14

Gestural imagery and cohesion in normal and impaired discourse

Susan Duncan

14.1 Introduction

Language production makes use of speakers' abilities to shape, direct, and locate their hands and bodies in space and in relation to interlocutors and to objects in the environment (Goldin-Meadow 2003; Kendon 2004; McNeill 1992, 2005; Streeck, unpublished). According to McNeill and Duncan (2000), these abilities support formation of "material carriers" of linguistic conceptualizations in situated language use. This amounts to a claim that aspects of linguistic communication are borne by parts of the body other than the speech articulators; in other words, communication is embodied. Such a claim is in line with recent work, for example by Glenberg and colleagues (Glenberg and Kaschak 2002), that rejects theories of language production and comprehension which hold these processes to have the character of "amodal symbol manipulation". We return to this issue in the Discussion. The natural language data presented here suggest an influence of spontaneous coverbal gestures on moment-to-moment spoken expressions.

The analyses of speech and coverbal gestures presented in this chapter draw on videotaped stories told by healthy individuals and by individuals with Parkinson's Disease (PD), a neurological disorder with a variety of debilitating effects on motor behaviors and cognition (see below). Bodily movements of all kinds, including coverbal gesture, may be impaired as the disease progresses.

Unrehearsed storytelling performances of both speaker groups are examined and compared for evidence that coverbal gestures may function as embodied representations of meaning that help build and maintain cohesive storylines. Evidence that gestures may have this function, generally, appears in the form of occasional speech errors of a type and in proportions not predicted by psycholinguistic models of language production such as Levelt's *et al.* (1999). These are speech errors of substitution that will be described in detail below. The main focus is on instances when a storyteller momentarily substitutes the name of one character in his or her story for that of another. Close examinations of the speech–gesture combinations that storytellers produce, leading up to these errors, suggest the following. When particular gesture features (for example, a gesture's location in a certain area in front of a storyteller) repeatedly co-occur with spoken references to a particular story character, a stable association is built up between the gesture feature and the spoken references to the character. We observe that speech errors of

substitution tend to occur when storytellers, for a variety of reasons, must alter their use of the gesture feature that has heretofore been stably associated with references to the character. At the moment of shift, a substitution error can occur.

The observations we report, draw on linguistic descriptive analysis of videotaped stories. The observations permit us to formulate a hypothesis concerning gestures' impact on moment-to-moment speech production. In the Discussion, we sketch a possible experimental approach to testing the hypothesis. The hypothesis is that gestures ("visuo-spatio-motoric representations") can function as a kind of motor memory that builds over extended intervals of storytelling (narrative discourse) and can trigger choice of referring form or lexical access. The descriptive analysis of the "natural histories" of the gestures that seem to have a role in triggering speech errors, provided below, are discussed in connection with the proposal that language use is an embodied cognitive process.

The task of telling a complex story from memory can be psychologically demanding. This is particularly true if the story involves several characters, locations, and activities, all interconnected in an overarching storyline. Psycholinguistic research based on analysis of the spontaneous gestures that occur with unrehearsed speech has shown that gestures pattern in relation to the overarching storyline of a narration in a variety of ways. For example, each time a storyteller mentions a character, object, or location, the mention has the "information status" either of being "new" (never mentioned before) or "given" (already an established part of the story). Gesture forms, and the likelihood of gesture occurrence, pattern in relation to this given/new information status of mentioned referents. Introduction of new referents in speech is typically accompanied by elaborate, feature-rich gestures. Subsequent mentions of the same referents (now given information) may be accompanied by relatively simplified gesture forms, or by no gestures (Levy and McNeill 1992; McNeill and Levy 1993).

Further, cognitive psychological research shows that in other types of tasks, such as explaining how one solved a math problem, gestures function to reduce "cognitive load" (Goldin-Meadow *et al.* 2001). The finding is that, when speakers gesture while explaining their solutions, they perform better on later tests of recall of information from a secondary task, indicating that their coverbal gesturing functioned to free up working memory capacity (or to reduce "cognitive load"), making this memory capacity available for the secondary task. The latter evidence suggests that gesture may function as a kind of memory store when people speak and as such could play a cognitive role in phenomena such as maintenance of discourse reference and maintenance of a cohesive storyline. This is in addition to gesture's role of enhancing the salience of these aspects of a speaker's story for intended recipients. Here we will examine evidence that suggests that gestures, as "visuo-spatio-motoric representations" active during language use, function as physical, perseverating embodiments of discourse entities and themes. The goal of this paper is to present a small sample of descriptive linguistic data containing speech errors of substitution. These data elucidate this possible cognitive role of gestures in the production of extended natural discourse and we formulate a hypothesis about this gesture function that is amenable to further empirical evaluation.

We observe what we will refer to here as "spatialized gestural indexing" (or lack of such indexing) of referents in the discourse leading up to such speech errors. Analysis of these "spatial frames of reference" (see below) established by gestures shows that the target errors of substitution tend to occur in intervals during which the speaker is shifting between frames of reference or in intervals prior to the establishment of a consistent frame of spatial indexing. We trace the discourse "natural history" of each of a sample of speech errors of substitution, examining the extended discourse contexts in which the errors arise, for clues to what triggered them.

The excerpts containing such errors of reference are drawn from corpora of stories, told without rehearsal, to listeners who actively engage in the interaction. The stories were elicited from speakers of two kinds: (i) healthy adults with no known neurological impairment that would affect language production or cognition; and (ii) individuals with PD, a progressive neurological disorder with debilitating effects on motor function (Fahn 2003), cognition (Gabrieli *et al.* 1996; Stebbins *et al.* 1999; Locascio *et al.* 2003), and speech–language abilities (McDonald 1993; Ramig 1996; Lewis *et al.* 1998; Murdoch 2001). The impact of PD on gesture in language is currently a topic of some study (e.g. Duncan 2002). Theories of language that hold imagery—realized as manual and bodily motoric representations—to be intrinisic to language use may be informed by study of the effect of motor (gestural) dysfunction on language performance. For example, to the extent that gestural establishment of spatialized frames of reference during storytelling cognitively assists healthy speakers in maintaining a cohesive, coherent storyline, then we would expect that speakers with PD, whose gesturing is either severely reduced or whose manual and arm movements are not agile and responsive, to tell more fragmentary stories and have more errors of reference than healthy individuals. Of particular interest, given the examples of PD discourse data examined below, is the tendency in some individuals with PD to produce perseverative motoric behaviors; for example, in production of speech sounds. The potential for atypical perseveration of gestural movements or gestural holds during language production makes it possible that some speakers with PD could show a tendency to occasionally have difficulty relinquishing particular gestural images while proceeding along a story line. Such aspects of motor dysfunction in PD point to the relevance for our understanding of the role of gestures in language production and for the topic of embodied communication of data from individuals with this neuromotor disorder.

The explication of the particular errors of substitution that we examine in the excerpts below suggests that their source is either: (i) incompatibility between competing spatial schemas, in accord with which discourse referents (e.g. characters, objects, locations) are gesturally represented and a cohesive storyline is maintained in the ongoing storytelling activity; or (ii) inadequate establishment of such spatial schemas in the first place. If this suggestion concerning the origins of the type of speech errors we analyze here is tenable, then our findings challenge models of language production that lack the means to specify a causal role for gestural representations in lexical access (Levelt 1989; Levelt *et al.* 1999). This challenge will be addressed in the Discussion.

14.2 General notes on spatial organization of narrative discourse

The narrative discourses this exposition concerns are stories, told from memory, of a 6.5-minute, action-packed cartoon about a cat and a bird (Warner Bros., *Canary Row*, 1950; see also Sowa *et al.*, this volume). The cat attempts several times to catch the bird, using various strategies and disguises, but fails every time. Relevant for our examination of narrative use of space, in the cartoon the storytellers describe, the cat is most often located on the right side of the viewing screen, the bird most often on the left, and the cat typically moves from right to left across the screen in pursuit of the bird.

Two people participate in each storytelling elicitation. One watches the cartoon and then both participants are videotaped as the one tells the story of the cartoon to the other. (See McNeill 1992 for further details about the cartoon narration elicitation technique.) Listener participants are encouraged to be active, engaged listeners so that, after they have heard their partners tell the story, they will be able to re-tell it to another listener. Narrations typically are 5 to 8 minutes long. Those produced by neurologically healthy individuals typically are accompanied by a lot of spontaneous gesture. The narrations produced by individuals with PD often, but not always, have a comparatively lower amount of coverbal gesturing.

The gesturing that occurs with narrative discourse is a heterogenous domain of behavior. Gestures certainly serve multiple functions and pattern in a variety of ways in relation to co-occurring speech, to speaker mentation, and to the social–interactional context and environmental context. The patterning in gesture that we will focus on is the speakers' use of space; specifically, what may be referred to as "spatial axes of discourse". Several axes may be identified in the speakers' gesture spaces. Over the course of a narration, speakers typically index multiple axes by manually, or otherwise bodily, "placing" entities that are being referred to at locations in their gesture space that then can persist with the assigned meanings over discourse intervals in stable relationships with other locations in that space. This gestural use of space has many characteristics in common with use of space in American Sign Language discourse, as it has been described by Liddell (2003).

In the simplest case, a speaker who witnessed the cat begin to chase the bird on the right side of the screen and continuing to the left side, may produce a right-handed gesture expressive of the cat's path-of-motion that starts on the right side and moves to the left side of her own gesture space. This mirrors the recalled visually-encoded image. McCullough (2005) found that the [left↔right] directionality of speakers' gestures often shows fidelity to the organization of action in the cartoon. The [left↔right] ("L–R") spatial axis of discourse may be analyzed as manifesting an "observer viewpoint" of the cartoon events (McNeill 1992). In Figure 14.1, the top row of video stills gives an example of a speaker using a L–R spatial axis, in which the right-side, right-handed gestural placement of one of the cartoon characters (the cat) mirrors that character's position on the screen in the actual cartoon.

In contrast, by adopting a "character viewpoint", a speaker–gesturer superimposes the discourse entity's perspective on her own. An example of this is when the cat and the bird

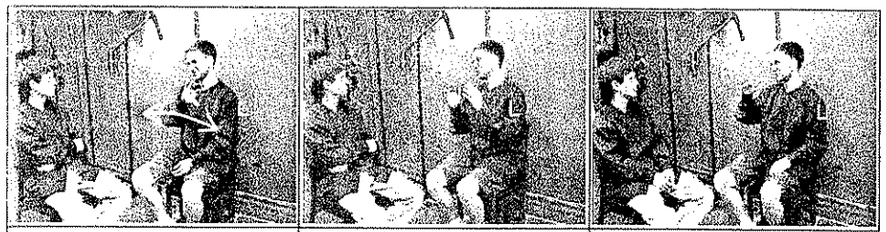

Figure 14.1 A narrative sequence in which discourse referents are fixed first on a left-right (L–R) spatial axis, followed immediately by one that fixes the same referents on the away-from-body (AB)/toward-body (TB) axis to represent character viewpoint.

in the cartoon look across a street at each other, using binoculars. Speakers describing this cartoon event often pantomime holding binoculars up to their faces with both hands. Many also point and move their index fingers away from their faces at eye level—an iconic, character viewpoint representation of one character's line of sight directed toward the other character. This spatial axis is referred to below as away-from-body/toward-body ("AB–TB"). In Figure 14.1, the bottom row of video stills gives an example of use of an AB–TB spatial axis that is expressive of character viewpoint. Other spatial axes of discourse include "social–interactive" and "blends". In the former, the speaker orients gestures of various kinds toward the interlocutor. The latter are combinations of the different spatial axes.

14.3 The "natural histories" of speech errors

Cartoon storytellers organize their gesture space in relation to multiple, distinct axes over the course of telling their stories. Discourse referents, gesturally indexed either at precise spatial loci or in more diffuse regions of gesture space, define these axes. Over the course of a story, a speaker may repeatedly visit, in gesture, the referential loci and axes she has created. In the framework assumed for the analyses presented here, this is the visuo-spatio-motoric

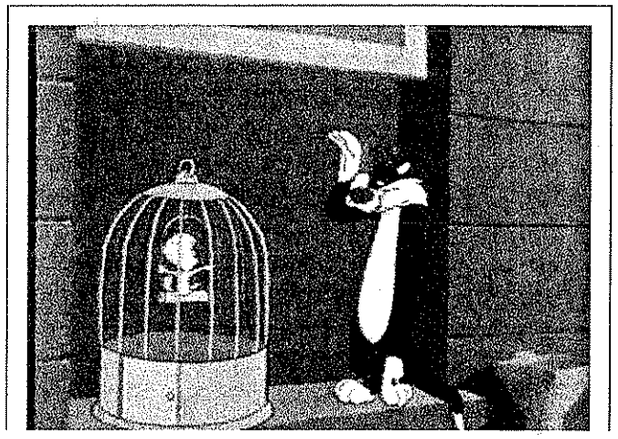

Figure 14.2 Image from the cartoon showing the standard spatial arrangement of the two main characters: bird on the left and cat on the right.

dimension of discourse cohesion. In this view, spatialized gestural indexes of discourse referents are persisting, embodied, linguistic-conceptual representations.

Below, we consider extended intervals excerpted from five, full-length narrations by different speakers, three of whom are healthy adults and two of whom have PD. Each excerpt contains one or more spoken errors of reference to the cat or the bird, or misuses of pronominal reference. These five were selected, in part, because the speech errors of substitution they contain may be discussed, for simplicity, mainly in terms of the speakers' use of just the L–R and AB–TB spatial axes. We examine them with the goal of accounting for the etiology of the speech errors in terms of a psycholinguistic processing role for persistent, spatial gestural representations.

14.3.1 Speaker KP

Excerpt 1, below, comprises about 2 minutes of KP's cartoon narration. We cut in, midstream, at KP's description of the scene shown in Figure 14.2. KP continues from this cartoon scene, describing how the bird's owner knocks the cat off a window sill, and then describes the events of the next cartoon episode, in which the cat climbs up inside a drainpipe that ends near the bird's window. The cat fails to reach the window, however, because the bird throws a bowling ball into the pipe and knocks the cat back down.

(1) uh next / there's a- ***Tweety***$^{\text{LEFT-1}}$ is seen / uh ***swinging***$^{\text{LEFT-2}}$
in his uh / ledge of the bir- ***in the birdcage***$^{\text{LEFT-3}}$ / and uh /
suddenly Sylvester$^{\text{LEFT HAND AT RIGHT-1}}$ appears / uh / on the ***window sill***$^{\text{LEFT-4}}$
/ $^{\text{RIGHT\_2}}$
uh / moving his finger$^{\text{RIGHT-3}}$ along with- / with ***Tweety*** /$^{\text{RIGHT HAND AT LEFT-5\&4}}$
uh wi- with Tweety's / uh swinging$^{\text{RIGHT-5}}$ /
and- and / ***Tweety jumps up*** $^{\text{LEFT-6}}$ in / excitement ***you know agitation***$^{\text{RIGHT}}$

and / runs out of the birdcage /BOTH HANDS: CVPT
and / Sylvester[RIGHT-6] uh / chases him[RIGHT-7] around #
and ***then***[LEFT-7] uh / a few seconds later uh /
the / ***caretaker of Tweety***[LEFT-8] or a / ***grandmother***[LEFT-9] or- / figure or- /
the / blue- wearing a blue dress #
is- / is shown uh / ***beating***[LEFT-10] / th- Sylvester on the head- over the head
with an umbrella /
and- / and uh / Tweety shouts uh some kind of a / snide remark
as you know / Sylvester[RIGHT-8] / d- uh / you know / falls out[RIGHT-9] /
and / next Sylvester[RIGHT-10] is seen uh / pacing / outside / the building /
uh outside uh ***Tweety's***[LEFT-11] apartment building /
and he notices[RIGHT-11] uh a- a- a big-[RIGHT-12] / I believe it's a- a water pipe[RIGHT-13]
of some s- some sort of pipe / or chute[RIGHT-14] /
and he decides to crawl up the chute /BOTH HANDS: CVPT
an- but / Tweety ***in the window***[LEFT-12] notices this
and uh / picks up a bowling ball / and drops it down the chute /BOTH HANDS: CVPT
and- / and that / hits Sylvester[RIGHT-15]
at some point in the middle of the chute BOTH HANDS
and- / and then / it ***drops down***[LEFT]
★ and / ***Tweety***-[LEFT] / or / ***Sylvester***[LEFT] ***falls out***[LEFT] / ★
uh with the bowling ball / between his leg /BOTH HANDS: CVPT
and so **he / starts rolling down the street**[LEFT] /

Figure 14.3 shows video stills of the gestures that accompanied the beginning utterances included in Excerpt 1. In rows (a) and (d) of Figure 14.3, KP gesturally represents Tweety with his left hand on the left side of gesture space. In row (c), he represents Sylvester with his right hand on the right side of gesture space. The gesture in row (b) blends the two kinds of gestural "articulation" (hand associated with Tweety and spatial locus associated with Sylvester), in a way that suits the discourse moment in which Sylvester and Tweety are "suddenly" both at the same location.

The speech error of substitution that we are interested in occurs three lines from the bottom of Excerpt 1. The utterance of which it is a part is indicated with a star on either end. We can examine the history of spoken and gestured references to the bird ("Tweety") and the cat ("Sylvester") that precedes the speech error for clues to what may have generated the substitution.

Across this interval, KP reliably moves his left hand to locations in the left side of gesture space when referring to Tweety, to Tweety's activities (e.g. swinging) or to the grandmother, who is on Tweety's side (literally as well as figuratively) in the cartoon. In the annotated transcript, gesture-accompanied spoken forms that refer to Tweety and activities/entities related to Tweety are italicized and in bold font. The gestural placement of

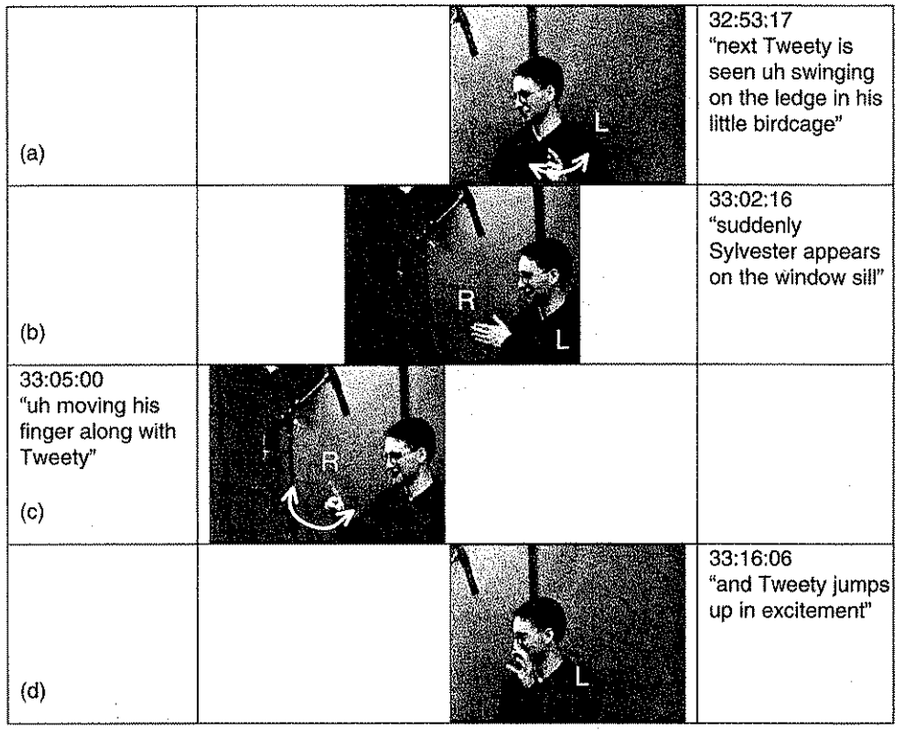

Figure 14.3 Narrative sequence in which speaker KP manually–spatially distinguishes the two main cartoon characters.

these activities/entities that occur on the left side is indicated with superscripted "LEFT" and these gestural references are numbered (from just the beginning of this excerpt, though note, many left-sided gestures representing Tweety have preceded this set in the extended discourse). We see that, in all, there are twelve separate gestural references to Tweety on the left side of gesture space in this excerpt, all but one of them performed with the left hand as well, prior to the interval of the discourse in which the speech error occurs.

Gesture-accompanied spoken forms that refer to Sylvester in Excerpt 1 are shaded in grey. The gestural placement of Sylvester and activities/entities related to him that occur on the right side are indicated with superscripted "RIGHT". These gestural references are also numbered in sequence. In all, there are fifteen gestural references to Sylvester on the right side of gesture space, all performed with the right hand, prior to the interval of the discourse in which the speech error occurs. Three intervals of character viewpoint ("CVPT") gesturing in the center of KP's gesture space (annotated with underlining) occur in this excerpt as well. However, overall in this interval of discourse, KP firmly establishes a L–R spatial axis, in which the gestural arrangement of referents mirrors the arrangement of cartoon characters he viewed earlier on video. Also, he establishes left *hand* and right *hand* "identities" for Tweety and Sylvester, respectively.

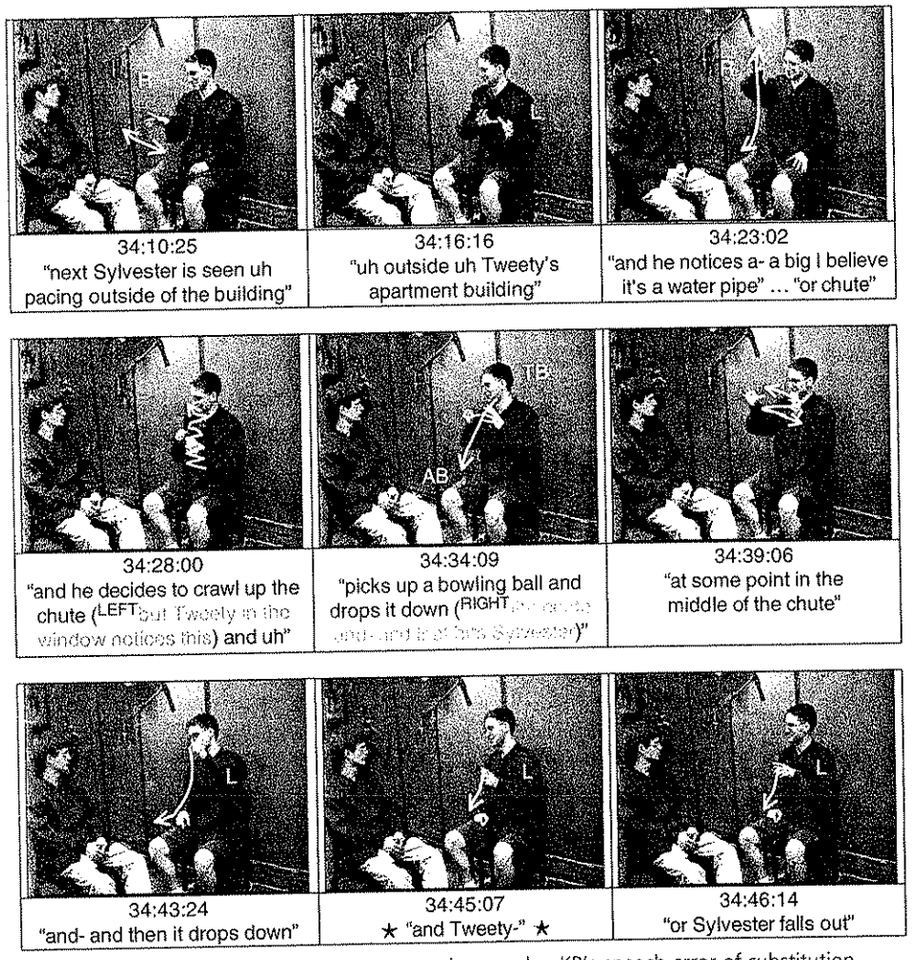

Figure 14.4 The narrative sequence encompassing speaker KP's speech error of substitution.

The gestures that accompany the utterances of Excerpt 1, starting at its middle section, "next Sylvester is seen uh/pacing", are shown in Figure 14.4 (a few of the gestures of this interval are omitted from among these stills to save space). The three video stills in the top row display the L–R spatial axis of discourse that the speaker has established. The three in the middle row display the gestures the speaker performed with both hands in the middle of gesture space. These are not part of the L–R axis. The bottom row shows the gestures that preceded and accompanied the speech error of substitution, "Tweety" for "Sylvester".

14.3.1.1 Analysis of the substitution error

Just prior to this error, it is the speaker's left hand that has continued on from his CVPT, two-handed depiction of the bowling ball hitting Sylvester after Tweety dropped it on him in the pipe. The ball and its movement are associated with Tweety; they flow from him.

So it makes sense that the left, "Tweety hand" would be the one to continue representing the ball as it falls. We note that the speaker did focus some attention on Sylvester being hit by the ball inside the pipe. Nevertheless, at time 34:43:24 (the lower left video still in Figure 14.4), the speaker says, "*it* [the ball] drops down", rather than, "*he* [Sylvester] drops down". We can infer the speaker's continued focus on the ball, and perhaps a focus on the ball as the agent of Tweety, from both his pronoun choice and his hand choice. Concerning the speech error of substitution, the obvious thing to point out is that, in the entire narration leading up to this point, Sylvester as a discourse entity had never been embodied in the left hand, only Tweety had. This spatial and motor indexing of Tweety had been reinforced with many repetitions over the discourse history. The conceptual–linguistic "vitality" of the left hand as a spatio-motoric representation, in context, is revealed in the triggering of the (now) inaccurate referring form. We can infer that the speaker did not intend to say, "Tweety", because he immediately detects and corrects this error, reproducing the left handed gesture to accompany "Sylvester falls out".

14.3.2 Speaker MI

The video stills in Figure 14.5 show the gestures that accompany the utterances in the first three transcript lines of Excerpt 2. This is almost the very beginning of MI's whole narration. He starts out with a two-handed "presentation gesture" (or conduit metaphoric; see McNeill 1992, p.14) whose meaning is some abstraction having to do with the cartoon story as a whole. With the left- and right-handed gestures that follow, MI sets up his own narrative spatial framework, locating Sylvester the cat on his left (at time 00:39:18) with his left hand and Tweetybird on his right (at time 00:42:00) with his right hand. Note that this L–R arrangement is the opposite of these characters' positioning in the cartoon (which schema, we noted, was adopted and maintained by speaker KP). In MI's narration, the cat and the bird continue spatialized in this antiveridical way for about the first 3 minutes, until the speech error of substitution occurs. At that point, MI reverses the characters' positions in gesture space and continues on with them that way, mirroring the cartoon's layout.

Figure 14.5 At the beginning of his narration, speaker MI sets up the left–right spatial axis of discourse according to which he will organize the first half of the narration.

(2) really the first / couple of scenes kind of set the whole story /BOTH HANDS: CVPT
and that is Sylvester^{LEFT} / across the street^{LEFT} from Tweetybird /
looking out^{LEFT} of his window / at ***Tweetybird***^{RIGHT} inside a window /
Tweety meanwhile is simultaneously looking at Sylvester /BOTH HANDS: CVPT
at this point / the story turns into how Sylvester^{LEFT}
is going to try and go into the apartment across the street /LEFT-5 HAND MOVES RIGHT
to get Tweetybird /
and for the next six minutes or so the story is on
his diff- different ***escapades in trying***^{RIGHT} to get a- ahold of uh Tweetybird /
he's foiled over and over again /
the first time he goes across^{LEFT} /
– Approximately 2 minutes of narration are omitted here –
now / he is / really challenged /
the old lady calls downstairs and says she's checking out /
presumably with Tweetybird /
★ **Tweetybird**-^{RIGHT} uh / **Sylvester rather** /^{RIGHT} ★
is hiding kind of in the ***mail slots***^{RIGHT} and hears this

The utterances in the top eleven transcript lines of Excerpt 2 contain six left-hand and left-space gestural references to Sylvester. Throughout his narration, this speaker, who is left handed, emphasizes Sylvester's actions. In doing so, he produces many more left-hand than right-hand gestures, particularly in the first 3 minutes. In the opening sequence transcribed in Excerpt 2, there are just two right-handed gestures. The one that establishes Tweetybird on the right (at time 00:42:00) involves a particular hand shape—hand held up, palm oriented away from his body and cupped, index and middle fingers touching the thumb—a "precision grip". The next time this gesture occurs, about 02:45 minutes later, it is placed at the same location in gesture space, in synchrony with the substitution error that is the focus of our analysis of this example.

The other right-handed gesture in this initial sequence seems best analyzed as a blend of the location and activities relevant to both bird and cat. Though the utterance concerns "escapades" of Sylvester, and thus we might expect a left-hand gesture, in the narration these escapades will occur as incursions into Tweety's space on the right. Thus, a right-hand, right-side gesture that indexes, "escapades in trying (to get ahold of Tweetybird)", is interpretable in relation to the spatial axis of discourse the speaker is establishing.

To simplify exposition, the transcript for Excerpt 2 omits approximately 2 minutes of MI's narration, during which the established locations of Sylvester and Tweetybird on the L–R axis are reinforced with repeated gestural representations, similarly to what was described earlier for KP. The speech error of substitution occurs just after MI begins recounting the fifth episode of the cartoon. Figure 14.6 shows the video still in which the

Figure 14.6 The immediate context of speaker MI's speech error of substitution.

speaker begins to say "Tweetybird" (time 03:15:01) in synchrony with a repeat of the precision grip gesture that he originally produced (time 00:42:00) to place the bird at that location in gesture space.

14.3.2.1 Analysis of the substitution error

Recall that MI, up to this point, has been gesturing about the cat's and the bird's locations in reverse of how they actually appear in the cartoon. As he begins to recount the fifth episode, the speaker prepares to describe the layout of the front desk area of the hotel where the bird and its owner are staying. This layout is a factor in how Sylvester plans the fifth episode's strategy for capturing the bird. Because it is significant, most cartoon narrators attempt to describe the relevant feature of this layout, which is this: in the cartoon, we see the hotel desk clerk talking to the bird's owner on the phone and behind the clerk, on the right, the cat is hiding in a mail cubbyhole. The cartoon frame moves to a close-up of the cat's face, on the right side of the screen, as he listens to the phone conversation for information that will enable him to find and capture the bird. Figure 14.7 shows this close-up from the cartoon.

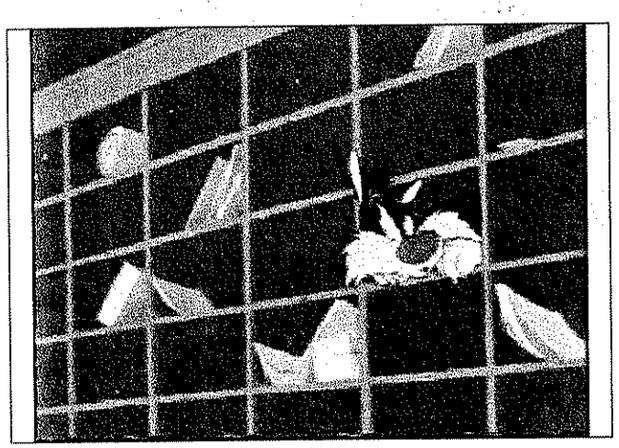

Figure 14.7 Video still form the cartoon with a close-up of the cat on the right.

MI's gestural depiction of Sylvester in the mail cubbyhole (Figure 14.6, the rightmost video still) mirrors the spatial arrangement he viewed in the cartoon and is the action that confirms his reversal of his L–R axis of discourse. Regarding the substitution error approximately 2 seconds earlier, we suggest that four factors contributed to it: (i) MI intends to recount the important plot element of Sylvester's location behind the hotel desk, which has been cinematographically emphasized in the cartoon (the close-up), possibly resulting in accurate recall of the stimulus image at the pertinent moment in the unfolding narration; (ii) a left-hand and left-space representation of Sylvester violates the spatial axis of discourse that has held sway to this point in his narration; (iii) the utterance immediately preceding the substitution error concluded with the vocalization, "Tweetybird"; (iv) the gesture that forms at the moment MI prepares to reference the location of Sylvester's hiding place on the right is a "precision grip" located at just the position in gesture space where Tweety was first located. It reprises the same handshape used almost 3 minutes earlier. In other words, the referring form "Tweetybird" is in the speaker's working memory, associated with a spatio-motoric representation that has the dimensions: right-side location and right-hand precision grip handshape. This established representation competes with a newly emerging one. In the new one, Sylvester is relocated to the right, in accord with the vivid visual image provided by the cartoon, and motivated presumably by the speaker's intention to refer to Sylvester in connection with the significant plot element that is his physical location in this scene.

Again, as with KP's substitution error above, we understand that the speaker did not consciously intend to say, "Tweety", nor was he in a state of mental confusion, because he immediately reacts to his utterance as an error, substituting, "Sylvester", accompanied by a gesture that contrasts markedly in form with the precision grip that had just synchronized with "Tweetybird". MI pops his right hand open to a flat palm with the five fingers spread and tensed as he says, "uh Sylvester rather". This is followed by the two-handed gesture (Figure 14.6, rightmost still) referencing the mail cubbyhole and Sylvester hiding in it on the right.

14.3.3 Speaker D

The substitution error in Excerpt 3 occurs quite early in D's narration. Up to the moment she says "puddytat" and then corrects it, all of this speaker's depictions of the cartoon characters and actions have been CVPT gestures arrayed on the AB–TB spatial axis of discourse.

(3) and he's looking out[BOTH HANDS: CVPT]
and loo- he's looking acr- he's- he's-[BOTH HANDS: CVPT]
and the window / is labeled bird watchers' society /[BOTH HANDS: CVPT]
and so across the street / in a cage / is little golden Tweetybird[BOTH HANDS: CVPT]
with bino- his own mini binoculars[BOTH HANDS: CVPT]
and he's like "I tawt I taw a puddytat I did I did" /[BOTH HANDS: CVPT]
so of course Sylvester is completely thrilled /[BOTH HANDS: CVPT]

★ that there is a puddytat- / I mean *a* / ***Tweetybird***$^{\text{LEFT}}$ ★

across the street that he can get at /

so he runs down the stairs$^{\text{RIGHT}}$ / goes to the building$^{\text{RIGHT TOWARD LEFT}}$

Figure 14.8 shows three utterance–gesture combinations that are discontinuous. The leftmost video still is one instance from D's discourse, of the AB–TB spatial axis that she established and reinforced with multiple gestures about cartoon settings and events during the interval leading up to her substitution error. In this interval, the gestures that predominate are those representing how the cat and the bird are looking at each other across the street, using binoculars. Gestures similar to the one shown in the leftmost video still of Figure 14.8 are repeated a few times in CVPT representations of each of these characters. Despite the fact that the bird is very small and has tiny binoculars and the cat is large and uses regular-sized binoculars, D's gestural representations of the two characters' mutual spying behavior are identical. At the instant of the substitution error, D has momentarily ceased this CVPT gesturing to scratch her chin (not shown). While scratching, she utters the substitution error, "puddytat", and immediately corrects it by saying, "Tweetybird", accompanied by a left-hand pointing gesture toward left gesture space. This pointing gesture inaugurates a new L–R spatial axis of discourse. She follows it with a right-hand iconic gesture about Sylvester descending stairs on the right side of gesture space. The characters of cat and bird are now positioned on this new L–R axis in a way that mirrors their positions in the cartoon, and D proceeds to build the next interval of her narration on this L–R spatial axis.

14.3.3.1 Analysis of the substitution error

If, as the descriptive data reviewed so far seems to suggest, spatial gestural represesentations participate fundamentally in organizing units of language production, the obvious fact to underscore concerning D's substitution error is that, prior to beginning her description of the cat's first attempt to catch the bird, she had not yet established a spatial axis of discourse on which these two characters were clearly distinguished. Rather, to that point she had alternately embodied each of these characters in essentially identical CVPT gestures. Her error of reference occurs in an interval that seems like a brief "lull" between larger discourse units. D is scratching her chin. Her attention may be slightly unfocused. She has finished describing the characters' mutual spying behavior and, we know from

Figure 14.8 Speaker D's AB–TB spatial axis, on which the bird and the cat were ambiguously represented, followed by set-up of a L–R axis synchronized with error self-correction.

what follows immediately in her narration, is likely at that moment forming a discourse intention to describe the cat's first attempt to catch the bird. However, the immediate speech production requirement is to finish out the current utterance, along with the discourse unit that it concludes, with an appropriate object of the phrase, "that there is a {...}". Given that the new discourse intention focuses on the cat's action, this seems the likely source of the incorrect referring form. We can infer that "puddytat" was not part of the intentional state governing the current utterance because she immediately self-corrects. Synchronous with the self-correction, she initiates a L–R spatial axis on which the referents are clearly distinguished and this is further support for the hypothesized role of spatial gestural represesentations in organizing discourse production. The alacrity with which the speaker sets up this L–R axis, in the process of correcting her error, gives the impression that she feels a need for such a spatial axis in order to forestall further such errors.

14.3.4 A speaker with Parkinson's Disease

Excerpt 4 is an interval from a narration by an individual who has moderately severe, "stage 3" PD (Hoehn and Yahr 1967), meaning, primarily, that she is at the point in the progression of the disease where balance problems onset. She had been on levodopa therapy for several years at the time of our videotaping and this medication ameliorated many of the symptoms of her disease, including hand tremor. Overall, this speaker tells a reasonably complete version of the cartoon story to her listener. Her speech is slower than that of the neurologically unimpaired speakers discussed above, and there are more intervals of dysfluency of the kind seen in the second line of Excerpt 4, than is typical for neurologically healthy speakers. The PD speaker does gesture quite a lot, however, and with both hands, though her overall rate of gesture is lower than that of unimpaired speakers. The substitution error we focus on is an incorrect pronominal reference, in the sixth transcript line, marked with black stars. The PD speaker refers to the cat as "she". Prior to this description of the bird's owner in interaction with the cat, the speaker has been correctly using the masculine pronoun to refer to the cat. There is a further speech error of substitution in this excerpt, "the luggage is in the door here", marked with white stars. In the cartoon, as is routinely described by neurologically healthy storytellers, the luggage that Sylvester has come to pick up is in the hotel room behind the door, rather than *in the door* itself.

(4) so he goes up to the room and knocks on the door
in a- in a bell- / bell cost- / costume- bellman's costume
and knocks on the door and says- /
granny looks out the top of the / window LEFT HAND MOVES ABOVE HEAD & HOLDS
and says / could I help you LEFT HAND HELD
★ ***and she said*** LEFT HAND HELD ★
I'm here to pick the luggage up LEFT HAND HELD
☆ ***okay my bird and the / luggage is in the door here*** LEFT HAND HELD ☆

I'll be- / I'll meet you downstairs LEFT HAND HELD

so he goes in / picks the bird up / takes the bird down /

This excerpt from a PD speaker was selected for inclusion in this analysis because her gesturing shows a certain characteristic that we have observed in a proportion of PD speakers who are part of a current, ongoing study of PD narrative discourse (Duncan *et al.* unpublished). This is a tendency for particular features of coverbal gesture (e.g. hand shape, location in space) to perseverate across rather long discourse intervals, seemingly imperturbable by discourse forces that dynamically shape and change the gestures of unimpaired speakers across similar intervals.[1] In other words, some PD speakers' gestures sometimes seem to become overly fixed in certain configurations. An instance of this makes a useful addition to our examination of the power of spatial gestural representations possess to affect choice of referring forms.

Figure 14.9 shows the PD speaker with her left arm and hand raised above her head. The hand is held aloft this way for the whole interval of speech in Excerpt 4 that is shown in italicized, bold face font. The gesture locates "Granny", the bird's owner, in the position of looking out through the transom over the hotel room door on which the cat has just knocked. Granny's and the cat's relative positions are shown in the middle and right video stills of Figure 14.9. Granny's strikingly odd location in this scene has significance for a subsequent plot twist in the cartoon. Therefore, most narrators put some effort into describing this spatial layout. While neurologically unimpaired speakers also frequently gesture above their heads when describing Granny's location, they tend not to hold the gestures there, unchanging, across utterances that refer to other details of the scene.

14.3.4.1 Analysis of the substitution errors

We propose that this PD speaker's gestural representation of Granny's location, being so marked and held for so long, exerted a shaping pressure on selection of referring forms. When the moment arrives for the speaker to switch focus to Sylvester below, as she prepares to quote him, her arm and hand representing Granny above are still firmly in place, a materialization of continuing, Granny-focused thinking. Similarly, her gesture maintains Granny at a location "in the door", and that is the phrase, nonsensical in relation to the cartoon, that she produces in the next utterance. A striking feature of this and similar speech errors of substitution we find in our corpus of PD narrative discourse is the fact that the speaker seems unaware of having erred. There is no attempt at correction, and, without missing a beat, the speaker proceeds to recount the subsequent cartoon events.

[1] Of course, neurologically healthy speakers regularly have intervals of held gestures, too, and often hold gestures depicting the bird's owner's position above the door in descriptions of this same episode. The gestural configuration described for the PD speaker here, however, is held an unusually long time, while she goes on to tell story content that typically spurs healthy speakers to lower their hands to produce new gestures.

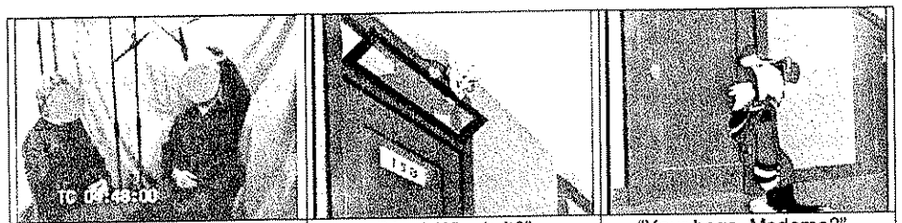

Figure 14.9 A persistent, left-handed gestural representation of a cartoon character's location, high up, performed by a speaker with Parkinson's disease.

14.3.4.2 A general note on errors of reference in PD speakers

In the corpus of stories by individuals with PD, from which Excerpt 4 is drawn, we encounter the kind of substitution error described for the PD speaker just now (including the absence of self-correction) with some frequency. However there is another etiology of errors that seems applicable to even more instances in this speaker group. We noted above that, while PD speakers do gesture a fair amount despite their neuromotor impairment, overall, the corpus of their stories reveals this aspect of their language performance to be "tamped" relative to neurologically unimpaired speakers. The cartoon elicitation technique used for these comparative studies is notable for prompting most speakers to gesture quite a lot over their 5- to 8-minute narrations. It is rare that a neurologically healthy person will not gesture at all during that time, but it is not so rare for a storyteller with PD to narrate with almost no gestures.

Recall the explanation of speaker D's substitution error as being due, in part, to the fact that she had not yet set up a spatial axis of discourse on which the two cartoon characters were distinguished. The suggestion is that one source of this type of speech error is the absence of any spatial framework of discourse reference. In this connection, consider Excerpt 5 from another PD speaker, followed by the listener re-telling. This speaker also has moderately severe PD. She recounts the cartoon story (in a fragmentary fashion) to her listener (who is neurologically healthy), with her hands resting in her lap the whole time.

(5) and **he** / climbed up the / drainpipe
and **he** dropped a / bowling ball down the drainpipe /
and somehow it got inside **him**
I didn't understand that /
and **he** went rolling over
to the bowling alley
and you could hear **him** hit a strike /
– *Subsequent listener re-telling*:
the cartoon was about Tweetybird / and the cat /

and / **they** went / to the hotel /
and there was this monkey- / this grandma there
I can't / remember much of it /
and um she didn't like **them** so **they** left /
and the cat / threw a bowling ball down the / drainpipe
outside the building

Excerpt 5 exhibits a kind of non-specific pronominal reference that we encounter with some frequency in samples from the PD narration corpus. An effect on communication of this lack of specificity is evidenced by the listener's accommodation: she collapses the cat's and the bird's roles into one, referring to them only as, "they" and "them."

When inadequate use of pronouns to distinguish the cartoon characters extends for long intervals of discourse, it is not so meaningful to analyze individual instances as errors of substitution. However, frequent non-specific pronominal reference by speakers who do not, or who are unable to, establish spatial axes of discourse may be seen as further motivation to hypothesize a causal role for spatial gestural representations in discourse reference.

14.3.5 Summary and some additional notes on speech errors

For each of the speech errors of substitution and errors of pronominal reference discussed above, we find a plausible explanation in the gestural representations in the surrounding extended discourse. KP's substitution error occurred at the moment that his left hand in left gesture space shifted from indexing Tweety to indexing Sylvester. MI performed the first half of his cartoon narration with the two main characters positioned in the reverse of how they appear in the cartoon he saw. His substitution error occurred at the instant he flipped this spatial axis of his discourse. Speaker D, when initially framing her narration, ambiguously represented the two main characters using similar CVPT gestures. The resolution of her substitution error involved establishing a L–R spatial axis for the characters.

Each of the explications above might seem like a "just so" story; however, examination of a range of such errors of reference in the corpus (comprising more than fifty 5- to-8-minute stories) from which these examples were drawn, reveals a possibility that such errors are most likely to occur in intervals of discourse where either (i) *no* gesturing that spatially indexes referents occurs in the preceding discourse context, or (ii) there is evidence of conflictual activation of more than one spatial axis or other manual-motoric representation of an entity at the moment of the error in the discourse. Note that the speech errors of substitution we observe in the corpus of stories are not limited to proper names of characters or pronominal references to these characters. Focus on such examples simplified presentation of the phenomenon here; however, in the corpus data we observe substitution errors in other categories of referring forms, making this seem to be a general phenomenon of lexical access. An example is one speaker who recounts the cartoon event of Sylvester, dressed as a bellhop (as in Figure 14.9), pulling the cover off Tweety's birdcage. She says, "he pulls the cage off" and immediately self-corrects. Similarly to the excerpts analyzed above, characteristics of the gestural representations preceding this error of substitution suggest a partial impetus for the error.

We do find that speech errors of the sort described here are not frequent in the cartoon narrations of neurologically healthy speakers. A search of the whole corpus of such narrations showed that there was rarely more than one such error per full narration. This suggests a general functionality of spatial gestural representations in language use; that is, perhaps they very reliably function to help speakers keep referents sorted out and distinct from one another when they tell complex stories. It could be that only under special circumstances are spatial axes of discourse likely to be the source of lexical access errors. PD language use may qualify as a special circumstance. In the ongoing examination of PD narrations, it is emerging that such errors occur with somewhat higher frequency in the narrations of that speaker group.

14.4 Discussion and conclusions

In regard to how language engages meaning, Glenberg and Kaschak (2002) note that the dominant research approach considers language to be a "symbol manipulation system [...] using abstract, amodal, and arbitrary symbols (i.e., words) combined by syntactic rules". Modularist, serial stage models of speech production such as Levelt's (1989) "Blueprint for the speaker" and its simulation version WEAVER++ (1999), are prominent exemplars of this way of conceiving of language processing. The empirical observations feeding such modeling exercises are often single-word or single-phrase speech production in controlled experimental picture naming tasks; a very different sort of language use than we consider in this chapter. Though a generally acknowledged weakness of the WEAVER++ simulation of "Blueprint for the speaker" is that it only accounts for essentially error-free lexical access and production, its authors have demonstrated that the model can be "tweaked" to produce phoneme substitution errors of the "*r*at"/"*c*at" variety. Within its own empirical domain, WEAVER++ has enjoyed considerable success. For instance, the model-derived prediction that substitution errors of the "*r*at"/"*c*at" variety will outnumber those of the "cat"/"dog" variety holds for picture naming tasks.

As noted in the summary section above, errors of the phoneme substitution type are virtually non-existent in our two corpora of stories. That is, as yet, we have encountered no instances in which a speaker said something like, "Sylweety," or "Twylvester," or like, "covage," or "caver" (i.e. blurring "cage" and "cover"). Lexical substitution errors of the kind we do observe, with some frequency, seem connected to discourse macrolevel representations. An influence of macrolevel discourse processes on moment-to-moment speech production is imagined within the Levelt framework but is not part of the mechanics of the model. Further, the only motoric representations the model is concerned with are those having to do with speech articulation. There is no obvious place in such a model for gestural representations that operate at the level of discourse organization and that can be the impetus for the errors in lexical access examined above.

Another dimension of the observations on substitution errors presented in this chapter seems problematic for this dominant framework. This is the hypothesized role of speaker intention in the planning of utterances. Levelt (1989) notes,

> [t]alking as an intentional activity involves conceiving of an intention, selecting the relevant information to be expressed for the realization of this purpose, ordering this information for expression, keeping track of what was said before, and so on. [...] The sum total of these mental activities will be called *conceptualizing* [...] The product of conceptualizing will be called the preverbal message.
>
> (p.8, italics in the original)

The concept of intention invoked in this passage and others in Levelt's *Speaking: From Intention to Utterance*, is broad. Nevertheless, this formulation, particularly the notion "preverbal message", appears to sequester all the various factors that would shape spoken forms in an interval that concludes before the relevant unit of overt speech production begins. Speakers KP, MI, and D each substituted an unintended referring term for an intended one. We know of their true intentions because each immediately self-corrected. Thus, some process that does not intersect with the speaker's intentional state (which Levelt's model assumes is coded in the preverbal message) has some power to prompt lexical access, even as the speech articulators are being shaped. It is not enough to explain away the substitution errors we analyzed here as mistakes due to confusion because in each case there is a rationality to the error; one sense in which it is actually not a substitution error. MI's quite forceful (though errorful) uttering of "Tweetybird" is, in terms of the history of embodied meanings in his discourse, the appropriate speech performance to have occurred at the instant that his right hand, shaped as a precision grip, reaches that specific location in right gesture space. "Tweetybird" is the established meaning of that embodiment, by this juncture in his discourse. The fact that actual lexical choice may at times be at odds with intended lexical choice points to a need to rethink at least the "*conceptualizer*"–"*formulator*" connection in the Levelt model.

Should the hypothesis suggested by the descriptive analyses presented here, concerning the origins of substitution errors, find support in a controlled experimental study, however, the data reported here are relevant for the growing consensus that the whole class of models in which language use is conceived of as amodal symbol manipulation needs rethinking. McNeill's "Growth Point" theoretical framework (McNeill 1992, 2005; McNeill and Duncan 2000; Sowa *et al.*, this volume) addresses the limitations of modularist models, emphasizing how they skirt consideration of the dynamics of discourse context and gesture and the effects of those on language production:

> The 'Speaking' model [...] is composed of linked modules. Each module stands in a one-to-one equivalency to some component of a classical static linguistic description [...] Context is problematic. Context can be represented only as a data source, like world knowledge or inputs from the physical environment, viz., it can be handled statically, but cannot be treated dynamically or embodied in the conceptual organization of the utterance, since doing so would render structures unstable and open the module to influences outside the allowed inputs from other modules, and hence undermine its very modularity. This of course is the fatal conflict of modularity versus context and points to a profound inappropriateness of the modular approach in a dynamic model.
>
> (McNeill 2005, p. 132–3)

The model of lexical access advanced by Krauss and colleagues (e.g. Krauss *et al.* 2000) also bears mention here. This is also a modularist language production model, having

much in common with Levelt's "Blueprint for the speaker." The Krauss *et al.* model embodies the hypothesis that coverbal gestures exist to promote accurate lexical access. By hypothesis, they do so by shaping and maintaining mental images for sufficient intervals that they may serve as reference points for the lexical access process. This process attempts to locate the mental lexicon entry in the speaker's mind which best captures the intended meaning contained in the "preverbal message" as this intention is being processed through the "formulator". It should be clear that the data on unintended referring forms presented in this paper are as problematic for the Krauss model, which does incorporate a gesture production module, as for the Levelt model, which does not. In the Krauss framework, it seems that gestures can only assist in arriving at the correct choice of referring forms; "correct" as determined by the speaker's intention as represented in the preverbal message (in Levelt/Krauss terms). According to the Krauss model, gestures reflect speaker intention, which shapes the preverbal message. That speaker MI, for instance, self-corrected his "Tweetybird" reference, permits us to observe that his preverbal message concerned Sylvester. According to the Krauss model, gesture should therefore have assisted the formulator to locate that referring form. Further, the Krauss model deals only with production of individual lexical items, whereas the data presented here suggest an influence of embodied representations that are responsive to discourse-level processes. The latter, in the Krauss model as in Levelt's, are external to the processes that are explicitly modeled.

Glenberg's and Kaschak's (2002) view of language use as "grounded in bodily activity", though not conceived in relation to the modality-dependent process of meaning creation we describe here for coverbal gesturing, is also central to the alternative consensus about language as embodied. These authors, citing Ochs *et al.* (1996), do comment on coverbal gestures as embodiments of meanings that speakers (in that case, physicists and students of physics) are having difficulty grasping; embodiments that elucidate concepts by grounding discourse about them in bodily action. The findings of Spivey and colleagues, concerning visuospatial indices of objects and events in speakers' environments and their role as memory supports involved in organizing high-level cognitive processes—including language use—similarly necessitate reconsideration of language use as amodal (Spivey *et al.* 2004; Richardson *et al.* 2003). Also germane is the notion of "motor memory" as an explanation, for example, of why the Japanese are often observed to "write" Kanji characters in the air when trying to recall their forms, prior to putting pen on paper to write the characters (Sasaki 1987). The speech–gesture discourse histories of substitution errors, such as those examined for this chapter, make it seem plausible that rehearsal, within even short intervals of discourse, of embodied linguistic-conceptual meanings, potentiate motor memory effects that may account for the observed substitution errors.

The data from PD speakers presented here suggest a further consideration relevant to such possible motor memory effects on discourse production. Above, we noted that our ongoing analysis of PD natural discourse reveals that errors of the type examined here are relatively more common in PD speakers than in neurologically healthy speakers. We also noted that PD speakers less frequently self-correct their errors or even seem to notice them.

This seeming absence of awareness can be quite striking, as some PD narrators build their cartoon stories with what seems like a very casual approach to anaphoric reference. These differences between PD speakers and healthy speakers suggest a role for self-monitoring of performance during discourse production that is independent of utterance production processes themselves; a "metacognitive" capability (e.g. Proust, this volume). There are known cognitive deficits associated with PD (see, e.g. Locascio *et al.* 2003), including impaired "cognitive control" (Gabrieli *et al.* 1996) of tasks that involve maintenance and update of information in working memory. The data on speech errors from healthy speakers presented here, and the possibility that such speech errors are more frequent in speakers with impaired metacognitive abilities, reveals that language production can proceed, to some extent, fueled by representations that are not entirely under the cognitive control of the speakers producing the language.

The descriptive linguistic observations reported here provide a basis only for a proposal concerning the role of spatial gestural representations in production of spoken discourse referents. They do suggest avenues for expanded empirical research, however. For example, one could attempt to engineer the sort of spatial reorganizations we hypothesize are partially responsible for some substitution errors, by modifying the cartoon elicitation slightly. Since one source for speakers' L–R spatial axes of discourse appears to be the L–R positioning of the characters in the cartoon eliciting stimulus, this aspect of the stimulus could be modified. The second half of the cartoon, for instance, could be shown in mirror image of the actual cartoon, with the possibility that study participants would then feel pressure, at the pertinent moment in their narrations, to flip their L–R axes, violating established spatial gestural schemas. There are further possibilities for expanding this line of research, a goal of which would be to better link data on discourse uses of coverbal gesture (a rather abstract domain, despite its embodied nature) to the accumulating wealth of data showing that human cognition generally is embodied and also embedded in context (see also, e.g. Kirsh 1995a, b, Kirsh 2000). This line of research could thus contribute to bringing all such data to bear on reconsideration of the modularist, amodal symbol manipulation models of human language use that have dominated psycholinguistic research for two decades or more.

Acknowledgements

The data for this study were collected and analyzed while the author was funded by NSF KDI grant BCS-9980054 and NIH NIDCD grant 5R01DC001150–14. I thank James Goss, Elena Levy, David McNeill, Ipke Wachsmuth, and two anonymous reviewers for their helpful comments on earlier drafts.

References

Duncan S (2002). Preliminary data on effects of behavioral and levodopa therapies on speech-accompanying gesture in Parkinson disease. In *Proceedings of the International Society of Speech and Language*, Rundle Mall, S.A. Australia.

Duncan S, Galati A, Goodrich W, Brandabur M, and Ramig L (unpublished). Impairments in complex language use and coverbal gestures in idiopathic Parkinson's disease.

Fahn S (2003). Description of Parkinson's disease as a clinical syndrome. *Annals of the New York Academy of Sciences*, **991**, 1–14.

Gabrieli JDE, Singh J, Stebbins, GT, and Goetz, CG (1996). Reduced working memory span in Parkinson's disease: Evidence for the role of a frontostriatal system in strategic memory. *Neuropsychologia*, **10**, 322–32.

Glenberg AM and Kaschak MP (2002). Grounding language in action. *Psychonomic Bulletin and Review*, **9**, 558–65.

Goldin-Meadow S (2003). *Hearing Gesture: How our Hands Help us Think*. Cambridge, Mass: Belknap Press.

Goldin-Meadow S, Nusbaum H, Kelly S, and Wagner S (2001). Explaining math: Gesturing lightens the load. *Psychological Science*, **12**, 516–22.

Hoehn MM and Yahr MD (1967). Parkinsonism: onset, progression and mortality. *Neurology*, **17**, 427–42.

Kendon A (2004). *Gesture: Visible Action as Utterance*. Cambridge, UK: Cambridge University Press.

Kirsh D (1995a). The intelligent use of space. *Artificial Intelligence*, **73**, 31–68.

Kirsh D (1995b). Complementary strategies: Why we use our hands when we think. <http://adrenaline.ucsd.edu/kirsh/articles/cogsci95/cogsci95.html>.

Kirsh D (2000). A few thoughts on cognitive overload. *Intellectica*, **30**, 19–51.

Krauss R, Chen Y, and Gottesmann RF (2000). Lexical gestures and lexical access: a process model. In D McNeill, ed. *Language and Gesture*, pp. 261–83. Cambridge, UK: Cambridge University Press.

Levelt WJM (1989). *Speaking: From Intention to Utterance*. Cambridge, Mass: MIT Press.

Levelt WJM, Roelofs A, and Meyer A (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, **22**, 1–75.

Levy ET and McNeill D (1992). Speech, gesture, and discourse. *Discourse Processes*, **15**, 277–301.

Lewis FM, Lapointe LL, Murdoch B, and Chenery HJ (1998). Language impairment in Parkinson's disease. *Aphasiology*, **12**, 193–206.

Liddell SK (2003). *Grammar, Gesture, and Meaning in American Sign Language*. Cambridge, UK: Cambridge University Press.

Locascio JJ, Corkin S, and Growden JH (2003). Relation between clinical characteristics of Parkinson's disease and cognitive decline. *Journal of Clinical and Experimental Neuropsychology*, **25**, 94–109.

McCullough K-E (2005). *Using gestures during speaking: Self-generating indexical fields*. Unpublished doctoral dissertation, Linguistics Department, University of Chicago, Illinois.

McDonald S (1993). Viewing the brain sideways? Frontal versus right hemisphere explanations of non-aphasic language disorders. *Aphasiology*, **7**, 535–49.

McNeill D (1992). *Hand and Mind: What Gestures Reveal about Thought*. Chicago: University of Chicago Press.

McNeill D (2005). *Gesture and Thought*. Chicago: University of Chicago Press.

McNeill D and Duncan S (2000). Growth points in thinking for speaking. In D McNeill, ed. *Language and Gesture*, pp.141–61. Cambridge, UK: Cambridge University Press.

McNeill D and Levy ET (1993). Cohesion and gesture. *Discourse Processes*, **16**, 363–86.

Murdoch BE (2001). Subcortical brain mechanisms in speech and language. *Folia Phoniatrica et Logopaedica*, **53**, 233–51.

Ochs E, Gonzales P, and Jacoby S (1996). "When I come down I'm in the domain state": Grammar and graphic representation in the interpretive activity of physicists. In E Ochs, EA Schegloff, and SA Thompson, eds. *Interaction and Grammar*, pp. 328–69. Cambridge, UK: Cambridge University Press.

Ramig L (1996). Neurological disorders of the voice. In BW Vinson, B Vinson, and M Crary eds. *Organic Voice Disorders: Assessment and Treatment, A tribute to G. Paul Moore*, pp. 323–43. San Diego: Singular Publishing Group Inc.

Richardson DC, Spivey MJ, Barsalou LW, and McRae K (2003). Spatial representations activated during real-time comprehension of verbs. *Cognitive Science*, **27**, 767–80.

Sasaki M (1987). Why do Japanese write characters in space? *International Journal of Behavioral Development*, **10**, 135–49.

Spivey MJ, Richardson DC, and Fitneva SA (2004). Thinking outside the brain: Spatial indices to visual and linguistic information. In J Henderson and F Ferreira, eds. *The Interface of Language, Vision, and Action*, pp. 161–89. New York: Psychology Press.

Stebbins GT, Gabrieli JDE, Mascari F, Monti L, and Goetz CG (1999). Delayed recognition memory in Parkinson's disease: A role for working memory? *Neuropsychologia*, **37**, 503-10.

Streeck J (unpublished). *Gesture: The Manufacture of Understanding*. Amsterdam/Philadelphia: John Benjamins.

Embodied Communication in Humans and Machines

Edited by

Ipke Wachsmuth,
Manuela Lenzen,
Günther Knoblich

OXFORD
UNIVERSITY PRESS

OXFORD
UNIVERSITY PRESS
Great Clarendon Street, Oxford OX2 6DP
Oxford University Press is a department of the University of Oxford.
It furthers the University's objective of excellence in research, scholarship,
and education by publishing worldwide in
Oxford New York
Auckland Cape Town Dar es Salaam Hong Kong Karachi
Kuala Lumpur Madrid Melbourne Mexico City Nairobi
New Delhi Shanghai Taipei Toronto
With offices in
Argentina Austria Brazil Chile Czech Republic France Greece
Guatemala Hungary Italy Japan Poland Portugal Singapore
South Korea Switzerland Thailand Turkey Ukraine Vietnam
Oxford is a registered trade mark of Oxford University Press
in the UK and in certain other countries
Published in the United States
by Oxford University Press Inc., New York

First published 2008

A catalog record for this title is available from the British Library
Data available
Library of Congress Cataloging in Publication Data
Data available
Typeset by Cepha Imaging Private Ltd., Bangalore, India
Printed in Great Britain
on acid-free paper by
Biddles Ltd. King's Lynn, Norfolk
ISBN 978–0–19–923175–1
10 9 8 7 6 5 4 3 2 1