, also note the differences between the two types of semiosis. Speech componentializes the event: a directed path ("up") plus the idea of interiority ("thróugh"). This analytic segregation further requires that direction and interiority be concatenated, to obtain the composite meaning of the whole. In contrast, gesture is a synthesis. The whole emerges as one symbol. The semantic elements in speech are simultaneously aspects of this imagery whole. No concatenation is required. Meaning determination moves from whole to parts, not from parts to whole. The effect is a uniquely gestural way of packaging meaning—something like "rising hollowness." Thus, speech and gesture, co-expressive but non-redundant, represent one event (climbing up inside the pipe) in two forms: analytic/combinatoric and global/synthetic—at the same instant.

This kind of gesticulation is also our focus in the IW case. IW is unquestionably capable of combinations of unlike semiotic modes of these kinds in packaging meanings. It is important, however, to register a distinction within the gesticulation type introduced by IW himself. Some of his gestures, he says, are constructed: planned in advance, launched at will, and controlled in timing and motion throughout—carried out, in other words, exactly as he carries out his practical, world-related movements. His second type he calls 'throw-aways'—"ones that just happen. Sometimes I'll be aware of them because there may be something around me … but most are just thrown away." 'Throw-aways'

[4] More extensive accounts are in McNeill (1992) and McNeill (2005).

are not explicitly planned and monitored, and precisely for this reason are of great interest.

The binding of speech and gesture

A final point is the binding of gestures and speech when they participate in the formation of cognitive units, a binding so strong that efforts to separate them fail—either speech and gesture remain together or they are jointly interfered with; in either case the speech-gesture bond is unbroken. We expect the same to hold with IW's 'throw-away' gestures (his 'constructeds,' arising from deliberate planning, generally do not show the same binding with speech). The following are experimental examples of tight binding gleaned independently of IW from the gesture literature:

- Delayed auditory feedback—the experience of hearing your own voice played back after a short delay—produces major speech disturbances but does not interrupt speech-gesture synchrony (McNeill 1992).
- Stuttering and gesture are incompatible. The onset of a gesture inoculates against stuttering and, conversely, the onset of stuttering during a gesture interrupts it instantly (Mayberry & Jaques 2000).
- People blind from birth, who have never seen gestures and have no benefit from experiencing them in others, gesture and do so even to other blind people whom they know to be blind (Iverson & Goldin-Meadow 1997).
- Memory loss interrupts speech and gesture jointly; it is not that gesture is a 'gap-filler' when memory fails (McNeill 2005).
- Conversely, gestures protect memory from interference (Goldin-Meadow et al. 2001).

The speech-gesture units in these settings are held together by the requirements of idea unit formation: thought in speech takes place simultaneously in imagery and linguistic form; to think while speaking is to be active in both these modes at once. Speech and gesture are thus yoked, because both are essential to this distinctive form of cognition. For a recent statement of a 'growth point' hypothesis that explains this double essence of thinking while speaking, see McNeill et al. (2008). We return to the growth point at the end of this chapter.

IW's gestures

The BBC brought IW, Jonathan Cole and Shaun Gallagher to the University of Chicago for filming in July 1997. We wanted to record IW under a variety of conditions, both with and without vision. IW cannot be simply blindfolded, since he would be unable to orient himself and be at risk of falling over. We devised a tray-like blind, pictured in Figure 2, that could be pulled down in front of him, blocking vision of his hands, while allowing him space to move and preserving his visual contact with his surroundings.[5] IW was videotaped retelling the above-described animated cartoon. He also was recorded under the blind in casual conversation with Jonathan Cole. In 1997, we did not appreciate the importance of testing IW's instrumental actions without vision but we had

[5] Nobuhiro Furuyama suggested the blind experiment. The blind was designed and built by David Klein.

an opportunity to test his performance on this kind of task in April 2002, when IW and Cole came back for a second visit to the University of Chicago.[6]

Fig. 2. IW seated at the blind designed for gesture experiments.

Significant variables in assessing IW's gesture performance

To have a systematic approach to IW's gestures, we pay specific attention to the following variables:

Timing: synchronization with co-expressive speech.

Morphokinesis: the shape of the gesture in terms of hand forms and use of space.

Topokinesis: the location of hands relative to each other in space, including but not limited to the approach of one hand by the other.

Character viewpoint (CVPT): the perspective of the character being described; a gesture from the CVPT is close to mimicry.

Observer viewpoint (OVPT): the perspective of the narrator or an observer.

With vision, IW's gestures display all the above features (over a sample of gestures). Without vision, they show some but not all features: exact timing with speech, morphokinetic accuracy, and OVPT. Topokinetic accuracy and CVPT, however, become rare. The loss or reduction of these two particular features implies that his gestures without vision depart from the pathway of world-related action control (regarding CVPT as mimicry or action simulation). The preservation of speech-gesture synchrony implies that the system that remains is integrated with speech. The ensemble of preserved and lost features suggests a dedicated thought-language-hand link. This link will be discussed in more detail later in the chapter.

[6] The second round of experiments was supported by a grant from the Wellcome Trust to Jonathan Cole and by funds from Ian Waterman.

IW's gestures with and without vision (1997)

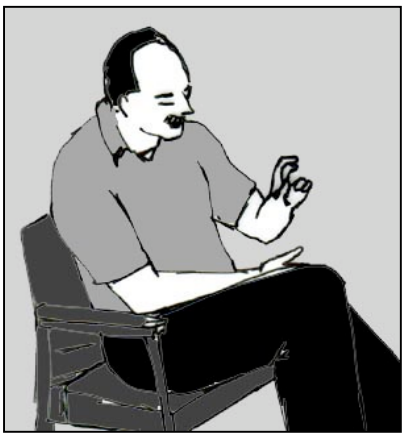


Fig. 3. IW iconic gesture with vision.

IW's gestures with vision are similar to those produced by normal speakers, although they are fewer in number and tend to be isolated, performed one by one, in keeping with his self-conscious constructed-gestures strategy. Figure 3 shows a narrative gesture made with vision. IW was describing Sylvester after he had swallowed a bowling ball that Tweety had dropped inside the pipe. Both morphokinesis and topokinesis are indistinguishable from normal. His hand appears to bracket a small figure in the central gesture space and move it downward, wobbling right and left slightly as it went down. The motion is co-expressive with the synchronous speech: [**//he // wiggles his way down**] (bold face indicates speech accompanying gesture). The only clue that control is other than normal is that IW looks at his hand during the gesture. The viewpoint in this case is that of an observer; elsewhere, in his full description of the bowling ball episode, the character viewpoint also occurs (OVPT and CVPT refer to the accompanying gestures, not the spoken forms):

OVPT: "tiny little bird" – left hand appears to outline bird (cf. Fig. 3)

CVPT: "bowling ball" – both hands appear to thrust down on ball

OVPT: "wiggles his way down" – left hand again outlines bird, wiggles

CVPT: "places it" – left hand appears to push down ball

OVPT: "gets a strike" – hands move laterally from center space

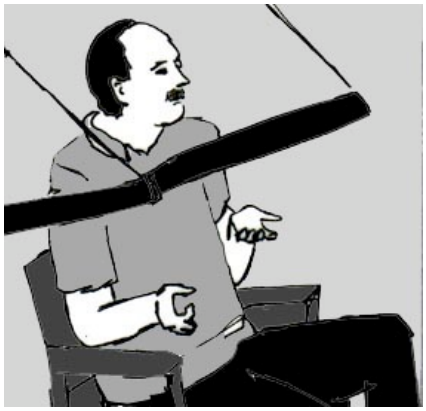


Fig. 4a, b. IW coordinated two-handed iconic gesture without vision.

Figure 4 illustrates a narrative gesture without vision, a coordinated two-handed tableau, in which the left hand is Sylvester and the right hand is a trolley pursuing him. IW was saying, "[and the $_{a}$tram $_{b}$**caught** him up]" (a, b referring to the first and second panels of the illustration). His right hand moved to the left in exact synchrony with the co-expressive "caught". Moreover, a poststroke hold extended the stroke image through "him" and "up" (underlining) and thus maintained full synchrony of the meaningful configuration in the stroke with still unfolding co-expressive speech. It is important to recall that this synchrony and co-expressivity were achieved without proprioceptive or spatial feedback. We thus see in IW, without any feedback, the double semiosis of synchronous gesture and speech.

Fig. 4 demonstrates another similarity of IW's 'throw-aways' to normal gestures. The gesture is complex, it uses two hands doing different things in relation to each other, the whole imagery depicting a situation in which the entities identified in speech are changing their relationships in time and space. Such complexity contributes to communicative dynamism; that is the case with Fig. 4—the event is the denouement of a buildup and the main discursive point.

Topokinetic versus morphokinetic accuracy

The gesture in Figure 4 was accurate morphokinetically but not topokinetically; as the right hand approached the left, the right and left hands did not line up. Figure 5 illustrates another case of topokinetic approximation. IW was describing "a square plank of wood" and sketched a square in the gesture space. The illustration captures the misalignment of his hands as he completed the top of the square and was about to move both hands downward for its sides.

Fig. 5. Lack of topokinetic accuracy without vision.

We also asked IW to sketch simple geometric shapes in the air without vision. Morphokinetically, a triangle and a circle were readily created but topokinetically there was always some disparity (Figures 6a-b show the end positions of a triangle and circle, respectively). For comparison, we also asked undergraduate students at the University of Chicago to sketch geometric figures without vision. Figure 7 is the end point of one such sketch of a triangle. Positioning is exact to the millimeter.

Fig. 6a, b. IW's misalignment as he outlines a triangle and circle without vision.

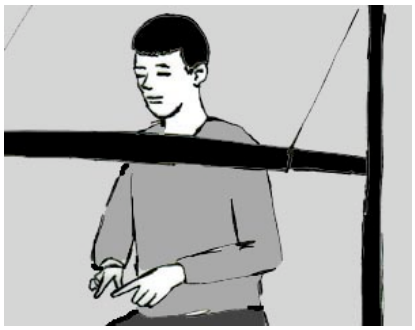


Fig. 7. Accurate completion of triangle by subject with intact proprioception and spatial sense without vision.

Instrumental actions

Similarly, instrumental actions denied vision are difficult for IW. Such actions require topokinetic accuracy. Figure 8 shows two steps in IW's attempt to remove the cap from a thermos bottle. The first is immediately after Jonathan Cole has placed the thermos in IW's right hand and placed his left hand on the cap (IW is strongly left handed); the second is a second later, when IW has begun to twist the cap off. As can be seen, his left hand has fallen off and is turning in midair. Similar disconnects without vision occurred during other instrumental actions (threading a cloth through a ring, hitting a toy xylophone, etc.—this last being of interest since IW could have made use of acoustic feedback or its absence to know when his hand had drifted off target, but still he could not perform the action).

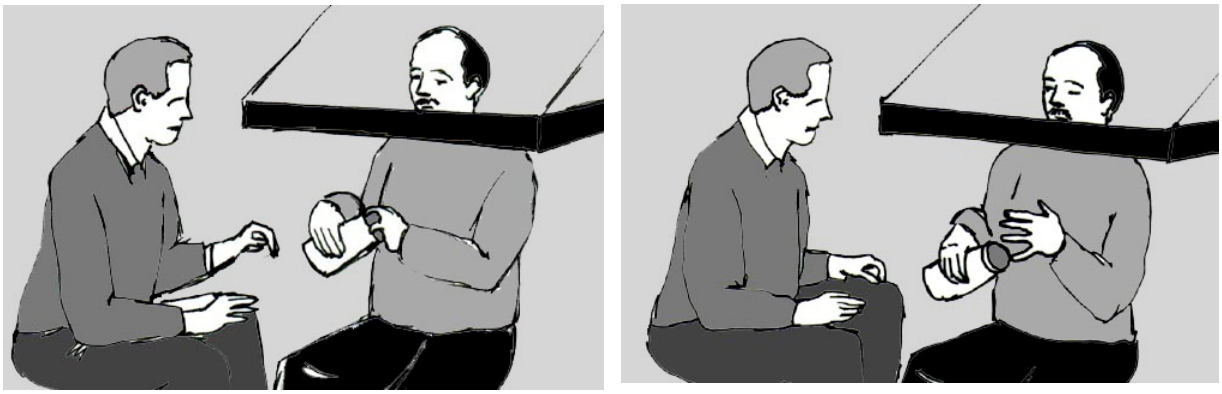


Fig. 8a, b. IW attempts to perform an instrumental action (removing cap from a thermos).

Significance of the IW results so far

The IW case shows that, without vision, gestures continue to occur with accuracy up to the morphokinetic level, and possess the tight binding at points of co-expression with speech that characterizes unaffected gestures—all this without feedback of any kind. An

important hypothesis is that a dedicated thought-language-hand brain link underlies combinations of semiotically unlike meaning packages that can be partially dissociated from the brain circuits involved in world-related actions. IW's use of space is especially informative. Although he has no exact sense of where his hands are, he can align them morphokinetically to create a 'triangle', because triangularity affords a direct mapping of a concept into space. Likewise, the meaning of "catching up to" is sufficient to guide the hands into a morphokinetic embodiment of this idea, without an intervening action, real or simulated (cf. discussion in Gallagher 2005).

The morphokinetic/topokinetic distinction also explains the near disappearance of CVPT without vision. Gestures like 'holding it' and 'places it', with CVPT, resemble Tweety's instrumental actions of holding the bowling ball and placing it. These CVPT gestures have meanings as simulated actions of a kind that require the level of control that, for IW, only visual guidance provides. Hence they become difficult when vision is absent.

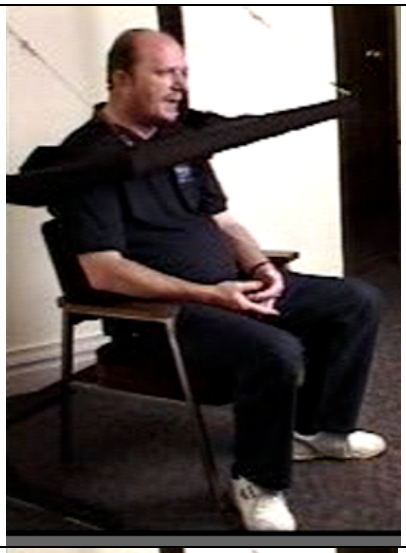
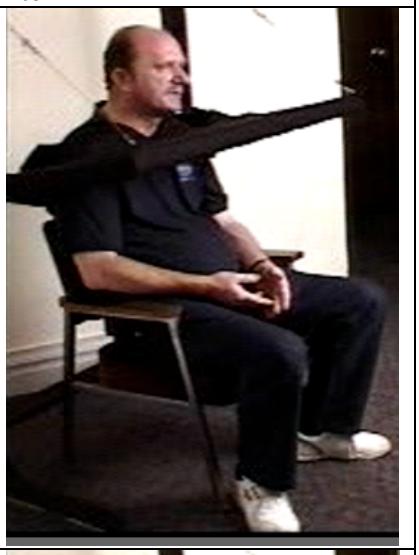
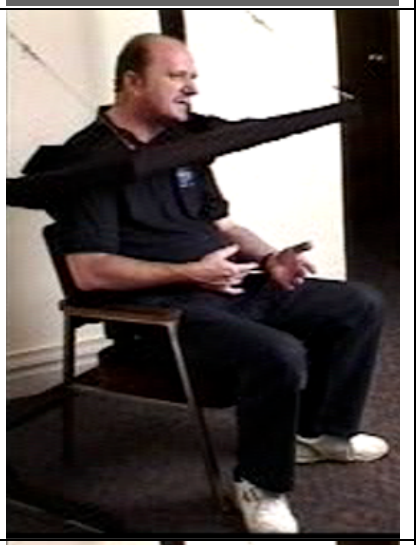
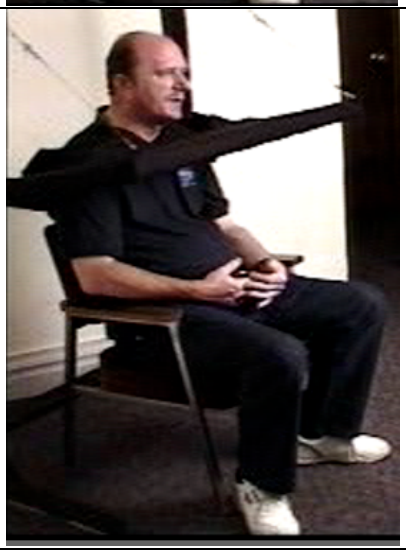
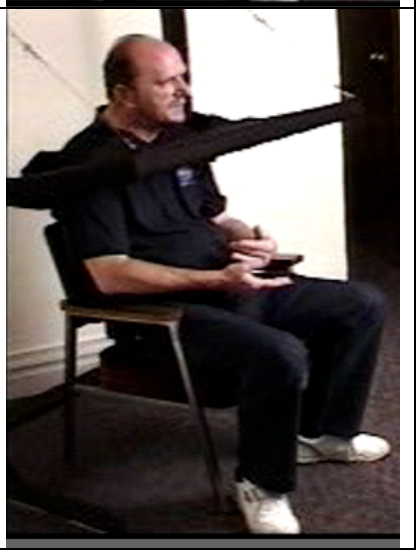
IW can control speech and gesture in tandem (1997)

A striking demonstration of the thought-language-hand link is that IW, without vision, can modulate the speed at which he presents meanings in both speech and gesture, and do this *in tandem*. As his speech slows, his gesture slows, too, and to the same extent, so that speech-gesture synchrony is exactly preserved. If what he is forming are cognitive units comprised of co-expressive speech and gesture imagery in synchrony, this joint modulation of speed is explicable. He does it based on his sense (which is available to him) of how long the joint imagery-linguistic cognitive unit remains 'alive'; peripheral sensory feedback need not be part of it. During a conversation with Jonathan Cole while still under the blind, IW reduced his speech rate at one point by about one-half (paralinguistic slowing), and speech and gesture remained in synchrony:

Normal: "and I'm startin' t'use m'hands now"
Slow: "because I'm startin' t'get into trying to explain things"

The gestures are of a familiar metaphoric type in which a process is depicted as a rotation in space (possibly derived from ancient mechanisms, perhaps millwheels or clockworks: metaphoric gestures often freeze-dry images that exist now only in this gesture form; cf. McNeill 1992 for other examples). IW executes the metaphor twice; first at normal speed, then at slow speed. The crucial observation is that the hand rotations are locked to the same landmarks in speech despite the different speeds. IW's hands rotate in phase at normal speed, opposite phase at slow speed. Nonetheless, if we look at where the hands orbit inward and outward we find that rotations at both speeds coincide with the same lexical words, where they exist, and with the same stress peaks throughout. Figure 9 shows the maximum inward and outward hand motions and the coincident speech.[7] Brackets indicate where linguistic content was identical at the two rates.

[7] The presentation of speech and gesture events in this figure, by adding an extra panel and selecting the limits of rotation in each panel, improves accuracy without changing the analysis from that in McNeill (2005). While the similarities of motion at the two speeds are compellingly obvious in the original video, we are confined here, of course, to still images that are, we acknowledge, not easily deciphered. But if you look at the images and relate them to the appended comments, you can see the force of the example.

Normal Speed (bracketed material=0.56 sec., 5 syllables) **"and [I'm startin' t'] use m'hands now"**		**Slow Speed** (bracketed material=0.76 sec., 5 syllables) **"-cuz [I'm startin' t'] get into"**
	and I'm ⇐ 'cuz I'm ⇒ hands move outward, then inward from the position shown.	
	startin' ⇐ startin' ⇒ hands again move outward, now starting to move out of phase.	
	t' use m- ⇐ t' get in- ⇒ At right, hands rotating out of phase, left hand rotates max in, right hand max out; corresponds to both hands max in at left, with hands rotating in phase.	

-y hands now
⇐

-to try(in')
⇒
Hands back in phase, both move outward.

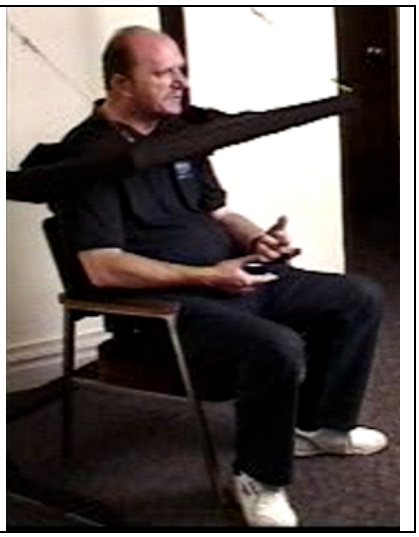


Fig. 9. IW changes rate of speech and gesture in tandem, maintaining synchrony. Note that motion of hands outward and inward occurs at same speech points.

This agreement across speeds shows that whatever controlled the slowdown, it was exactly the same for speech and gesture. Bennett Bertenthal (pers. comm.) points out a possible mechanism for this tandem reduction. Speech and gesture, slowing together, could reflect the operation of a pacesetter in the brain that survived IW's deafferentation; for example, the hand moves outward with a peak, an association that could be maintained over a range of speeds. The rotating hands were as noted metaphors for the idea of a process. The pacesetter accordingly could be activated by the thought-language-hand link and co-opted by a significance other than the action of rotation itself. This metaphoric significance is consistent with the timing, since the hands rotated only while IW was saying "I'm starting to…" and there was actually a cessation of gesture between the first (normal speed) and second (reduced speed) rotations as he said "and that's because", indicating that the rotation and any phonetic linkages it claimed were specifically organized around presenting the idea of a process as a rotation in space.

Summary of IW's gestures without vision

The following points summarize what we have seen of IW's gestures in the absence of visual, proprioceptive or spatial position feedback:

- Gestures have diminished CVPT.
- Gestures preserve morphokinetic accuracy and lose topokinetic accuracy.
- Gestures are co-expressive and synchronized with speech.

Phantom limb gestures

V. S. Ramachandran and S. Blakeslee in *Phantoms in the Brain* (1998) describe Mirabelle, a young woman born without arms. Yet she experiences phantom arms and performs 'gestures' with them—nonmoving gestures, but imagery in actional-visual form.

> Dr: "How do you know that you have phantom limbs?" M: "Well, because as I'm talking to you, they are gesticulating. They point to objects when I point to things."

> "When I walk, doctor, my phantom arms don't swing like normal arms, like your arms. They stay frozen on the side like this" (her stumps hanging straight down). "But when I talk, my phantoms gesticulate. In fact, they're moving now as I speak." Ramachandran & Blakeslee (1998, 41)

Mirabelle's case points to a similar conclusion as IW's—dissociation of gesture from practical actions. In Mirabelle's case, moreover, intentions create the sensation of gestures when no motion is possible. Presumably, again, the same thought-language-hand link is responsible.

Overall significance of the IW case

The IW case suggests that control of the hands and the relevant motorneurons is possible directly from the thought-linguistic system. Without vision, IW's dissociation of gesture, which remains intact, and instrumental action, which is impaired, implies that the "know-how" of gesture is not the same as the "know-how" of instrumental movement (using Shaun Gallagher's terms). In terms of brain function, this implies that producing a gesture cannot be accounted for entirely with the circuits for instrumental actions; at some point the gesture enters a circuit of its own and there is tied to speech. A likely locus of this dedicated thought-language-hand link in the brain areas 44 and 45: Broca's area. The earlier mentioned paper by McNeill et al. (2008) presents a theory of how this link could have been selected evolutionarily in this brain area (called the 'Mead's Loop' model in the paper).

Conclusion: Growth points, material carriers, and inhabitance

To conclude this chapter we describe the *growth point* (GP) hypothesis mentioned briefly earlier; Vygotsky's concept of a *material carrier* (in Rieber & Carton 1987); relate these to the concept of *inhabitance* from Merleau-Ponty (1962) while elaborating somewhat on the phenomenology of gesture; and explain the interconnections among all three concepts as they apply to the IW case.

The growth point

It is beyond doubt that IW, at least in his 'throw-aways', is creating what we term growth points. GPs organize speech and thought. A GP is an irreducible, 'minimal unit'[8] of imagery-language code combination. It is the smallest packet of an idea unit encompassing the *unlike* semiotic modes of imagery and linguistic encoding that we observe when speech and gesture coincide at points of co-expressiveness. A GP is empirically recoverable, inferred from speech-gesture synchrony and co-expressiveness. It is inferred (not 'operationally defined') from a) gesture form, b) coincident linguistic segment(s), c) co-expression of the same idea unit, and d) what Vygotsky (1987, p. 243) termed a 'psychological predicate'—the point of newsworthy content that is being differentiated from the immediate context of speaking (of which, more below).

The temporal and semantic synchronies represented in Fig. 1 and shown dramatically by IW when he reduced speed in speech and gesture in tandem, imply a GP in which imagery and linguistic information are jointly present, so that one does not occur without

[8] The concept of a 'minimal unit' with the property of being a whole is from Vygotsky (1987, pp. 4-5).

the other. In Fig. 1 we infer the simultaneous presence of the idea of ascent inside the pipe in the two unlike semiotic modes. Even when the information ('semantic content') in speech and gesture is similar, it is formed according to contrasting semiotic modes.

The GP is so named because it is a distillation of a growth process—an ontogenetic-like process but vastly sped up and made functional in online thinking-for-speaking. According to this framework, it is the initial unit of thinking-for-speaking (Slobin, 1987) out of which a dynamic process of utterance-level and discourse-level organization emerges. Imagery and spoken form are mutually influencing. It is not that imagery is the input to spoken form or spoken form is the input to imagery. The GP is fundamentally both.

The existence of simultaneous unlike modes creates instability; an idea in two contending forms at once. This instability nonetheless is an essential part of the GP and its role in speaking and thought—it drives thinking-for-speaking to seek resolution (McNeill & Duncan, 2000).[9] Stability comes from 'unpacking' the growth point into grammatical structures (or viable approximations thereto) with usually further meanings actualized. A surface linguistic form emerges that cradles the GP in stable and compatible form. This role of grammar—unpacking and supplying 'stop-orders' for the changes initiated by imagery-linguistic code instability—is an important clue for how speech in discourse is produced (see McNeill 2005 for detailed discussion).[10] In Fig. 1, the locution "up thróugh" is analytic: up-ness and interiority are separated. The words also have syntagmatic values acquired from combinations within and beyond the phrase. The gestural image embodies the same information in the form of 'Sylvester as a rising hollowness' but without analysis or combinatoric value. Unpacking resolves the tension by placing both components, linguistic and gestural, into a finished syntactic package that does not violate the image, realizes the syntagmatic potential of the linguistic side, and includes the production of further content ("he goes up through it this time," including the metanarrative indexical, "this time," that relates the event being described to a previous one).

A final point is that we can fully understand what motivates any image-speech combination only with reference to how a GP relates to its context of occurrence. The GP-to-context relationship is mutually constitutive. The GP is a 'psychological predicate'—the point of differentiation from this context. The speaker so represents the context that this differentiation becomes possible. A robust phenomenon concerning gesture is that the form and timing of gestures select just those features that differentiate the psychological predicate in a context that is at least partly the speaker's own creation (see McNeill, 2005, pp. 108-112).

We observe all these hallmarks of GPs, including this correlation, in IW's speech and gesture. The "caught him up" gesture, for example, was a psychological predicate that

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[9] The reasons why semiotic opposition creates instability and initiates change include:

a) *conflict* (between semiotic modes: analog imagery/analytic categorical), and

b) *resolution* (through change: fueling thinking-for-speaking, seeking stability).

Simultaneous semiotic modes comprise an inherently dynamic psycholinguistic model.

[10] When gesture and speech synchronize, as in Fig. 1 and Fig. 4a-b, the two modes are in direct contact. If there is less than perfect synchrony, the 'double essence' of the same meaning in unlike semiotic modes can still stimulate unpacking. The ultimate criterion is whether an idea is embodied in two modes (with or without different aspects of the idea) that creates instability.

embodied newsworthy content in a context from the preceding narrative discourse of Sylvester on overhead wires running to escape a pursuing trolley. The gesture depicted the pursuit and overtaking by the trolley and was exactly synchronous with the linguistic segments "caught him up." The GP as inferred is this combination of semiotic modes for the idea of Sylvester being overtaken. The unpacking into "and the tram caught him up" settles it into a stable syntactic package (the next element in IW's tale describes how he was then shocked—another GP with its instability to be followed by stability through unpacking).

Material carriers

We get a deeper understanding of such an imagery-language dialectic by introducing the concept of a 'material carrier'. The concept clarifies reasons why IW, despite his careful attention to movement up to and including the construction of some gestures, yet performs, without meaning to, unattended 'throw-aways'. A material carrier—the phrase was used by Vygotsky (1987)[11]—is the embodiment of meaning in a concrete enactment or material experience.[12] A material carrier appears to enhance the symbolization's representational power. The concept implies that the gesture, *the actual motion of the gesture itself*, is a dimension of meaning. Enhancement is possible if the gesture *is* the very image; not an 'expression' or 'representation' of it, but *is* it. From this viewpoint, a gesture is an image in its most developed—that is, most materially, naturally embodied—form. The absence of a gesture is the converse, an image in its least material form.[13] We describe here a theoretical model of how materialization has this effect on representational power, and when gestures do and do not occur with speech (cf. Goldin-Meadow 2003). A striking illustration of the material carrier is what Cornelia Müller (2008) terms the 'waking' of 'sleeping metaphors'—new life given to inactive metaphors, in which gesture brings back to awareness a metaphor's original source. Müller gives an example of a German metaphor ("gefunkt", 'sparked', the equivalent to English 'clicked', for suddenly falling in love). The expression is usually hackneyed and not apprehended as a metaphor. However, it can be awakened by a gesture. A speaker,

[11] Pointed out by Elena Levy. The quote (recovered thanks to Tae Kunisawa) is: "That which is specific to this particular form of sound has remained unexplored. As a consequence, this research has not been able to explain why sound possessing certain physical and mental characteristics is present in human speech or how it functions as a component of speech. In a similar manner, the study of meaning has been defined as the study of the concept, of the concept existing and developing in complete isolation from its material carrier. To a large extent, the failure of classic semantics and phonetics has been a direct result of this tendency to divorce meaning from sound, of this decomposition of the word into its separate elements." (in Rieber & Carton, 1987, p. 46).

[12] As suggested by the semantic satiation phenomenon (Severance & Washburn 1907, recovered thanks to Fey Parrill): staring at TREE, say, soon disrupts the word. It ceases to be a meaningful symbol and its actual material form seems to change perceptually. A 'satiation effect' for gestures would be equally interesting to document. Trying such an experiment, David McNeill deliberately repeated a gesture that seems typical of him (a gesture for the concept of a growth point no less; see Parrill 2007), and almost immediately experienced a shift from significant symbol to mere hand rotation for the movement. If vulnerability to semantic satiation indicates the strength of the material carrier in a symbol, this gesture is strong indeed.

[13] The material carrier concept thus helps explain why sometimes there is no gesture. Of course, gestures may be suppressed in certain fraught situations, but if gestures are occurring in general, then when no gesture occurs we see the *lowest level of materialization*.

describing her first love, said "between us somehow it sparked ['clicked']" (Müller's translation). As she said "between us" her hand rose upward next to her face in a ring shape but with an unusual orientation—the fingers pointing at her own face; then, as she uttered the metaphor itself, "gefunkt", her hand abruptly turned outward—her gesture materializing the 'dead' metaphor as a sudden event, an electrical spark.[14]

IW shows the reality of materialization in yet another form. At one point in the 2002 experiment Jonathan Cole demonstrated, as IW watched, an object-directed transitive action (removing the cap from the thermos); IW then imitated the action. While he could not perform the action himself without vision (Fig. 8), we were interested in seeing if he could imitate it under conditions where topokinetic accuracy was not a factor, and indeed he could. But what was unexpected is that IW spontaneously spoke as he imitated the cap removal (he described his movements as he performed them). This was a fully spontaneous and unanticipated performance, not something we suggested, even though, of course, a spontaneous sprouting of speech is what the GP hypothesis implies—the two forms of materialization co-occurring.

The inverse experiment happened equally accidentally in a separate study of IW by Bennett Bertenthal (pers. comm.). Here, too, imitation was the task (he was shown a video, without sound, of other people's gestures and asked to imitate them). As before, IW spontaneously began to speak. The experimental assistant asked him to not speak, as that was not part of the experimental protocol. IW complied and—the important observation for material carrier purposes—his imitations immediately *simplified and shrank dramatically in size*. Whereas, with speech, they had been large, complex and executed in the space in front of his body (he was not under the blind), without it they were simple, miniaturized and confined to the space at his lap. This was so even though imitation of other people's gestures was his target and he had vision of his hands.

These effects are impressive indications that two materializations, speech and gesture, co-occur, support and feed one another, and that when one goes awry or missing the other tends to follow.

Phenomenology and the scientific study of gesture

The entire conception of speech and gesture is moved to a new level when we draw on the work of Maurice Merleau-Ponty for insight into the thought-language-hand link and the temporal alignment of speech, gesture and significance into GPs. First, however, we have to elucidate the situation of present-day gesture studies with respect to the notoriously difficult relationship between phenomenology and (cognitive) science. Merleau-Ponty for one makes a specific distinction between his philosophy of embodiment and the empirical-scientific approach to the role of the body in language use and cognition in general.

Empirical conceptions tend to focus on the body-as-object and describe embodied language use in terms of its objective features, such as the speech sounds uttered, the

[14] Müller views the metaphor dynamically, as a *process* by which the speaker and her listener generate metaphoricity in the context of the speech event; clearly a conception germane to the position of this book. The activation of the metaphor, and the semiotic impact of the sparking image, is a variable, dependent upon the speaker's thought processes and the context of speaking. The gesture, as a material carrier, is an active component of this process.

specific gestures which were made or found patterns of neurological activity. In a two or more step process, the speaker —or rather her cognitive system —embodies some pre-existing meaning (a 'thought') through the realization of complex combinations of different kinds of material carriers (such as the verbal, the manual, the facial and the postural modality), and thus linguistic meaning is 'externalized'. In this approach, the body in language use functions as a machine that can talk, a machine that can 'translate' a private and disclosed thought into the conventionalized medium of material carriers. This kind of mechanistic communicative theory naturally follows from a framework that describes the linguistic event solely from a third-person point of view. The empirical scientist takes a neutral stance vis-à-vis the object of her investigation, i.e. people involved in a conversation *over there*, and she relies on inference in order to discover what goes on when people talk.

Merleau-Ponty on the other hand, being a member of the phenomenological tradition, stresses the importance of acknowledging first-person experience (a description of the body-as-subject) whenever the issue of meaning (perceptive as well as linguistic) is concerned. From this perspective, we do not have the sensation that the speaker's expressive body *mediates* between her thoughts and the listener's cognitive capacities, but on the contrary, we experience that we have a *direct access* to each other's intentions. Embodied meaning makes immediate sense from the perspective of the speaker and the listener. In fact, in this account, meaning coming into existence, its bodily expression and, in a sense, even meaning reception, are *one and the same thing and happen in one and the same instance*. In contrast with empirical conceptions, here the speaking subject (a 'first person') does not *provide* her thoughts with a material carrier, nor does the listening subject *infer* meaning from her objective perception of someone's expressive bodily movements. Phenomenological embodiment of linguistic meaning is fundamental, it is an a priori fact: the mental (a 'thought', or 'intentional content') and the physiological (its material carrier) are co-emergent (in Heidegger's terms they are 'equiprimordial'). The emergence of meaning and its bodily expression therefore can be said to constitute two aspects of one and the same phenomenon, viz. the speaker's bodily existence in a world which she makes part of and hence to which she is fully attuned. In the next paragraphs we will discuss some implications of this phenomenological framework for any theoretical account of gesture in general and for the case of IW in specific.

With regard to these theoretical antipoles, the empirical-scientific third-person perspective and the phenomenological first-person perspective, where should we locate an approach to gesture that propounds a thought-language-hand link to account for the synchronization of what Duncan (2006) has called the 'three rhythmic pulses': speech, gesture and significance? Lived experience, despite its importance for the understanding of multimodal co-expressivity, by definition cannot be exhaustively described from an objective point of view, but taking a third-person stance is exactly one of the defining traits of the scientific métier —and also that of a science of gesture. Language use necessarily precedes doing linguistics and the unmediated way in which the speaker and her listener grasp the integrated communicative event can, after the fact, never be paralleled by listing the objective features of that event. Only the linguistic subject, because of her non-scientific but actively engaged stance and her ability to grasp a situation *all at once*, can understand the true nature of meaning. The thought-language-

hand link, with its power of co-expressiveness, is a suitable way of scientifically approaching this '*all at once-ness*', which exclusively objective descriptions of the role of the body in language use traditionally have difficulties to grasp[15]. Because the thought-language-hand link by definition both distinguishes and equates the three pulses, thus fulfilling both scientific and phenomenological aspirations, it enables us to operationalize the abstract, philosophical concept of the body-as-subject by being capable of inspiring empirical, experimental research.

For a first investigation into the philosophical significance of gesture, we may turn to Merleau-Ponty's *Phenomenology of Perception* (1962) to give us insight into the duality of gesture and language and the ontological status of the GP —its multifaceted cognitive or perceptive way of being. Gesture, the instantaneous, global, nonconventional component, is "not an external accompaniment" of speech, which is the sequential, analytic, combinatoric component; it is not a "representation" of meaning, but instead meaning "inhabits" it:

> "The link between the word and its living meaning is not an external accompaniment to intellectual processes, the meaning inhabits the word, and language 'is not an external accompaniment to intellectual processes'.[16] We are therefore led to recognize a gestural or existential significance to speech…. Language certainly has inner content, but this is not self-subsistent and self-conscious thought. What then does language express, if it does not express thoughts? It presents or rather it *is* the subject's taking up of a position in the world of his meanings" (p. 193; emphasis in the original).[17]

The GP is a mechanism geared to this "existential content" of speech—this "taking up a position in the world". Gesture, as part of the GP, is inhabited by the same "living meaning" that inhabits the word (and beyond, the discourse). A deeper answer to the query, therefore—when we see a gesture, what are we seeing?—is that we see part of the speaker's current cognitive being, her very mental existence, at the moment it occurs. This applies equally to all speakers, IW included. By performing the gesture, a core idea is brought into concrete existence and becomes part of the speaker's own cognitive bodily existence at that moment.

Following Heidegger's removal of the modernist oppositions between subject and object, language and outside world, Merleau-Ponty's account states that a gesture is not a representation, or is not only such: it is a form of being. Gestures (and words, etc., as well) are themselves thinking in one of its many forms—not only expressions of thought, *but thought, i.e., cognitive being, itself*. To the speaker, gesture and speech are not only 'messages' or communications, but are a way of cognitively existing, of cognitively being, at the moment of speaking.

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[15] Most empirical-scientific conceptions —at least implicitly —infer that because (and after the fact of speaking itself) a communicative event can be divided up into different aspects by the linguistic scientist, a cognitive system necessarily also must process these aspects one by one (and therefore consecutively) before finding ways of integrating them into a coherent interpretation.

[16] Merleau-Ponty's quotation is from Gelb and Goldstein (1925, p. 158).

[17] We are indebted to Jan Arnold for this quotation.

The speaker who creates a gesture of Sylvester rising up fused with the pipe's hollowness is, according to this interpretation, embodying thought in gesture, and this action—thought in action—was part of the person's being cognitively at that moment. Likewise the woman who gestured a sudden transformation with "gefunkt" and IW in his rotating metaphor of the 'getting into' process that he was undergoing. To make a gesture, from this perspective, is to bring thought into existence on a concrete plane, just as writing out a word can have a similar effect. The greater the felt departure of the thought from the immediate context, the more likely is its materialization in a gesture, because of this contribution to being. Thus, gestures are more or less elaborated depending on the importance of material realization to the existence of the thought. We observe the same elaboration of gesture in proportion to the importance of materialization in IW as well, and this is the final step of demonstrating the utter normality of his gestures of the 'throw-away' type.

Our second phenomenological excursion into the nature of speech and gesture concerns the notion of 'co-expressive non-redundancy', which was used to signify the convergence of two different modes of semiosis, the analytic/combinatoric verbal mode and the global/synthetic gestural mode, to represent one event (Sylvester climbing up inside the pipe) at the same time. An investigation of the concept of 'co-expressiveness' will shed light on how to interpret its non-redundancy.

How is speech-gesture synchrony attained? Because the use of language and gesture *is* the speaker's taking up of a position in the world, *is* the speaker's way of cognitively being, the perfect synchrony of the different aspects of the speaker's expressive bodily behavior becomes self-evident[18]. As scientists we notice how well speech and gesture are attuned and how they break down together, but this is because we, as heirs to the modernist ideal of universal doubt, implicitly *first* take both linguistic modes as belonging to a different system, as having a life of their own, and *then* wonder how synchrony might be attained. In a framework, however, which takes cognitive being and the bodily expression of linguistic meaning to be one and the same, co-expressiveness becomes equal to bodily expressiveness in general. As we said, embodiment in the phenomenological sense is an a priori fact, and from this naturally follows that co-expressiveness of speech and gesture is a necessary given. Linguistic multimodality is the origin of meaning itself, and therefore the different modes are co-expressive.

What does this tell us about the 'non-redundancy' of the co-expressiveness? The very appearance of the concept of 'redundancy' in a discussion of linguistic multimodality belongs to a minimalistic framework in which the verbal is seen as the fundamental carrier of linguistic meaning and gesture as an additional mode (an "external accompaniment" of speech). When we ask the question "Why do we gesture?" we picture a still body which in the first place is capable of verbally expressing itself and which, in a linguistic event, may opt for the adding of gesture. Instead, if we take our active embodied existence as a given, we could also ask the question "Why wouldn't we gesture?" and picture a body engaged in the world, for which it is only natural to use its full capacities of expression. In this sense, what was 'redundant' not only becomes 'non-

[18] This is Gallagher's point with respect to IW when he states that the timing of his gestures vis-à-vis his speech acts remains intact because "[t]he co-expressiveness of the two modes (gesture and speech) contribute to their synchronization." (2005:113)

redundant', but even 'obligatory': using *all of your body* to convey linguistic meaning is standard practice[19]. Susan Goldin-Meadow (1999) has found that use of gesture reduces cognitive burden on the part of the hearer as well as on the part of the speaker, and as such a combination of speech and gesture makes the intended meaning more easily understandable (instead of soliciting the heightened cognitive activity which we would expect from an increase of contextual information). Our phenomenological framework can easily accommodate these findings because if we describe linguistic action in terms of a speaking subject making a contribution to being, using *more* co-expressive modalities will bring *more* of the same meaning about and for a listener it will be harder not to get what is expressed, as all bodily signs point into the same semiotic direction.

To end this section we will apply phenomenological philosophy to understand better the distinction between IW's 'throw-aways' and his 'constructeds'. Recall that his constructeds were fewer in number, were isolated, performed one by one and in a self-conscious manner. On the other hand, he produces his throw-aways with ease, though with some topokinetic problems. In a sense, by making this distinction, IW summarizes the whole point about the impossibility for third-person empirical-scientific approaches to fully capture the nature of gesture and for first-person phenomenological approaches to say anything objectively valid about gesture. When IW is unaware of his perfectly synchronized gesturing (when he is producing what he calls 'throw-aways'), he is immersed into the first-person point of view and he uses his whole body to convey his intentions. He bodily expresses his cognitive being at that time. However, when he is constructing his constructeds, he takes the third-person stance of the scientist who knows gesture from experience, but is unable to fully reconstruct it from a neutral point of view. He consciously divides his utterances and hand movements up by objectifying their features and then tries to attain synchrony. His cognitive being at that time (trying to control his hand moves) clashes with what he is trying to express with his hands (whatever the conversation is about). Co-expressiveness breaks down —and so does synchrony.

To sum up

To sum up this chapter we can ask: does IW show growth points; do his gestures act as material carriers; and do his meanings, in Merleau-Pontian fashion, inhabit them? IW's own distinction between 'constructed' and 'throw-away' gestures is critical at this point. His 'throw-aways' are indistinguishable from the gestures of unaffected speakers. That is, they comprise growth points with simultaneously encoded co-expressive linguistic content, to jointly differentiate what is newsworthy in context; offer the

[19] As this is a chapter on IW and gesture, we have focused on the manual modality. However, Merleau-Ponty's use of the term '*la geste*' cannot be unequivocally translated into 'gesture'. *La geste* refers to any aspect of the body deployed to convey meaning. But of course, because Merleau-Ponty's phenomenology of language is one about bodily expression in general, anything said there holds for the manual modality too. Historically, manual gestures have been the principal focus of observation (there may be evolutionary reasons to expect the hands to be primary) but studies, especially recent ones, have included the head (McClave, et al. 2008), gaze (McNeill, et al. in press) and vocal gestures (Okrent, 2002) within a single framework of semiosis. These can be powerfully unified with the conception that linguistic meaning is obligatorily conveyed with all the body in unison (and that it is the suppression of elements that is exceptional).

benefits of material carrierhood; and are inhabited by positions in his world of meanings. IW's very lack of awareness of them suggests this status. Unawareness is to be expected of positions in the world of meanings, and in this respect gestures are no different from most spoken words, of which, qua words, we are also usually unaware as we use them. The occurrence of this complex of processes in IW, despite deafferentation and his reworking of motion and control, suggests the existence of a thought-language-hand link in the human brain, the inheritance of us all, that survived his neuronpathy.

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