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FEATURE ARTICLE

The relationship between language and coverbal gesture in aphasia

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EDITOR'S NOTE

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THE RELATIONSHIP BETWEEN LANGUAGE AND COVERBAL GESTURE IN APHASIA *

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Abstract

The relationship between language and gesture constitutes an intriguing field of interest and has attracted considerable research on aphasic as well as healthy individuals. In this paper controversial positions on gesture use in aphasia shall be presented, addressing the issue to what extent aphasics are able to employ the nonverbal channel as a means of compensation for purposes of communication and speech production. Neuropsychological findings on the role of coverbal gesture in the speech production process will be discussed. Finally a short presentation of recent research on the mirror neuron system as a possible neural substrate for both language and gesture shall open new ways to look at the issue of debate.

Introduction

In aphasiology a close connection between language and gesture has long been recognized. The investigation of the gestural behavior of aphasic patients constitutes one possible approach to find out more about the nature of this relationship, advancing at the same time knowledge about the role of gesture in the speech production process in normals and the neural bases of gesture and language. Finally, understanding of the role of gesture in aphasia can have important implications for the therapy and rehabilitation of patients.

The present review starts with a brief presentation of the two major positions that are maintained in the study of gesture in aphasia, which are also of relevance for the more defined area of body movements that accompany speech, i. e. coverbal gesture. Central studies of coverbal gesture in aphasics that have provided evidence for these positions shall be described. I will report research establishing the relevance of gesture for both listener-directed communicative purposes on the one hand as well as within-speaker situated speech production processes on the other hand. Next the issue of gesture use as a possible means of compensation for the impaired language facilities in aphasia will be discussed. In the subsequent section I will review some of the more recent neuropsychological findings on coverbal gesture in the speech production process which have contributed to further unravelling of the nature of the relationship between language and gesture. I conclude with a few words about possible

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new insights onto the brain organisation of gesture and language contributed by recent developments in neuroscience.

Asymbolia and Movement Disorder Positions

The basic question that needs to be addressed in the discussion of gesture use in aphasia is whether in aphasic patients nonverbal communication breaks down in similar patterns as verbal expression, suggesting a "central communication disorder" affecting both the gestural and language based channel. Or is it, on the other hand, the case that aphasic patients maintain the competence to express themselves nonverbally as has been suggested as early as 1825 by Bouillaud?

Within this debate evidence for both positions exists, mirroring the controversial explanations for the frequent co-occurrence of apraxia and aphasia after left hemisphere damage. In regard to this somewhat broader area of the interrelationship between deficits in volitional control of purposeful movements and deficits in language use basically two different positions are maintained. The first one proposes that a single, generalized faculty for symbolic activity underlies communication in both the gestural and the verbal channel. Finkelnburg (1870) was the first to take this approach by suggesting that aphasia reflects the more generalized disorder of "asymbolia". As a consequence, aphasia should also manifest itself in an impairment of representational gestures. Evidence in favour of this claim of aphasia and apraxia as symptoms of a common underlying cognitive disorder was found for example by Duffy & Duffy (1981), who reported strong correlations between severity of aphasia and deficits in the production and comprehension of representational movements (pantomime).

The second position interprets apraxia and aphasia as independent disorders, which co-occur in individuals with left hemisphere brain damage due to some overlap in the neural representation of these two functions. This view is held for instance by Goodglass & Kaplan (1963) who found specific disturbances of nonverbal communication independent of the degree of severity of aphasia. Wang & Goodglass (1992) refer to this position as the "movement disorder" position, in which pantomime production is considered as a high-level manifestation of apraxia.

Early Empirical Evidence and Interpretations

Starting in the late 1970s a number of studies examined claims regarding gestural activity accompanying speech. Two early studies already revealed controversial findings on gesturing in aphasia:

Goldblum (1978) compared unilateral and bilateral movements in 10 aphasic patients, 10 left hemisphere-lesioned patients without aphasia, 10 right hemisphere-lesioned patients, and 5 normal subjects. No statistical tests were made but gesture-to-word ratio was observed to be greater in the anterior aphasic group. In all groups the same repartition was found for the various gesture categories (automanipulations, descriptive gestures and accompaniment gestures), but anterior aphasics tended to produce more descriptive gestures compared to the other groups. Such findings suggest that gesture use does not necessarily follow the same course as language breakdown.

Cicone, Wapner, Foldi, Zurif and Gardner (1979) analysed the use of communicative gesture in short conversation samples taken from informally constructed interviews with two anterior aphasics, two posterior aphasics and four normal subjects. They found that the posterior aphasics produced more movements per time unit than the anterior aphasics, whereas the normal subjects had intermediate production. However, the differences between anterior and posterior aphasics disappeared when only the left hand was considered. Secondly, they found that the nature of the produced movements differed between the aphasic groups, with the posterior aphasics executing more 'complex gestures' (i.e. sequences of several motor units). The proportion of representative (emblems, pantomimes, numbers, writing in the air) and non-representative units also differed: representative gestures were more frequent in the anterior group and less frequent in the posterior group, but in both groups the pantomime subcategory was reduced in comparison with controls. The anterior aphasics more frequently used gestures that were not accompanied by words, i.e. they fell back on the gestural mode of communication. Additionally, the messages (both verbal and verbal plus gestural) made by posterior aphasics were rated as less clear than those made by normal controls. In contrast, the Broca's aphasics equalled or surpassed the normal controls in the clarity of their communication. The authors state that these results yield a "coherent picture of communication profiles in aphasia" with "gestures and spontaneous speech of aphasics [exhibiting] the same configurations of properties" (Cicone et al., 1979, p. 344). Broca's aphasics thus produce simple, unelaborated units with a high degree of referentiality in both modalities, the output being clear but sparse. Wernicke's aphasics on the other hand produce a considerable amount of gestures which furthermore are quite elaborated and complex, but either nonreferential or only "generally" referential and appearing vague and unfocused - a pattern that is very reminiscent of their often jargon-like speech output. Cicone et al. offer two explanations for this apparently very intimate tie between speech and gesture. First, they suggest the possibility that gesture is directly dependent upon language, and that "speech functions as the major, and dominant channel, with the nature and the quality of the gesture [being] secondary reflections of the properties of speech", (1979, p. 345). This position would be supported by the finding that overally speech carried the most information for both aphasic groups. The second explanation offered is in line with the view of a single "central organizer", a center that initiates and determines the clarity and complexity of both speech and gesture. The idea of such a central organizer was put forward by Kimura (1976), who proposed that the left hemisphere is dominant in the control of complex motor sequences. Cicone et al. view such an explanation as plausible due to reasons of parsimony and the hypothesized common origins of both speech and gesture (see Hewes, 1973 and the more recent position of Rizzolatti and Arbib, 1998, which is reported at a later point in this paper). In conclusion these authors suggest that aphasic patients are not notably successful in overcoming their linguistic impairments by adopting gesture as an alternative channel for communication.

Feyereisen and Seron (1982) attend to the discrepancy between the findings of Goldblum (1978), who found more gestural activity in anterior aphasics, and Cicone et al. (1979), who reported more gestural activity in posterior aphasics. They illustrate how such a discrepancy can result from the use of different scoring methods: While in the former study a gesture-to-word ratio was considered, in the latter frequency of gestures was calculated per time unit. To shed more light onto the role of fluency, Feyereisen (1983) examined the amount of gesturing in 6 "high-fluent" vs. 4 "low-fluent" aphasics and found no statistical differences between these groups. He did note however that nonverbal production was greater for aphasics than for normal controls, and concluded that rather than fluency, it was various disorganizations in the verbal output that elicited more gesticulation.

Gesture as a means of facilitating speech production

When studying gestures accompanying speech, the question of the purposes of the gesturing is of major interest. A series of research teams have focused on finding answers to the question why speakers employ certain kinds of body movements at certain points in the conversation.

In this light Feyereisen and Seron (1982) specifically relate their findings to the *speech-encoding difficulty hypothesis* (but unfortunately do not further specify the nature of the gestures that they consider, e.g., referential vs. nonreferential). Within this framework it is assumed that gesture production could be better understood as reflecting cognitive processes, rather than simply as attempts to communicate in a structured code. Filled or unfilled pauses are seen as instances where a person encounters difficulties in encoding their speech. Indeed, body movements tend to occur more frequently at the beginning of phonemic clauses, just after such pauses. The increased gesture production observed in aphasic patients would thus be linked to the increased occurrence of hesitations in their verbal output that denote speech-encoding difficulties. However, as Feyereisen and Seron also point out, this analysis is very simplified. Findings based on studies of normal subjects (Butterworth & Beattie, 1978) illustrate the complexity of the relationship between gestures and speech encoding: (1) More movements are made during fluent execution phases; (2) during hesitant planning phases most movements occur during verbalization; conversely, in the execution phases most movements occur during hesitations; (3) gestures with a relationship to the verbal content accompany the hesitations during the execution phases more often than the verbalizations made during the planning phases. It should be noted that in subsequent work Beattie and Shovelton (2000) found contrasting findings to this last point. In this more recent study iconic gestures did not occur with lexical accessing difficulties. Although they appeared with words of low transition probability, these words were uttered quite fluently, thus contradicting the earlier notion that iconic gestures primarily assist in the process of lexical access. Rather, the authors suggest, they may serve some communicative function.

A considerable amount of research has worked on further unraveling the function of gestures accompanying speech, specifically focusing on the question whether gestures serve communicative purposes or assist in speech production processes. To shed more light on this issue restriction of listener visibility has been employed in a number of studies.

The effect of listener visibility on gesture production

If gestures are not communicative signals but part of the speaker's encoding effort, they should not be affected by the suppression of the visual channel in the interaction. However, if they carry communicative information it would be expected that speakers should decrease their usage in the case of restricted visibility between the interlocutors.

Evidence for the first argument was found by Rime (1982). In this study 20 dyads of male undergraduate students were asked to discuss the topic "movies", with half of the pairs being separated by an opaque screen. A hidden videocamera recorded one of the two participants. The prediction that an interaction without visibility would be marked by a disappearance of nonverbial behaviours which are supposed to contribute to the transmission of information was not supported by the data. With regard to facial movements as well as movements of the head and body, behaviours remained similar across the two experimental conditions. Three differences could be observed but did not reach statistical significance: In the interactions without visibility, speakers showed less partner-directed gaze, less communicative gestures and longer autistic gestures (active hand contact with the self or with an object). Rime concludes "thus, even when they are made inoperant in the transmission of information, nonverbal behaviours continue to emerge among interactors, a conclusion which simply confirms what could be observed in everyday life from people involved in telephone conversations" (1982, p.125). Thus, the author argues, rather than communicative purposes it is other functions, such as assistance to the speech encoding processes, which probably account for the abundance of nonverbal behaviours among interlocutors.

Bavelas, Chovil, Lawrie and Wade (1992) distinguished between two classes of gestures and found differing results for these distinct groups. They examined the videotaped data of 15 dyads of female undergraduate students narrating a "close call". Attention was put to *topic gestures* and *interactive gestures*. While topic gestures are depicting semantic information directly related to the topic of the discourse, in the authors' description the interactive gestures are referring directly to the interlocutor while giving no information about the topic. They include some iconic reference to the interlocutor in their physical form (and are –according to the authors- called *batons* or *beats* in other studies). No significant difference in the rate of topic gestures was observed between the two conditions. However, there was a significantly lower rate of interactive gestures in the condition with restricted visibility. Thus the two types of gestures are established as functionally different. Bavelas, Chovil, Lawrie and Wadie highlight that words and topic gestures work together to convey semantic information in a highly integrated matter. Interactive gestures, which are made for the other person to see, serve to involve the listener without disrupting the topical verbal narrative.

However, contrary to these findings other researchers report that representational gestures are produced more frequently when the listener is visible than when he is not. Cohen and Harrison (1973) found that speakers describing the route to a destination gestured about twice as often face-to-face as they did speaking over an intercom, and suggested that gestures are employed as intentionally communicative. Krauss, Dushay, Chen and Rauscher (1995) criticize this interpretation. In their study, speakers were asked to describe abstract graphic designs and novel synthesized sounds. The authors did find as well that speakers gestured more in face-to-face situations than when communicating over an intercom, but speaker visibility had no enhancing effect on communication accuracy, i.e. it did not help listeners to correctly identify the described object. Krauss, Dushay, Chen and Rauscher admit that conversational gestures do convey some semantic information to a listener and thus serve communicative functions, but stress that the primary function of these gestures lies in the facilitation of speech production as they reflect motoric representations of some of the concepts expressed in speech. In a study by Emmory and Casey (2002) participants were asked to describe where to place puzzle pieces to complete a puzzle grid. Subjects produced more gestures in face-to-face sessions as compared to the condition where visibility to the addressee was restricted by a screen. Emmorey and Casey point out that their findings fail to support the hypothesis that gesture functions primarily to facilitate lexical retrieval and argue that gesture is an act of communication as well as an act of thought.

With regard to these conflicting reports Alibabi, Heath and Myers (2001) present a summary of the research on whether interlocutor visibility influences gesture production, providing information on how the various studies differ methodically (e.g., differences in the task, in the type of gestures examined, covert or open camera use). In their own experiment narrators told the content of short animated cartoon to a listener in both a face-to-face interaction and a screen condition. In the coding process *representational* gestures (depicting semantic content) and *beat* gestures (simple, rhythmic gestures without semantic content) were distinguished. Again it was found that representational gestures were used at a higher rate in the face-to-face condition. Beat gestures were used at similar rates in both conditions. Reconciling the conflicting findings in the literature the authors conclude that both representational and beat gestures serve speaker-internal *and* communicative functions.

Gesture as a means of compensating for impaired language in aphasia

With both the communicative and speech-encoding functions of gesture established, the question whether aphasic patients are able to utilize the nonverbal channel as a means of compensation for their impaired language facilities still needs to be considered more closely. Here again we enter upon the debate on a similar versus a differential breakdown of language and gesturing abilities in aphasia. In this section I will first report some results on gesture use as a means of compensation for the communicative aspect of language. Regarding the conflicting evidence of research teams methodological difficulties with the examination of gesture use shall then be mentioned. Finally a study focusing on the compensatory use of gesture for speech-production processes will be presented.

Gesture as a means of compensation for communicative purposes

In a study about intraindividual variations in aphasic language Wiener and Kaplan (1988) also employed the experimental design of restricted listener visibility. They observed that patients produced significantly fewer gestures per minute of speaking time when visual access between them and the interviewer was restricted than in the unrestricted condition, indicating the communicative function of gestures. The same result had already been observed in an earlier study by the same authors (Glosser, Wiener & Kaplan, 1986) where the gestural communication of aphasics was the main point of interest. Thus they clearly distinguished gestures with communicative value from movements that may occur only incidentally or that accompany encoding of gestural or verbal communication. The examined gestures were (1) *deictics* – pointing movements denoting the spatial or temporal location of a concrete object or event; (2) *pantomimics* – movements which mimic some visual or kinesthetic attribute of a concrete object or event, (3) *semantic modifying and relational gestures* – movements which modify, amend, or contrast with the content of communication in other channels (e.g., gestures indicating uncertainty or ambiguity about the communication such as palms up or circling, or emphatic gestures such as palms down or chops) and (4) *"other" gestures* which seem to have communicative intent but are not classifiable within the other specified categories. Within this scheme, deictic, pantomimic, and "other" gestures were considered as less complex than semantic, modifying, and relational gestures, which typically encode a wider range of discriminations and relationships between actors, objects, events and attributes. The communicative value of all these designated gestures was tested by eliminating visual access between interviewer and subject and the result of this manipulation was a significantly reduced production in the restricted condition as compared to the face-to-face condition. Furthermore, in the natural face-to-face interaction, no differences in the rate of gestural communication were found between the examined groups (5 mild aphasics, 5 moderate aphasics and 5 controls). However, the more severely impaired aphasic subjects showed a proportionally decreased use of the more complex communicative gestures while producing proportionally more of the non-specific, non-consensually shared, unclear gestures. Thus, rather than the pure frequency of gesture production, it was the pattern (specifically, the level of complexity) of gestural communication that correlated (negatively) with the linguistic impairment. The authors further noted that gesture production (with the possible exception of the "other" i.e. non-specific or unclear gestures) did not covary with instances of encoding difficulties in speech. Glosser, Wiener and Kaplan suggest that "rather, the major function of these hand and arm gestures appears to be the transmission of information to the addressee or decoder of the message, though", as they also admit, "they may also serve secondarily to aid the addressor or speaker to process and encode the information contained in a message" (1986, p. 355). With regard to fluency the data revealed that individuals who regularly produced longer, complete verbalizations without dysfluency and who could include more information in the oral-verbal channel (i.e., the fluent aphasics and controls) used fewer gestures per word, while the less fluent subjects produced more gestures per spoken word. These results are consistent with Goldblum's (1978) finding that anterior aphasics produce more gestures per word and also with the

Cicone et al. (1979) report that nonfluent aphasics produce gestures without accompanying speech more frequently then fluent aphasics and controls. While the communicative adequacy and success of the gestures that nonfluent aphasics may substitute for their impaired verbal communication was not directly examined in their study, Glosser, Wiener and Kaplan note that it is rather the "less complex, less specific, and less clear ("other") gestures which are most associated with increased dysfluency in speech (disruptions)" (1986, p. 357). Such a result speaks against the possible deployment of gesture as a compensatory means of communication. These "other" gestures are seen as representing both unsuccessful attempts of communication as well as difficulties in verbal encoding. In conclusion, the findings of this study were interpreted as consistent with the notion of a central communication disorder in aphasia, which disrupts referential communicative behavior in all channels in a similar fashion.

A different stance was taken by Herrmann, Reichle, Lucius-Hoene, Wallesch and Johannsen-Horbach (1988) who investigated whether in cases of severe aphasia, the verbal deficit can be compensated by the use of nonverbal strategies. In contrast to the studies described so far, the conversation setting under examination was more naturalistic, with close relatives of the patients chosen as communication partners rather than an at least to some extent unfamiliar interviewer. The subjects were 7 severely aphasic patients (classified as global aphasics by the Aachen Aphasia Test, AAT) who had suffered cerebral infarctions 12 to 78 months before the assessment. Four categories of nonverbal communicative behaviour were differentiated in this study: (1) *speech focused movements*, i.e. communicative actions that subserve spoken language and cannot be interpreted in isolation; (2) *descriptive gestures*, i.e. actions which convey information independent of spoken language and therefore can be interpreted in isolation; (3) *codified gestures*, i.e. codified actions, the use of which is not restricted to the given situation or context, but which are generally used in connection with or as a substitute for verbal utterances (e.g. nodding as a sign of approval); and (4) *pantomime*, i.e. actions of a complex, usually sequential nature which can convey information by their systematic and creative representation of meaning. In this study the authors found that aphasic patients communicated more frequently and for a greater amount of time by nonverbal means than their partners. Secondly, the aphasics used significantly fewer speech-focused movements and significantly more codified gestures than their partners. On the other hand, there was no difference in the use of descriptive gesture, and pantomime was infrequently used. Examination of the communicative function of produced gestures showed that aphasics employed nonverbal behavior more often as speech substitutes while their partners more often accompanied their verbal output by movements which revealed no recognizable meaningful or reflective connection with the verbal content. Thirdly, about three-quarters of the aphasics' nonverbal elements were rated as adequate and meaningful, contributing to the flow of information within the communicative context. Herrmann et al. conclude from these observations that even severe aphasics are able to use the symbolic signs of descriptive and codified gesture in natural conversation settings as means of compensation for their verbal deficit, switching "from one severely impaired channel of communication to one less affected" (1988, p. 52). Such a finding is in disagreement with a strong version of the "asymbolia" position.

The use of body communication as compensation for speech impairment was also addressed by Ahlsén (1991). Ahlsén interprets the results of earlier studies on non-fluent aphasics that showed that patients use gestures for conveying factual information (e.g., Cicone et al., 1979) as indicative of a compensatory function. She further illustrates, in a longitudinal single case study, that body communication can carry a large part of the communication burden in fluent aphasia. Patient HS was first videorecorded 3 years and 8 months after aphasia onset. At that time he showed fluent but mainly stereotypic speech with rich prosodic variation and rich body communication. The second recording was conducted after 9 months of language training, and the third and final recording after 18 months of language training. Comparison data were taken from ten aphasics with different symptoms and six non-aphasic controls. During his speech rehabilitation HS's verbal expression took a noticeable turn for the better: He started out using a lower number of content words but an excessive number of words totally, a pattern typical for Wernicke's aphasics. In the second recording, the number of content words had increased, however, in many cases HS resorted to using pronouns. In the third recording, this excessive use of pronouns had decreased and HS produced a total number of words and a relative share of content words that was very close to those of the non-aphasic controls. Interestingly, this pattern of gradual improvement in speech was supplemented by a gradually reduced use of body communication. As stereotypical phrases were avoided more and more, so were gestures conveying factual information (illustrators such as pointing, or emblems such as nodding). At the second recording, interaction-regulating gestures rose to a peak, in particular those regulating turn-taking: As HS was striving to produce lexical items, he had to keep his turns, as well as pass them over to the interlocutor for help. At the time of the third recording, nonverbal communication for turn-keeping was even more frequent, but had decreased for seeking the interlocutor's help. Thus it can be concluded that for this particular fluent patient, body communication initially filled the function of carrying factual information. As speech became more and more adequate, the use of gesture became less and less. Also, interaction-regulating body communication played an important part in the development of revised communication strategies. Ahlsén states that the observed "inverse relationship between the development of body communication and verbal expression and the development of communicative patterns over time strongly support the claim that body communication in this case had a clear compensatory function" (1991, p. 11). It is interesting to note that this patient's compensatory strategy of nonverbal communication had developed spontaneously, prior to any therapy.

As can be seen, evidence regarding coverbal movements in aphasia has been inconsistent and even contradictory, leading to differing interpretations of the issue at hand. While of course no two patients and no two cases of aphasia are completely alike, the varying results may also to some extent be due to methodological differences employed in the studies.

Methodological Difficulties in the Study of Coverbal Speech

With regard to the incoherent evidence on coverbal movements in aphasia Hadar (1991) points out how the reasons for these inconsistencies may derive from the methodological difficulties involved in the study of gesture accompanying speech.

Firstly, there may be problems concerning the resolution of the technique and the subjectivity of analysis methods. What was coded as a communicative gesture by one research team might have been regarded as irrelevant by a different team, leading to markedly divergent observations. Secondly, the classification of coverbal movements is highly diverse. As a result, evidence cited as contradictory could instead refer to non-identical, and maybe even incomparable types of movement. However, despite terminological disagreements there is some agreement on the existence of two basic classes of coverbal movements: those which bear a content of their own ("ideographic", "iconic", "illustrative", "object focused", "symbolic") and those who don't ("batons", "beats", "speech focused", "motor"). The movement configurations that are seen in the former class are usually rather complex and designed to carry meaning, while movements of the latter class are usually fairly simple and tend to be coordinated with speech rhythm (McNeill, 1985). However, as Hadar (1991) also points out, while the practical classification of movements into these two classes is relatively reliable on the basis of visual information only, determining the meaning of symbolic movements is heavily dependent on the accompanying speech. The third troublesome methodological issue, then, concerns the determination of the symbolic (pragmatic, semantic) coordination between gesture and speech, which is particularly problematic in aphasia. The failure to produce or perceive pragmatic coordination between gesture and speech may simply reflect impaired semantic processing and therefore not be reliable evidence for a gestural impairment. This point casts doubt upon evidence recruited as indicative of an autonomous gestural impairment in Wernicke's aphasia (see Cicone et al., 1979; McNeill, 1985). In addition, Hadar emphasizes the necessity of determining the classification of gestures without recourse to symbolic coordination. He maintains that symbolic and motor movements can be determined according to their kinematic properties alone as the former tend to be relatively wide in space and of long duration, while the latter are relatively narrow and of short duration.

Gesture as a means of compensation for speech production processes

In order to address issues mentioned above, Hadar (1991) employed a computerized movement analysis system (CODA-3) with high spatial and temporal resolution. Five fluent aphasics, four non-fluent aphasics and six controls were examined in regard to movement of head and upper arms. The major findings were as follows: (1) In normal controls and non-fluent aphasics the head moved more than the arms and its movement, unlike that of the upper arms, correlated with speech rate. According to Hadar, this supports the idea that head movement is linked to speech fluency, while arm movement is linked, at least partially, to other processes such as lexical and semantic processing. However, arm movement may also be linked to dysfluency since the occurrence of a dysfluency increases the probability of its occurrence. (2) Both aphasic groups showed an increased level of coverbal movement in both incidence and amplitude, with non-fluent aphasics showing the greatest movement-to-speech ratio. This result is indicative of compensatory mechanisms. Considering the relative amplitude and the ratio of head to arm movement, Hadar interpreted the compensatory mechanisms as primarily motor and partly lexical in non-fluent aphasics and as primarily lexical/semantic in fluent aphasics. (3) The kinematic regularity of the body movements of aphasics did not differ from that of normal controls (allowing for some variation in the non-fluent aphasics due to rigidity), suggesting the absence of serious deficits in the organization of coverbal gesture in aphasia as proposed by Goldblum (1978) and Feyereisen (1983). Hadar sees the increase in motor movements in the aphasic population as implying greater investment in their speech production processes. If aphasics increase their effort to communicate nonverbally, they also increase their effort to communicate verbally, and movement could be designed to support the latter as least as much as to support the former. The primary function of coverbal movement is thus viewed as serving speech production processes such as semantic focusing, lexical selection, syntactic segmentation, prosodic modulation or motor control. Such a thesis is supported by evidence that speech production may be enhanced by body movements, both motorically and symbolically (e.g., Rime, 1983), and by the already mentioned observation that in normal subjects, gestures tend to occur in association with speech dysfluencies, apparently as part of a repair effort (Butterworth & Beattie, 1978). Hadar (1991) mentions that absence of gestural impairment in aphasia as well as compensatory increase in coverbal movement (due to its facilitative role) would fit well into such an approach. One would expect moreover that the gestural increase would depend on the nature of the aphasic deficit: patients with a primarily symbolic deficit should show increases in symbolic movements, while those with motor deficits should show increases in motor movements. Hadar's results are consistent with these implications.

Neuropsychological implications for the role of gesture in speech production processes

In the examination of the relationship between language and gesture a lot of evidence has been gathered to further specify the role of coverbal gesturing in speech production processes. I will start off this section by introducing McNeill's (1985) notion of growth points and the common mental substrate from which speech and gestures are generated which has led to a detailed discussion about the interaction of gesture and language at various loci in the speech production process. Subsequently a series of studies concerned with the role of gesture for facilitating speech will be presented. At the end of the section observations of semantic representations and motor planning and execution as interactive processes will be found.

In contrast to views of gestures forming a quite separate channel of communication, McNeill (1985) proposed that far from being psychologically distinct, speech and the nonverbal gestures that often spontaneously accompany it "share a computational stage; and are, accordingly, parts of the same psychological structure" (p. 350). The gestures he examined were iconic gestures or *iconix*, which reflect in their shape and trajectory the meaning of the verbal output and "are not interpretable in the absence of speech" (p. 351) and *beats*, which "have no propositional content of their own" (p. 359). Beats are typically small simple movements and are held to have textual functions like emphasis. McNeill (1985) locates this shared computational stage very early in the speech production process, at a point where "the verbal plan is at an early stage" (p. 367) and where semantic and pragmatic functions are decided upon. Both speech and gesture then perform these functions in parallel. As one case of evidence for this claim, McNeill notes that gestures dissolve together with speech in aphasia, pointing to a common locus for control.

Feyereisen (1987) however stresses some problems with this argument and cites potentially relevant dissociations: ideomotor apraxia without aphasia as well as aphasia without apraxia (e.g., patients can pantomime the use of objects they are unable to name). In addition, Feyereisen points out that if the neural substrates of two distinct functions are anatomical neighbours, and especially if they share physiological support of a major blood vessel, then damage to one will likely also affect the other. Feyereisen also has another point of criticism. In the process of speech production, McNeill (1985) distinguished the already mentioned early stage, which is associated with "inner speech" and involves both speech and gesture, from a later stage associated with a "covert verbal plan". Gesture should be disturbed only if the early stage is affected in aphasia but should be fine if later processes are impaired. Thus aphasics should either exhibit no gestural deficits or always the same pattern of gestural disturbance. McNeill however mentions two different patterns: a disorder of iconic gestures in Wernicke's aphasia and a disorder of beats in Broca's aphasia. According to Butterworth and Hadar (1989) it is unclear how this pattern of disturbance can be explained by a single locus of damage. They maintain that “a more natural explanation is that gestures are linked to the production process at more than one locus, and that damage at a given locus will give rise to a particular disorder of speech along with a concomitant disturbance of gesture” (p. 169). McNeill suggests that the synchrony of speech and gesture provides further evidence for a single computational stage. This claim about relative timing is considered too vague by Butterworth and Hadar (1989) who present studies that demonstrate gesture onsets prior to related speech onsets, findings that mark gestures as potentially separable events. Butterworth and Hadar (1989) also mention that the observed synchronisation of features of speech and gesture (e.g. amplitude peaks) “may be the result of low-level timing coordination, rather than the consequence of the intrinsic temporal characteristics of the underlying processes, as in two-hand coordination.” (p. 171). McNeill’s third claim of support for a common origin of gesture and speech is that they reflect semantic and pragmatic functions in parallel modes. However, cases of gestures and speech displaying conflicting meanings (e.g., Freud, 1938) speak against a rigid parallelism, suggesting that the cognitive system is sufficiently flexible to allow a range of semantic and pragmatic relations between gesture and speech.

In spite of these disagreements with McNeill’s (1985) position, Butterworth and Hadar (1989) still view gesture as closely linked to speech, yet on more than just one computational stage of speech production. They propose that *globally* gesture and speech are autonomous, with one being able to occur without the other. During speech however, speech production processes dominate gesture production so that the latter must conform to constraints of the former. In particular, the authors propose that the stage where lexical items are selected in abstract form from a semantically organized lexicon will dominate iconic gestures, while a later stage in which stress has been assigned its sentence position will dominate beats. Postural shifts and preparatory phases of gesture that are coordinated with changes of turn and changes of topic will be dominated by pre-linguistic message construction. In contrast to McNeill, who argued that gestures simply operate parallel to speech, Butterworth and Hadar stress the facilitative role of gestures in the speech production process at multiple stages.

In a more recent study Hadar, Wenkert-Olenik, Krauss and Soroker (1998) aimed at further clarifying this facilitative function by looking at the production of ideational gestures (wide and complex gestures that tend to occur just prior to content words) in different groups of aphasics. According to Hadar et al.’s (1998) definition, ideational gestures can be *iconic* (having a form that is suggestive of the meaning of the related word), *deictic* (pointing to the spatial location of the presumed reference), *emblematic* (having a fixed, culturally-specific conventional meaning, gestural analogues of words) or *indefinite* (having the complex form of iconic gestures but no lexical affiliates or other clear significations). Twelve aphasic patients were divided into three groups with deficits at clearly different cognitive loci. The first group had conceptual deficits, i.e. deficits affecting early processes of message construction, reflected in the impaired ability to organize multiple arguments in propositional frames. The second group had word retrieval problems (anomia) characterized by a semantic impairment. The third group also presented with anomia but made errors that were phonologic rather than semantic. Hadar et al. (1991) hypothesized that the facilitative role of gestures in lexical retrieval should result in compensatory increases in the production of lexical gestures in the latter two groups. Similarly, if gestures facilitate preverbal message construction, then conceptual deficits should result in a greater incidence of indefinite gestures, due to the putative processing lag between the early point in which the shape of the gesture is determined (conceptual processes) and the later point in which a word is selected. Hadar et al. (1998) found evidence in support of gestural facilitation for lexical retrieval, as both the semantic and phonologic anomics showed increased gestural activity; the semantic more so than the phonologic, suggesting the primariness of semantics in regulating the facilitative effects of lexical gesture. They also found that gestures in the conceptual subjects originated early in processing, but the results didn’t suggest that gestures might facilitate conceptual processing, as this group did not gesture more than normal controls. The authors interpret this as a failure to integrate some of the available semantic and pragmatic constraints on gesture form due to a disinhibition of gesture release. It should be noted that the results of Hadar et al. include contradictory findings. Anomic subjects did not produce more ideational gestures when compared with controls, which would be expected if such gestures facilitate lexical retrieval. Another problematic point in this study is that the operationalization of the impairments suffered by conceptually deficient patients seems to broad to support the experimenters’ predictions.

Considering the implications for the functions of ideational gestures Hadar et al. (1998) conclude that firstly, some ideational gestures ('lexical') facilitate word retrieval. These can be iconic or indefinite and may be of two kinds: They are either evoked to overcome a retrieval difficulty (marked by onset during a non-juncture pause) or as a speech-productive routine, irrespective of a retrieval difficulty. Butterworth and Hadar (1989) ascribe all lexical facilitation to failure-driven gestures. In their model, a difficulty in lexical retrieval initiates a second search for the target word or for an adequate alternative word. This reactivates a relevant set of conceptual processes, which in turn evoke related visuospatial images, aimed at obtaining additional semantic cues. In this view gestures function only in order to maintain or reinforce imagist activation. The second kind of lexical gesture, not associable with a retrieval failure, is inferred from two facts: firstly, the low proportion of gestures starting in non-juncture pauses in unimpaired controls; secondly, the lack of evidence for conceptual facilitation. Hadar et al. state that "by inference, some of the gestures which start during fluent speech, in addition to gestures starting during non-juncture pauses, must facilitate word retrieval" (1998, p. 123).

Some researchers, e.g. Krauss et al. (1996), ascribe all lexical facilitation to this kind of gesture. They suggest that conceptual processes routinely activate certain non-propositional representations, probably spatial and motoric. The activation of these representations is fed into the semantic lexicon and raises the level of activation of selected sets of lexical items that are conceptually related to the intended message, in a manner of priming. Note that according to Krauss et al. (1996) the gesture has to be actually performed in order to activate motor and spatial representations in a format capable of producing priming effects. All spatial concepts activate a gesture, but gesture is "switched off" by lexical selection. From this perspective, the high rate of gesture in anomic patients and during hesitation pauses could be due to the absence of a gesture-switch-off. Hadar et al. (1998) conclude that their data provide further evidence for the existence of this second kind of lexical facilitation, since conceptual facilitation, which had been thought to explain non-pause gestures, was not observed.

That physical actions and sensations relevant to semantic features of words directly influence on-line processing of these words has also been demonstrated by Klatzky, Pellegrino, McCloskey and Doherty (1989) who found that subjects performing a sensibility judgement task could produce responses more quickly if they assumed a posture in accordance with the word or phrase's meaning. Gentilucci and Gangitano (1998) showed the involvement of language in visuo-motor transformations by observing reaching movement for targets inscribed with the words "long" or "short". In a subsequent experiment Gentilucci, Benuzzi, Bertolani, Daprati and Gangitano (2000) also found word-gesture Stroop effects in such an experimental setting, i.e. the kinematics of grasping/reaching movements were deformed when the target object was inscribed with a word incompatible with the action (e.g., reaching up for an object labelled "down"). Similarly, Glenberg and Kaschak (2002) reported an "action-sentence compatibility effect", whereby when a sentence implies action in one direction (e.g., away from the body), participants have difficulty making a sensibility judgment requiring a response in the opposite direction (e.g., moving hand to a button box towards the body). Such experiments provide empirical evidence for the view that semantic representations and motor planning and execution are interactive processes.

New insights about the neural representation of language and gesture in the brain

Drawing upon findings such as reported by Klatzky et al. (1989), Bates and Dick suggest that gesture might be a "second window" onto speech planning at a preverbal semantic-conceptual level (2002, p. 298). In addition to behavioral findings, recently the discovery of the so-called "mirror neuron system" has added a new dimension to research concerning the neural representation of action and possible associations to language.

Mirror neurons are a particular class of visuo-motor neurons that were first found in the area F5 in the ventral premotor cortex of monkeys (Gallese, Fadiga, Fogassi & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese & Fogassi, 1996). These neurons fire both when the animal is planning a specific arm movement or gesture and also when the animal observes someone else performing that movement. Moreover, this region appears to correspond to Brodmann areas 44 and 45 in human neurological architecture, cytoarchitectonic regions that are often referred to as "Broca's area" (Petrides & Pandya, 1994; see also Rizzolatti, Fogassi & Gallese, 2002). In recent years the existence of a similar "mirror system" in humans has been demonstrated by a variety of electrophysiological studies (Fadiga, Fogassi, Pavesi & Rizzolatti, 1995; Hari et al., 1998; Strafella & Paus, 2000). Further evidence on the localization of the human mirror system has been obtained in PET and fMRI studies where activation in premotor and inferior frontal cortical areas (as part of a larger network involving superior temporal and parietal regions) are found during action observation and imitation experiments (e.g., Grafton, Arbib, Fadiga & Rizzolatti, 1996; Iacoboni, Woods, Brass, Bekkering, Mazziotta & Rizzolatti, 1999; Rizzolatti, Fadiga, Matelli, Bettinardi, Paulesu, Perani & Fazio, 1996). More specifically, there is evidence that Broca's area (BA 44) is involved with imitation of others' actions (Heiser, Iacoboni, Maeda, Marcus & Mazziotta, 2003; Iacoboni et al., 1999; Nishitani and Hari, 2000).

All this evidence seems to indicate a very closely interwoven relationship between language and action. Thus here may be the point of overlap between the neural substrates for gestures on the one hand, and language on the other, as it is known that Broca's area is implicated in the planning and articulation of speech and in language processing. This suggests that "perception, imitation, and spontaneous production of language are superimposed on a broadly distributed set of neural systems that are shared with the perception, imitation, and spontaneous production of manual gestures" (Bates & Dick, 2002, p. 299). According to Rizzolatti and Arbib (1998), the development of the human lateral speech circuit can be seen as a consequence of the fact that the precursor of Broca's area was endowed, before the appearance of speech, with a mechanism for recognizing actions made by others. According to these authors, the mirror system (located in F5/Broca's region where also the neural structures for controlling oro-laryngeal, oro-facial and brachio-manual movements can be found) was the neural prerequisite for the development of interindividual communication and finally of speech.

However, it should not be assumed that language and gesture are represented in one and the same brain area in exactly the same way, or that there are no areas of the brain which are relatively more important for one or the other. If this was the case, there would be no patients who exhibited dissociations in one domain over the other – as evidently some do. According to this kind of view, whether a patient would display correlated impairments in speech and gesture would not only depend on factors such as the site of brain damage, individual differences in premorbid brain organization, post-injury recovery, but also on the method of assessment and testing, which as mentioned above, can be a significant source of variability in this field. It will thus be very important to rethink our language and gesture assessment methods in the light of new findings from the "mirror neuron" perspective that action and language representations in the brain may be more related than previously thought.

Thus we are presented with a new view of the linkage between gesture and language, which still leaves much scope for further research, but allows a modern perspective for the interpretation of empirical findings from neuropsychology. With this modern view, we might be able to integrate the diversity of observed behavioral patterns in aphasia, without ascriptions to "asymbolia" or "movement disorder" positions.

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