The semantic specificity hypothesis: When gestures do not depend upon the presence of a listener

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Abstract

Humans gesture even when their gestures can serve no communicative function (e.g., when the listener cannot see them). This study explores the intrapersonal function of gestures, and the semantic content of the speech they accompany. Sixty-eight adults participated in pairs, communicating on an object description task. Visibility of partner was manipulated; participants completed half the task behind a screen. Participants produced iconic gestures significantly more for praxic items (i.e., items with physically manipulable properties) than non-praxic items, regardless of visibility of partner. These findings support the semantic specificity hypothesis, whereby a gesture is integrally associated with the semantic properties of the word it accompanies. Where those semantic properties include a high motor component the likelihood of a gesture being produced is increased, irrespective of communication demands.

Key words: Gesture Semantics Communication

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INTRODUCTION

Mary is directing someone to her office over the telephone. As she describes the route, she is making movements with her free hand. It rises vertically as she mentions taking the lift to the fifth floor. It chops the air as she tells the visitor to keep going straight on. The person on the other end of the telephone cannot see Mary, so just whom are the gestures for and why does Mary appear to produce them automatically and without awareness?

Gestures that accompany speech have traditionally been considered communicative. One commonly held view is that a speaker's gestures enhance the listener's reception of the message, and there is some support for this proposition. Studies have found greater effectiveness of communicating a message with gestures than without (e.g., Beattie & Shovelton, 1999; Kendon, 1980); others have found a higher rate of gesturing when speakers are face-to-face, compared to when the listener is out of sight (Alibali, Heath, & Myers, 2001; Krauss, Dushay, Chen, & Rauscher, 1995). Nonetheless, speakers do still gesture when the visible communicative demands are removed, as when a listener is out of sight. Also, gestures are not always crucial to understanding since listeners understand a variety of messages that are delivered without gestures. Studies that manipulate listener visibility do not find that gestures disappear when the partner is out of sight, merely that they reduce in frequency. This paper asks, why do some gestures persist in spite of visibility manipulations and what characteristics do they share? One aim is to identify the semantic properties of the words associated with hard-to-extinguish gestures. In so doing, this study sheds light on the intrapersonal, non-communicative function of gestures.

Despite some evidence for the communicative function of gestures, research since the 1980's, with both children and adults, has demonstrated the benefit to the *speaker* of gesturing. A look at how gesture is tightly coupled to the development of the language system demonstrates this. Manual actions play a crucial role in the development of speech, from when the infant first begins to babble, with hearing babies born to deaf parents even babbling with their hands (Petitto, Holowka, Sergio, & Ostry, 2001). Early milestones in gesture and language co-emerge developmentally, with the infant's first deictic gesture preceding the first word and gesture-speech combinations reliably predicting the onset of two-word speech (Bates & Dick, 2002). Furthermore, blind babies also produce gestures with the onset of language and their gestures resemble those of sighted infants (Iverson & Goldin-Meadow, 1997), even though they have never seen another person gesturing or learned the communicative utility of gesturing. Adults, of course, continue to produce co-speech gestures without conscious effort or thought and sometimes gesture when they cannot be seen, as in the example of Mary on the telephone.

Thus it would appear that we gesture as much for our own benefit as for the benefit of others. Is it possible to distinguish empirically between gestures that serve an *inter*personal function, and those that are *intra*personal? Put simply, do the interpersonal gestures disappear when a listener cannot be seen and do those gestures that remain have an *intra*personal function?

Several researchers have commented on the non-communicative – or intrapersonal – functions that gesture might serve (for a review see Krauss, 1998). Restricting or preventing gesture has been found to have a detrimental effect on the speech of both children (Pine, Bird, & Kirk, 2007) and adults (Rauscher, Krauss, & Chen, 1996), thus implying a linguistic facilitation role for gesture. Morsella and Krauss (2005) found that gesturing increases with lexical access difficulty; adults in their study gestured when in a tip-of-the-tongue state, even though the experimenter present knew the word they were attempting to retrieve. These and other studies have led a number of researchers to claim that the intrapersonal function of gestures is to facilitate access to the mental lexicon.

Gestures have been shown to serve cognitive as well as linguistic purposes, being involved in the thought processes required for speaking and in the construction of the pre-verbal message. The Information Packaging Hypothesis (Kita, 2000) proposes that gestures are implicated in the process of integrating nonverbal information into a format that is available for speech. Similarly, Freedman argues that gestures help to maintain the representation of a concept in preparation for speech delivery (Freedman, 1977, Freedman, van Meel, Barroso, & Bucci, 1986). Models such as these see gestures as operating more at the conceptual, rather than the lexical, level of speech production but still attribute to them an intrapersonal function.

Even studies that demonstrate the communicative function of gesture allow that some gestures may serve both the listener and the speaker. In a study that manipulated the communication and lexical access demands on the speaker, Jacobs and Garnham (2007), using monologue cartoon narratives, varied the novelty of both the target material and the listener and observed the effects on gesture. They found that when the speaker repeated the same narration three times to the same speaker, the rate of gesture fell over the course of the three narrations, albeit by less than 50%, but remained similar (less than 10%) when repeating to 3 different speakers. Jacobs and Garnham claim support for the communicative function of gesture but also acknowledge that the effects may be restricted to this type of task and that “it is possible they are restricted to a particular category of gesture” (2007, p. 297). Their caution is warranted, since half as many gestures were still produced in the condition where both communication and lexical demands were at their lowest. When evaluating the lexical and communicative contributions they state that “gestures may serve both functions” although in different contexts the primary function may vary (p.292).

Visibility manipulation is a plausible way to test the communication hypothesis. If speakers gesture more when they can see the listener, then the gestures they produce may have been generated to facilitate communication. Alibali, Heath, and Myers (2001) conducted a study where they manipulated the visibility of the communicative partner while participants narrated a cartoon. They then measured the production rate for representational and beat gestures. Their study asked whether the discrepant findings could be explained by some types of gesture being affected more than others by the visibility of the listener. Their speakers produced a significantly higher rate of representational gestures in the visible condition, but there was no difference for beat gestures. Alibali et al. propose the *semantic information hypothesis* wherein representational gestures are affected by visibility manipulation, since they convey semantic information. In contrast, beat gestures are not similarly affected because they do not convey meaning and cannot serve a communicative purpose. Noteworthy, however, is the finding that, “even though speakers produced more representational gestures when they could see their listeners, they produced such gestures at *surprisingly high rates* when the screen was in place” (2001, p. 178, italics added). When the listener was visible, speakers gestured at the rate of 8.37 representational gestures per 100 words. Yet when the listener was behind a screen the speakers still gestured at a rate of 5.65 gestures per 100 words, which is still a high rate of gesture when the listener is not visible. Therefore, although their study found some support for the communication hypothesis, Alibali et al. assert, “no definitive conclusions can be drawn based on the finding that representational gestures did not disappear….. in the screen condition” (2001, p.183).

This body of evidence, and Alibali et al’s (2001) semantic information hypothesis, converge on a view that the production of a certain category of gesture may vary according to communication demands. Beattie and Shovelton (2002) also claim that some representational or iconic gestures, i.e., those that convey semantic information about the word or concept, may be more communicative than others. However, the properties of the word the gesture accompanies, rather than the type of gesture produced, may account for differences in gesture production under differing visibility conditions. Krauss (1998) demonstrated that the spatio-dynamic features of concepts are reflected in gesture. Rauscher et al (1996) found that gestures occurred three times more often when participants' narratives contained spatial prepositions. Speech with a spatial content was also more detrimentally affected by gesture prevention than non-spatial speech. Feyerseisen and Havard (1999) found more gestures in participants' answers to questions requiring motor imagery than in those about visual or abstract topics.

There is corroborating evidence from recent brain imaging studies, which have identified specific *motor* cortex activation when people name an object with praxic (manipulable) properties (Weisberg, van Tourennout, & Martin, 2007) as well as recent findings that gestures and speech share the same motor control system (Gentilucci & Della Volta, 2008). In an empirical study with children Pine, Bird, and Kirk (2007) observed that they gesture more when naming objects with a strong praxic-motoric component (e.g., *binoculars, whisk* and *rolling pin*) than when naming those without. Morsella and Krauss (2005) also found that words rated as concrete, drawable, spatial and manipulable were more highly correlated with gesturing. Krauss argues that gesture research needs to address these semantic discrepancies and to determine the conceptual properties of words whose retrieval is associated with gesturing, adding that, "We do not know whether these gestures accompany all kinds of speech content, or occur more when people speak about some things than others" (2005, p. 416). Therefore, even within iconic, or representational, gestures that are semantically related to the words they accompany, some words are more likely to elicit gestures than others. This study aims to explore this further and seeks to increment our understanding of the semantic specificity of words associated with intrapersonal gestures.

Tasks used to investigate gestures tend to fall into two types: narration tasks and cognitive tasks. In addition, manipulations within the tasks include producing rehearsed as opposed to spontaneous speech (e.g., Chawla & Krauss, 1994), preventing speakers from gesturing (Frick-Horbury & Guttentag, 1998; Pine et al., 2007; Rauscher et al., 1996) or manipulating visibility (e.g., Alibali et al., 2001). Narration tasks generally involve participants watching a cartoon and then narrating it to a listener, and these have been found to reliably elicit gestures (Alibali et al., 2001; Beattie & Shovelton, 1999; McNeill, 1985; Ozyurek, & Kita, 1999; Rauscher, Krauss, & Chen, 1996) or describing the sequence of events depicted in comic strips (Jacobs & Garnham, 2007). These discourse tasks allow for the examination of the gestures that accompany individual clauses, usually removed from context and rated by judges (see Beattie & Shovelton, 2002).

Cognitive tasks, of the type employed in this study, elicit gestures by giving participants visual and/or verbal information. Some require the speaker to name a pictured object, a procedure well suited for patients with neurological damage resulting in aphasia (Rose & Douglas, 2001) or with children (Pine et al, 2007) or with the target object either present or absent (Morsella & Krauss, 2004; Wesp, Hesse, Keutmann, & Wheaton 2001). Others require speakers to identify target word from definitions (Frick-Horbury & Guttentag, 1998; Morsella & Krauss, 2005) or to provide verbal responses to questions (Feyereisen & Havard, 1999). Although the verbal production in these tasks does not always emulate spontaneous speech, they do allow for more systematic control over the speech content to be elicited, e.g., praxic and non-praxic, in the case of the task chosen for the present study. Here we asked participants to describe pictured objects to a partner. The task was chosen because it places demands upon both the lexical (accessing descriptive words) and communication (getting information across accurately to a partner) systems.

Therefore in this study we manipulated both the semantic properties of words and visibility of partner, to determine the types of words for which gestures persist when communicative demands are removed. We propose the *semantic specificity hypothesis*, which states that iconic gestures are more likely to occur with some types of speech than others. An iconic or representational gesture is integrally associated with the semantic properties of the word it accompanies. Where those semantic properties include a high motor component the likelihood of an iconic gesture being produced will be increased, irrespective of communication demands.

The gestures as communication hypothesis would predict that the presence of a partner would lead to a higher rate of gesture production, resulting in a main effect of visibility. However if gestures serve a more intrapersonal function the visibility manipulation should produce no difference. If gestures are primarily intrapersonal and dependent upon the conceptual properties of the words they accompany, the semantic specificity hypothesis predicts a main effect of object and no interaction, i.e., participants will produce more iconic gestures for praxic than non-praxic items, whether they can be observed by a partner or not.

METHOD

Design

The study employed a repeated measures design comparing frequency of production of iconic gestures, for words with either a praxic or non-praxic component, under within-subjects conditions of visibility and non-visibility of partner.

Participants

Sixty-eight university students, 42 females and 26 males, with ages ranging between 18 and 45 took part in the experiment in randomly selected pairs for course credit. During piloting, 50 adult participants provided ratings for the stimuli for the object description task.

Materials and Apparatus

The object description task comprised pictures of 20 objects, 10 praxic (telephone, iron, piano, vacuum cleaner (or 'Hoover'), scissors, dart, dental floss, stopwatch, razor, and stapler) and 10 non-praxic (radiator, tree, chicken, goal post, teeth, fish, rug, grapes, fence, and sound speakers). The objects were selected from a larger set of stimuli rated by 50 adults on a 5-point scale for *manipulability* ('*Manipulability* refers to how manipulable the object is and to what extent you use your hands to use it'). From the ratings, the 10 target items with the highest praxic, and 10 with the lowest praxic ratings were selected. (Mean manipulability rating, non-praxic items 1.01 (SD = .41), praxic items 4.40 (SD = .72), t (18) = 14.20, p =.001.)

Twenty numbered laminated cards, approximately 4" x 3", each displayed a black and white image of either a praxic item (e.g., scissors) or a non-praxic item (e.g., tree) with the item name printed underneath.

Participants were filmed in a laboratory; two separate video cameras filmed each participant independently; an overhead microphone recorded the audio conversation. The two videos were subsequently combined onto VCR videotape for analysis. Gestures were coded from the videotapes using a computer with the Noldus Observer XT software.

Procedure

Participants sat opposite each other across a table that split into two halves. Half of the task was carried out with the partner in view, and half with a screen between them. Praxic

and non-praxic items were interspersed within each set of 10 cards so each participant had 5 praxic and 5 non-praxic items to describe. After a practice trial, participants took turns turning over a card and describing the item on it to their partner without naming the object. The partners were required to guess the name of the object being described to them. The partner was allowed to guess as many times as they wanted, but the describer could not move onto the next trial until the correct answer had been given. After 10 cards had been attempted the experimenters then manipulated visibility by moving the screen either into the table gap or away from it, and gave the pair of participants a further 10 cards and asked them to continue. Although participants' view of their partner was completely obscured when the screen was present audibility was still good. Participants were aware they were being filmed.
Coding: Videos of the task were coded using the Noldus Observer XT software. The coder, who was aware of the purpose of the study, watched each of the recorded videos twice (once at an adjusted, slower speed) to ensure all gestures were coded accurately. All gestures relating to the object's function or shape were coded as iconic gestures (i.e., for floss: "you [use this in your mouth]" and for darts: "you throw these at a [round] board with [lines] on it). Beat (repetitive movements, such as tapping) and self-adapters (e.g., rubbing chin, scratching head) were also coded separately. Other types of gesture (e.g., pointing) occurred rarely and were not coded. Inter-rater reliability was confirmed by having a second rater, who was blind to the purpose of the study, code a subset of the sessions, with 90% agreement reached between the two raters (Kappa =0.11, p=0.00).

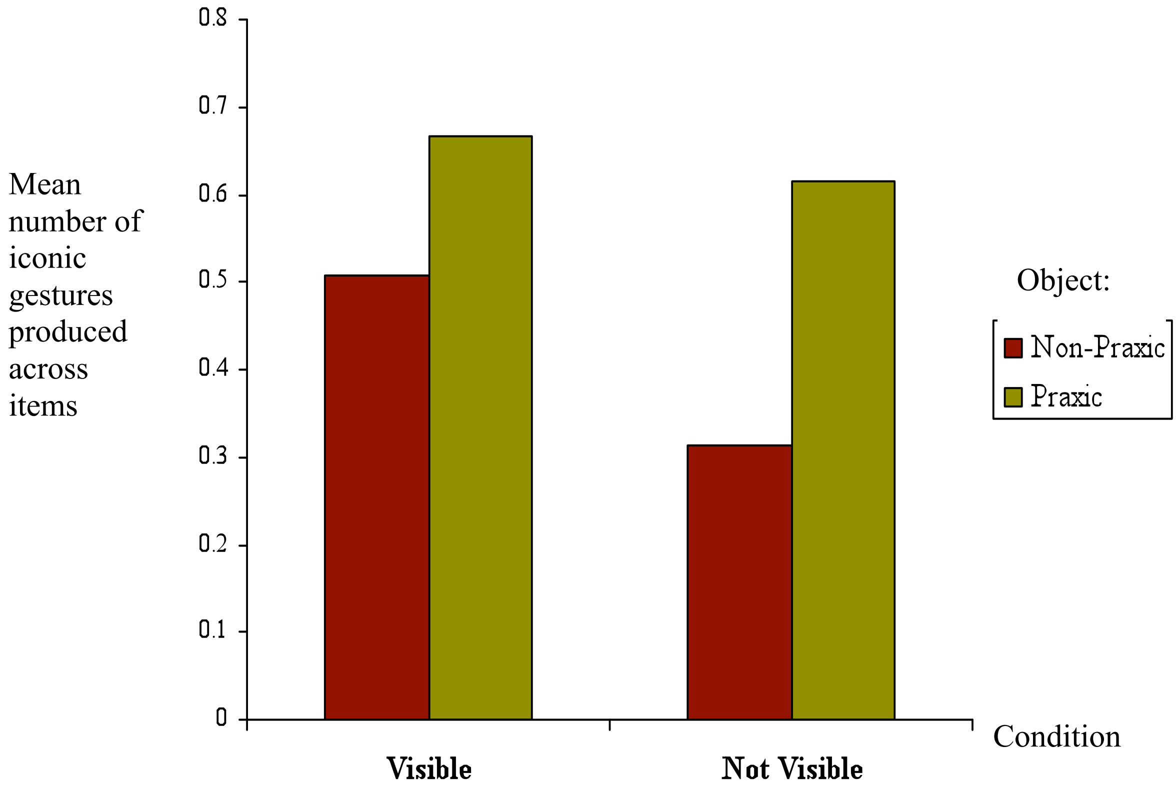
RESULTS

Our results focus on the iconic, or representational, gestures produced by participants when describing the objects under each condition (visible/non-visible). A gesture that was semantically linked to the objects' physical nature (representing either its function or shape) was coded as an iconic gesture. Beat and self-adaptor gestures were also coded but were infrequent (these gestures bear no semantic relevance to the speech content and tend to occur more with spontaneous speech, occurring on narration or discourse tasks). Beat gestures accounted for 37.7% of the gestures in the study and occurred in both the visible ($M = 0.03$ gestures per min, $SD = 0.05$) and the non-visible ($M = 0.05$ gestures per min, $SD = 0.07$) condition but were excluded from the analysis.

Gesture Production

The gestures the participants produced were measured as they described each object. Measurements were made of the number of iconic gestures produced by the describing partner on each object description trial and these were collated according to praxic and non-praxic objects for each condition. On average, participants spoke for 5.04 seconds (SD = 3.33) for each trial. The data were entered into a two-way repeated measures analysis of variance (ANOVA) with object praxis (praxic, non-praxic) and condition (partner visible, partner non-visible) as the two factors and iconic gestures as the dependent variable. Overall, participants gestured on 6.5 (out of 10) praxic items (*M per item* = 0.65, $SD = 1.22$) and on 4.1 (out of 10) non-praxic items (*M per item* = 0.41, $SD = 0.85$). The mean number of gestures produced in the visible condition was 0.59 ($SD = 1.26$) and 0.47 ($SD = 0.8$) in the non-visible condition (see Figure 1). There was a main effect of praxis ($F(1, 67) = 4.49, p < .05$), no main effect of visibility ($F(1, 67) = 0.81, p = 0.37$, ns), and no significant interaction ($F(1, 67) = 0.45, p = .50$, ns). Therefore, participants appeared to gesture more for praxic items, whether a partner was visible or not. Analysis of simple effects were non-significant and low, nonsignificant correlations were found in the amount of iconic gestures performed between the pair members in both the visible and non-visible conditions

Figure 1: The mean number of iconic gestures produced in the object description task, by condition.



To rule out the possibility that the difference in gestures for praxic and non-praxic objects may have been due to participants speaking for longer about one group of objects, a subset of the videos where the quality of the recorded speech was high (40 participants' data) was coded to ascertain the rate of gesture in relation to the duration of speech. Iconic gesture rates were higher when describing praxic items (*M* = 4.53 gestures per min (g/min), *SD* = 7.36) than non-praxic items (*M* = 1.95 g/min, *SD* = 4.44). There was little difference in iconic gesture production whether the observing partner was visible (*M* = 3.40 g/min, *SD* = 6.59) or not (*M* = 3.09 g/min, *SD* = 5.82). A repeated measures two-way analysis of variance (ANOVA) found no effect for visibility (F (1, 39) = 0.12, p = .74, ns), a main effect for praxis (F (1, 39) = 12.51, p < .01) and no interaction (F (1, 39) = 1.04, p = .31, ns), thus confirming the previous analysis.

DISCUSSION

Some co-speech gestures remain ubiquitous even in the absence of a visible communicative partner. The aim of this study was to address the issue of why people persist in gesturing when a listener is not visible, and the properties of words that accompany those apparently intrapersonal gestures. This is relevant to a number of alternative theories and explanations for why people gesture. Although empirical studies have demonstrated that a speaker gestures in order to communicate to a listener, there is also considerable evidence, supported by the findings here, to show that it is not unusual for people to gesture when they cannot be seen. In this study we explored some of the semantic properties of speech content that accompanies the gestures people produce when the partner is out of sight.

Although gestures have some communicative purpose, this does not appear to be their main function. They serve multiple intrapersonal functions, one of which may be to facilitate access to words in the mental lexicon. This is likely to occur by a process of cross-modal priming (Krauss, 1998) and by examining further the properties of words that are likely to be accompanied by gesture we can begin to shed some light on this issue. Our findings show that words with a high praxic element, i.e., words for objects that were manipulable, consistently elicited more iconic gestures than non-praxic words, whether the partner could be seen or not.

Why should people persist in producing more iconic gestures for speech relating to praxic than non-praxic items? Since motor actions are performed on praxic objects, there is clearly a spatio-motoric component underlying the linguistic representation. Neuropsychological explanations for the co-occurrence of gesture with speech that has a spatio-motoric content propose that motoric action is related to speech production. Wesp, Hesse, and Keutmann (2001) contend that gestures maintain spatial concepts in memory during lexical search. This is corroborated by findings from patients with neurological damage and by the Gestural Feedback Model (Morsella & Krauss, 2004), which ascribes more than direct lexical facilitation to gesture. Their model argues for gestures activating features that make up the semantic representations of target words through feedback from effectors or motor commands, supported by Weisberg et al's (2007) finding of localised motor cortex activation when people name an object with praxic properties. The increase seen in gesturing for words with a praxic element suggests that gestures do not act as direct lexical primes but that the process of activation may be mediated by spatio-motoric brain processes.

A range of tasks have been used in the field of gesture research. The object description task employed here required participants to describe a pictured object to a partner, who had to ascertain what was being described. This goes beyond simple picture naming tasks, by introducing some lexical constraints, and adds a communicative component without encountering some of the difficulties that arise from lack of control with narration tasks. By recording the gestures of the participant producing the description, a number of aspects of the process were controllable. First, the participant's speech was constrained by not being able to name the object before them. This forced them to try to find alternative descriptors, thus increasing the lexical demands on the speaker. This is not dissimilar to inducing a tip-of –the-tongue state in the speaker, a method that has been employed in other gesture studies (Frick-Horbury & Guttentag, 1998; Pine et al., 2007). Intrapersonal explanations of the function of gesture claim that greater lexical difficulty will be accompanied by an increase in gesturing, occurring whether the partner was visible or not. Second, the speaker was describing the object in order for their partner to be able to identify it. This placed the task in a communicative context and created an opportunity to observe whether gesturing increased when the partner was visible. This was not found; there were no differences in gesture rate whether the partner was visible or not. A third variable was introduced into the stimulus set, by having objects that were either praxic or non-praxic in nature. Again, if gestures are primarily communicative this manipulation of the properties of the objects should not have made a difference. The finding that participants gestured more for praxic objects, irrespective of partner visibility, could be said to argue against this view. Although there was communicative pressure on the speakers, they still gestured more for praxic objects when they could not be seen.

It could, of course, be argued that humans become so accustomed to gesturing for communicative purposes that they produce non-communicative gestures out of habit or simply because they are unable to repress automated motor processes. This may explain why participants continue to gesture for some non-praxic items, albeit to a lesser extent than praxic items. Was this the sole explanation, however, one would expect gesturing to continue to the same extent for all word-types. The findings presented here - for the semantic specificity of gesture persisting whether a partner is present or not - suggest there is an intrapersonal function for gesture when speaking about items with manipulable properties. Whilst the nature of this task and the presence of a partner cannot rule out the possibility that the gestures were linked to the speaker's communicative intent, the difference in gesture production for praxic words seems to lend support to the semantic specificity hypothesis. As well as showing that blind babies gesture from birth (Iverson & Goldin-Meadow, 1997), Goldin-Meadow also points out that "if speakers who have been blind from birth gesture when they speak, it tells us something about how important – or in this case, how unimportant – seeing gesture is to using gesture" (Goldin-Meadow, 2003, p.10).

This study supports previous research suggesting that certain types of words consistently evoke a higher gesture rate. Rauscher et al. (1996) demonstrated gesture elevation with spatial components of speech, Beattie and Shovelton (2002) found that some gestures were less communicative than others, and Feyereisen and Havard (1999) found an association between describing motor tasks and gesture production. Morsella and Krauss (2005) identified the properties of words that increased gesture production, finding them to be concrete, drawable, spatial and manipulable. These findings suggest that praxis is also coupled to gesture production and relates closely to the function of the object, for which there is a neurological evidence base. Functional magnetic resonance imaging showed that a distributed network of neural activity occurs when a person not only recognises, but also has experience of manipulating, objects used to perform specific tool-like tasks. They also do so with faster response times than to items that they have not manipulated (Weisberg, van Tourennout, & Martin, 2007). When speakers gesture the function of an object they not only access the representation in the mental lexicon but also its functionality in the pre-motor cortex. Gentilucci and Dalla Volta (2008) argue that language may have evolved from manual gestures, rather than from primitive vocalisations, because these actions tie in more closely with the objects and actions in the physical world, and hence speech and arm gestures share the same control system. Willems and Hargoot (2007) agree that this has resulted in a system where language and action recruit overlapping parts of the brain and share the same neural substrates. By recruiting more brain pathways in the process of producing a verbal utterance the speaker increases both the speed, and the chance, of accessing the word and this accounts for much of the behavioural data finding an intrapersonal function for gesture.

It is acknowledged that the conclusions drawn from this study offer little by way of explanation about all conversational gestures. There is inevitably a trade-off between controlling the context and type of speech produced in a laboratory-based experiment and spontaneity of speech, as well as some compromising of ecological validity. Furthermore, the findings relate only to concrete nouns and tell us little about gestures accompanying speech with more abstract properties. Indeed, there are many unanswered questions still outstanding in this area and we do not claim to have answered them all. Our findings simply provide more detailed evidence about the semantic specificity of co-speech gestures that cannot be explained by communication demands. This specificity will be further elucidated by careful consideration, also, of neuropsychological evidence that is emerging about the motor brain pathways recruited during speech. These questions, and others, render this area ripe for future research if we are to understand more about the mechanisms between speech, gesture and underlying motor and cognitive processes.

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