Left-Hand Gestures Advantage on Metaphor Explanation: Evidence for Gestures' Self-Oriented Functions

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Abstract

Research suggests that gestures influence cognitive processes, but the exact mechanism is not clear. Additionally, it has been shown that when a linguistic task (metaphor explanation) involves the right brain hemisphere, the left hand becomes more gesturally active. We hypothesized that gestures with a particular hand activate cognitive processes in the contra-lateral hemisphere. We examined whether gestures with the left hand enhance metaphoricity in verbal responses. Results showed participants produced more metaphoric explanations when instructed to produce gestures with their left hand as compared to the right hand or not gesture at all. In addition, we measured the mouth asymmetry during metaphorical speech to determine individual differences in right-hemisphere involvement in metaphor processing. The left-side mouth dominance, indicating stronger right-hemisphere involvement, positively correlated with the left-hand-over-right-hand advantage in gestural facilitation of metaphorical speech. We concluded that left-hand gestures enhance metaphorical thinking in the right hemisphere.

Keywords: Metaphor; representational gestures; brain hemispheric lateralization; mouth asymmetry.

Introduction

Several theoretical accounts have proposed the relationship between gestures and cognitive processes. According to the Lexical Retrieval Hypothesis gestures promote and facilitate speech on a surface level. Gesture related information enters the speech production system to help the grammatical and/or phonological encoding (Krauss & Hadar, 2001). Alternatively, according to the Image Maintenance Hypothesis (de Ruiter, 2000) gestures help the working memory maintain mental imagery during speech production. Finally, according to the Information Packaging Hypothesis (Alibali, Kita, & Young, 2000; Kita, 2000) gestures help speakers at the conceptualization level, i.e. to formulate the concept to be uttered.

The abovementioned theoretical accounts, which are complementary and not mutually exclusive, provide alternative explanations of the various cognitive processes that gestures may influence. However, there is a lack of conclusive evidence about the relevant process type (for a review see Kita, 2000). Furthermore, the mechanism through which gestures influence cognitive processes has been studied very little. This study attempts to bridge this gap by exploring the neural mechanism underlying gestures' self-oriented functions; that is the effect that gestures – and in particular representational gestures – have for those who produce them. We aim to determine if gestures influence thinking by activating cognitive processes in the hemisphere contra-lateral to the gesturing hand. This hypothesis is plausible because the hand choice for gesturing depends on the brain hemisphere that is predominantly active in a given linguistic task. In particular, Kita, de Condappa, and Mohr (2007) have shown that in right-handers the right-hand over left-hand preference for gesturing is significantly weaker whilst interpreting metaphoric expressions compared to non-metaphoric ones. This finding has been explained in terms of the key role that the right hemisphere has in the processing of figurative language (following the Right Hemisphere Hypothesis for Metaphor; see for example, Brownell, et al., 2007); that is when a metaphor task activates the right hemisphere, this activation increases the frequency of the left-hand gestures. The present study tested the reverse causality: Do left-hand gestures activate metaphorical processes?

To investigate this hypothesis, we manipulated which hand is used for gesturing and assessed the performance in a metaphor explanation task. More specifically, participants were asked to explain the metaphorical mapping in English idiomatic expressions with metaphorical meaning (e.g., "to spill the beans" meaning "to reveal secrets"). Gesture production was manipulated within subjects by asking participants to gesture with their left hand only, right only, or do not gesture at all. If gestures activate cognitive processes in the contra-lateral hemisphere, then metaphor explanations should demonstrate higher level of metaphoricity when participants gestured with their left hand compared to the other two gesturing conditions.

In addition, in order to further support the hypothesis, mouth asymmetry measurements during metaphor explanation were collected from the same group of participants. The right-sided mouth asymmetry observed during verbal tasks has been related to the left hemisphere cerebral specialization for language production (for a review see Graves & Landis, 1990). In addition, Argyriou and Kita (in prep.) show that mouth openings are more left-side dominant in a metaphor explanation task than in concrete explanations, indicating the right-hemispheric specialization for metaphor. Therefore, we expected that the observed left-side bias in mouth openings during metaphor explanation would be positively correlated with the left-hand gesture advantage on speech metaphoricity.

Method

Participants 31 right-handed, male, native English speakers and monolinguals before the age of 5 years (age: *M*= 20.35, *SD*= 2.86) participated in the experiment for course credit or £4. For handedness standardization the Edinburgh Handedness Inventory (Oldfield, 1971) was used. None of the participants had any previous serious injury to the face or jaw. All of them were recruited at the University of Birmingham. We focused on male speakers because bilateral representation of language processing in men is less compared to women (McGlone, 1980).

Stimuli For the two tasks we used English idiomatic expressions with metaphorical meaning, which have been previously shown (Kita et al., 2007) to engage metaphorical thinking. For example: "to dodge the bullet, to fall back down to earth with a bump, to get back in the saddle". 18 expressions were used for the main description task and 3 for the mouth asymmetry task. Order of stimuli was counterbalanced across participants.

Procedure Participants were tested individually. They were instructed to explain the meaning of stimuli as if they were explaining it to a non-native English speaker. To encourage metaphorical thinking, participants were instructed to include an explanation as to how the literal meaning can be mapped on to the metaphorical meaning of the expression (e.g., in the expression "to spill the beans", "beans" refer to secrets, and "spilling" refers to spreading them to everybody). During the description, each participant placed their left, then right and both hands on the surface of the table(s), and to keep them still for the whole procedure (see Figure 1). Order of hand prohibition was counterbalanced within participants. For the gesturing conditions, they were instructed to gesture with their free hand during the description.

Figure 1: Experimental conditions (from left to right) Right Hand Gesturing, Left Hand Gesturing, No Gesturing.

To record mouth asymmetry participants explained metaphorical expressions just as in the main task, whilst both hands were prohibited from gesturing. Hand prohibition was a necessary experimental control in order to collect a pure measurement of participants' hemispheric specialization for metaphor without any influence from gesturing. Video-recording zoomed-in on the face area.

Measures Verbal responses from the main task were transcribed and coded for their level of metaphoricity. The level of metaphoricity was measured based on whether the explanations included an explicit link between the literal and metaphorical meanings, and whether participants explicitly referred to the mapping between the source and target domains of the conceptual metaphor underlying each idiomatic expression (adopted from McGlone, 1996). More specifically, a ''0'' rating indicated that the explanation did not contain words or phrases referring to the conceptual metaphor and the source domain, therefore there was no metaphorical mapping between the domains (e.g., "To spill the beans is to tell someone a secret or gossip"); a rating of ''1'' indicated that the explanation contained words or phrases that might be construed as references to the source and target domain, but the references were ambiguous, and the mapping between the two domains implicit (e.g., "To spill the beans means to let something out, to tell someone something perhaps that you shouldn't been telling them; I guess the beans like information make a mess once spilling them"); a rating of ''2'' indicated that the explanation contained words or phrases that clearly refer to the source and target domain, and the mapping was explicit (e.g., "To spill the beans is to tell someone something that you were not meant to tell; something which was confidential, private, and the beans represent the information that was private and by spilling them you are telling the news").

33% of the total verbal responses were coded in terms of metaphoricity by a second "blind" coder. Coding of metaphoricity matched between the two coders 76% of the time (Cohen's weighted kappa κ_w= .68, *p*< .001, kappa maximum κ_{max}= .91).

Video recordings from the three gesturing conditions in the main task were analyzed using ELAN software (developed by the Max Planck Institute for Psycholinguists, Nijmegen, the Netherlands). They were coded for the existence of at least one gesture type; that is representational gestures, palm-revealing gestures, conduit, and other (e.g., beats).

Video recordings from the mouth asymmetry task were analyzed on a frame-by-frame basis using ELAN software. The first ten mouth openings were coded per trial for each participant (thirty mouth openings in total). We measured the laterality at the widest point the mouth opens since the lips open to the lips resting or the lips meeting completely. The options for laterality classification were: right-side dominant, left-side dominant, or sides equally open (see Figure 2). 23% of the data were coded in terms of right, left or equal dominance of mouth openings by a second "blind" coder. Coding of dominance matched between the two coders 75% of the time (Cohen's kappa κ= .62, *p*< .001).

The degree of left-side mouth dominance was computed for each participant based on the laterality (right-R, left-L, equal-E) of their 30 maximum mouth openings, and using the following formula: (L-R)/(L+R+E) (adopted and adjusted from Holowka & Petitto, 2002). Thus, a positive and/or low negative mean score indicated more instances of left-side dominant mouth openings during metaphor explanation (= right-hemispheric lateralization).

Figure 2: (From left to right) Examples of right, left, equal maximum mouth openings. “Right” and “left” refer to the speaker's right and left.

In addition, we calculated a left-hand gesture advantage index whilst participants gestured and explain metaphors in the main descriptive task. That is, the average metaphoricity per participant when gesturing with the left hand minus the average metaphoricity when gesturing with the right hand. Thus, a high and positive mean score indicated that participants were more metaphoric when gesturing with their left hand compared to the right (= left-hand gesturing advantage on metaphoricity).

Design and Analysis Out of the 522 trials in total in the main task, 4% was excluded as failed trials, either because participants did not proceed as instructed (e.g., no gesture production when right or left hand was free), or they did not know the expressions. The free-to-gesture hand formed our independent factor: right-hand vs. left-hand vs. not gesturing. The dependent variable was level of the metaphoricity of the explanations (see the section Measures).

Results and Discussion

Out of the 354 gesturing trials, 99% included at least one representational gesture; 23% included at least one palm-revealing gesture; 7% included at least one conduit gesture; 18% included at least one “other” gesture – comprising mainly of beat and metacognitive gestures. Thus, the instruction to produce gesture was effective and we may assume that whatever the gesturing effect is, it will be due to representational gestures during the gesturing trials.

One-way repeated measures ANOVA was conducted to compare the effect of gesturing hand on level of speech metaphoricity in the three gesturing conditions (left-hand gesturing, right-hand gesturing, not gesturing at all). There was a significant effect of the gesturing hand, $F(2,60)= 13.92$, $p< .001$, $\eta^2= .32$. Post hoc comparisons with Bonferroni correction between conditions indicated that level of speech metaphoricity was significantly higher when participants gestured with the left hand than not gesturing ($t(30)= 2.81$, $p< .001$); metaphoricity was significantly higher when gesturing with the right hand than not gesturing ($t(30)= 1.38$, $p= .028$); and metaphoricity was significantly higher when gesturing with the left hand compared to right hand ($t(30)= 1.43$, $p= .038$) (see Figure 3). Thus, the gesturing hand had an effect on the level of metaphoricity in speech. Specifically, gestures, especially, those by the left hand, improved metaphorical thinking.

Next we assessed the relationship between the left-side bias in mouth openings and the left-hand gesturing advantage during metaphor explanation. The positive (or low negative) scores for mouth asymmetry indicate a right-hemispheric lateralization (= that is participants open their left side of the mouth wider than the right whilst explaining metaphors). The high positive scores for the left-hand gesture advantage indicate that participants were more metaphoric when they gestured with the left than with the right hand. There was a significant positive correlation between the two scores ($r(29)= .38$, $p= .036$) (see Figure 4). Thus, the participants for whom the left-hand gesturing advantage was bigger tended to have a stronger right-hemisphere involvement in metaphoric speech production.

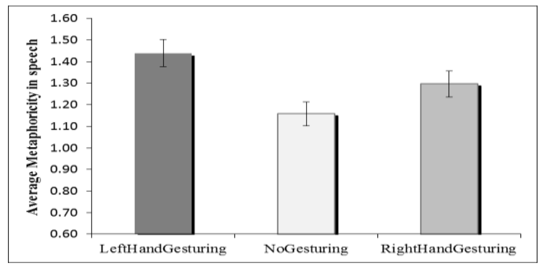

Figure 3: Average metaphoricity in speech in the three gesturing conditions. Error bars represent standard errors.

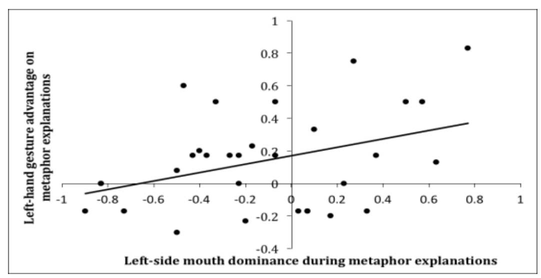

Figure 4: The scatter plot for the correlation between the left-side mouth dominance and left-hand gesture advantage during metaphor explanations.

General Discussion

The goal of the present study was to investigate a neural mechanism for gestures’ self-oriented functions. We measured the level of metaphoricity in metaphor explanations as a function of the hand used for gesture: the right hand, the left hand, and no hands. We found that speakers produced more metaphoric verbal responses when they gestured with either hand compared to not gesturing at all, and with left hand compared to the right. We propose that left-hand gestures led to better performance in metaphor explanation because they activated metaphorical processing in the right hemisphere.

The present findings are in line with the Information Packaging Hypothesis (e.g., Alibali, et al., 2000), indicating that gesture helps the conceptual planning of the speech, and in particular the conceptual mapping for metaphorical speech. In addition, the present results are compatible with previous studies on gesture and metaphor. For example, the present study found that metaphoricity was higher when gesturing, regardless of the hand, than when not gesturing. This is compatible with observations that gesture inhibition reduces the use of metaphorical spatial language (Bos & Cienki, 2011). More importantly, the findings shed new light on the inter-relation between hand choice for gesturing and hemispheric specialization. Kita et al. (2007) showed that hand choice for gesturing can be determined by the relative hemispheric specialization during different linguistic tasks; thus, right-hand preference is reduced during metaphorical explanations compared to non-metaphorical ones. Our findings provide evidence for the reverse causal link. That is, the gesturing hand can determine the level of speech metaphoricity, and in particular left-hand gestures enhance metaphor explanations. So, there seems to be a bi-directional causal relationship between left-hand gestures and metaphorical processing.

Although several studies manipulated gesturing in order to assess gestures' effect on cognitive processes (e.g., Alibali, et al., 2000), as far as we know, this was the first study to explore the neural mechanism for gestures' self-oriented functions, and link it with the hemispheric lateralization of cognitive processes. Crucially, the significant correlation between the left-side dominance in mouth openings during metaphor explanations, and the left-hand gesture advantage for metaphoricity indicated that the latter tends to be apparent in speakers who have strong right-hemispheric control for metaphor. Thus, it further supports the idea that gesturing activates cognitive processes in the contra-lateral hemisphere.

How exactly does this neural mechanism work? We may speculate *how* based on our current findings, and also in light of metaphor theories. The metaphorical mapping requires the conceptualization of a distant semantic relationship between the source and target domains of the metaphor, and it is thought to be predominantly computed in the right hemisphere, which processes coarse-grained semantic information (Jung-Beeman, 2005). Our findings revealed that left-hand gestures were particularly beneficial compared to the right-hand ones for the metaphorical mapping. Therefore, we suggest that left-hand gestures give some kind of "feedback" to the contra-lateral right hemisphere ("*Hemisphere-Specific Feedback Hypothesis*") and promote metaphorical processing, which crucially involves the right hemisphere. Finally, there is evidence that effect of the gesturing hand is due to representational gestures, because when we focused on trials in which only representational gestures were produced, pattern of the results remained the same: left-hand gesturing (M= 1.53, SE= .08), not gesturing (M= 1.15, SE= .06), right-hand gesturing (M= 1.39, SE= .08).

In conclusion, the current study enhances our understanding of the neural mechanism underlying gestures' self-oriented functions. Our findings confirm that gestures activate cognitive process in the contra-lateral hemisphere such that left-hand gestures enhance a right-hemispheric specialized process such as metaphor processing.

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