The Effect of Left-Hand Gestures on Metaphor Explanation

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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

There are many studies providing evidence for the relationship between gestures and cognitive processes, and several theoretical accounts explaining how gestures may determine cognitive processing. However, there is a debate about the type of processes gesture influences (e.g., lexical retrieval, imagery maintenance, and conceptualization; for a review see Kita, 2000), and the mechanism through which gesture influences cognitive processes is not yet clear. In this study, we will focus on the self-oriented functions, that is, the effect that gestures – and in particular representational gestures – have for those who produce them, and we will explore a neural mechanism for gestures' self-oriented functions, which has not been investigated in the literature.

According to the Lexical Retrieval Hypothesis gestures help speakers retrieve the lexical form on a surface level. In particular, it is suggested that gesture related information enters the speech production system to help the grammatical and/or phonological encoding (for a review see Krauss & Hadar, 2001). Evidence for this hypothesis comes mainly from speech fluency studies. For example, Rauscher, Krauss, and Chen (1996) showed that gesture prohibition led to more dysfluencies and slower speech rate when talking about spatial concepts. Therefore, it is proposed that gestures promote and facilitate speech production.

Alternatively, according to the Image Maintenance Hypothesis (de Ruiter, 2000) gestures have been thought to help the working memory maintain mental imagery during speech production. In particular, Wesp, Hesse, Keutmann, and Wheaton (2001) have shown that when speakers described images from memory, they used more gestures compared to talking about images they had a physical experience with; thus, indicating that gestures facilitate speakers to represent spatial information and maintain spatial imagery in working memory.

Finally, according to the Information Packaging Hypothesis, gestures help speakers at the conceptualization level; that is to formulate the concept to be uttered. In particular, Alibali, Kita, and Young (2000) showed that speakers gestured differently in two lexically comparable yet conceptually different tasks. Similarly, a gesture prohibition study (Alibali & Kita, 2010) showed that children who were allowed to gesture could focus more on present perceptual-motor information in their verbal descriptions compared to those who were prohibited from gesturing. Thus, it is suggested that gestures help speakers focus on relevant information, and plan concepts in the way suitable for verbalization.

The above theoretical accounts – which are not necessarily mutually exclusive, rather complementary – have attempted to explain how gestures may influence various cognitive processes. However, the mechanism for such effects remains to be explored. The aim of the present study is to determine whether gestures activate cognitive processes in the contra-lateral hemisphere. This is plausible because the hand choice for gesturing is influenced by 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 differential hemispheric specialization for linguistic processes, and in particular 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; for alternative views, see Cardillo et al., 2012 and Rapp, 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"). These expressions and task have been previously shown to engage metaphorical thinking, and furthermore to activate the right hemisphere. For example, when participants explain such metaphorical expressions they demonstrate reduced right-hand choice for gesturing (Kita et al., 2007), and reduced right-sided mouth dominance (Argyriou & Kita, in prep.) than when they explain non-metaphorical expressions. Gesture production was manipulated within-participants by asking subjects 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. Mouth asymmetry has been agreed to indicate relative hemispheric specialization for speech production, and in particular 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). Moreover, Argyriou and Kita (in prep.) showed that mouth openings are more left-side dominant in a metaphor explanation task than in a concrete phrase explanation task, 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. They were all right-handed according to a standardized 12-item handedness questionnaire (Oldfield, 1971): a score of "1", "0.5" and "0" was given for each right-hand, either and left-hand preference respectively. We calculated the mean of the sum of these scores, and defined as right-handed those participants who scored at least 8.5. 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 main descriptive task we used eighteen English expressions with metaphorical meaning. We created three (plus one in case one expression was unknown) additional metaphorical and concrete expressions for the mouth asymmetry task (see Table 1).

Table 1: Complete list of stimuli for the two tasks.

Metaphorical expressions for main descriptive task	
To burst someone's bubble	To sit on the fence
To cross that bridge later	To skate on thin ice
To dodge the bullet	To spill the beans
To fall back down to earth with a bump	To stand your ground
To get back in the saddle	To take the bull by the horns
To get hot under the collar	To tie up loose ends
To hold all the cards	To turn a corner
To leave a bad taste in the mouth	To turn the tables
To look on the bright side	Water under the bridge
Metaphorical expressions for the mouth asymmetry task	
To pour oil onto the fire	To spin a yarn
To set your sights higher	(To hit the nail on the head)
Concrete expressions for the mouth asymmetry task	
To pour oil into the pan	To spin a golf ball
To put a shelf higher	(To hit someone on the head)

Procedure

Participants were tested individually. They were seated on a chair, which was located between two tables of the same height (71 cm tall). The experimenter was facing the participant, and the video camera (Sanyo HD camera) was placed next to the experimenter. Stimuli were presented one by one on a white sheet of paper (font size 72, Times New Roman), which was held by the experimenter until the participant started the description.

Participants 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, participants were told to place one of their hands on the indicated marks (white sticky dots) on the surface of the table(s), and to keep it still for the whole procedure. For the total prohibition condition, participants were asked to place both their hands on the tables (see Figure 1). For the gesturing conditions, they were instructed to gesture with their free hand during the description (gesture encouragement instruction followed the paradigm in Chu & Kita, 2011). Participants were debriefed about the purpose of the hands immobilization after the experiment and the permission to use the data was allowed. Order of stimuli (forward - reverse), and order of hand(s) prohibition was counterbalanced across participants in a within-participants design.

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

In the mouth asymmetry task participants were instructed to explain metaphorical expressions, just as in the main task, and concrete expressions whilst both hands were prohibited. The order of the tasks (concrete – metaphor) was counterbalanced across participants. 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

The 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[1], a ''0'' rating indicated that the explanation did not contain words or phrases referring to the source domain of the relevant conceptual metaphor, therefore there was no metaphorical cross-domain mapping; a rating of ''1'' indicated that the explanation contained words or phrases that might be construed as references to the source domain, but the references were ambiguous, and the mapping between the two domains implicit; a rating of ''2'' indicated that the explanation contained words or phrases that clearly refer to the source and target domains, and the mapping was explicit.

One individual "blind" coder was trained and coded 33% of the total verbal responses in terms of metaphoricity. All answers from 10 randomly selected participants were coded (in total 180 trials were double coded). 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 on a trial-by-trial basis to locate 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 (sixty mouth openings in total). We measured the laterality at each maximum mouth opening. One maximum opening was defined as 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 for examples). Maximum openings during filled-pauses were included, but not the ones for non-speaking purposes (e.g., smile), nor the ones whilst participants were repeating the phrase to be explained.

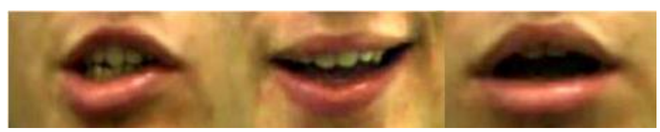

Figure 2: (From left to right) Examples of right, left, equal maximum mouth openings. "Right" and "left" refer to the speaker's right and left.

One individual "blind" coder was trained and coded 22% of the data in terms of right, left or equal dominance of mouth openings. All mouth openings from 7 randomly selected participants were coded (in total 414 maximum mouth openings were double coded). Coding of dominance matched between the two coders 79% of the time (Cohen's kappa κ= .66, 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 for each task (concrete and metaphor), and using the following formula:

[1] To illustrate how the 0–2 metaphoricity coding has been used, consider the following explanations generated for the item "to spill the beans": (a) "To spill the beans is to tell someone a secret or gossip" was coded with 0 because the explanation includes the meaning of the expression only. (b) "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" was coded with 1 because there is an implicit reference to the beans representing the information. (c) "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." was coded with 2 because it includes an explicit mapping between the source and target domains, and participant mentions the representation of each concept.

(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), and a high negative score indicated more instances of right-side dominant mouth openings (left-hemispheric lateralization).

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). A negative or low positive mean score indicated that participants were more metaphoric when gesturing with their right hand compared to the left.

Design & Analysis

Out of the 522 trials in total in the main task, 4% was excluded as failed trials; that is when the participants did not proceed as instructed (e.g., no gesture production when right or left hand was free), and when they did not know the expressions. The independent variable was which hand was free to gesture: right-hand gesturing, left-hand gesturing, not gesturing. The dependent variable was the 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.

We focused on trials in which only representational gestures were produced, and we limited the analysis to individuals who had trials with representational gestures only (2 participants were excluded; $N= 29$). 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 ($M= 1.39$, $SE= .08$). Also, the one-way repeated measures ANOVA remained significant ($F(2,56) = 14.87$, $p< .001$, $\eta^2= .35$). Thus, there is evidence that effect of the gesturing hand is due to representational gestures.

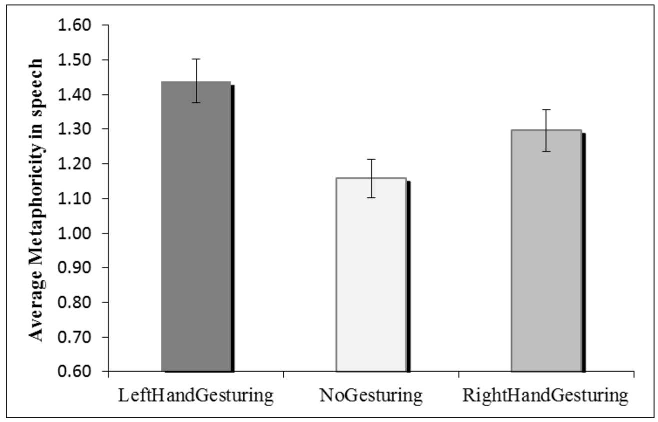

Figure 3: Average metaphoricity in speech in the three gesturing conditions. Error bars represent standard errors.

Next we compared the left-side bias in mouth openings during concrete and metaphor explanations. A one-way repeated-measures ANOVA performed on the left-side mouth dominance index with linguistic task as the independent variable yielded significant effect of the task, $F(1,30)= 6.45$, $p= .016$, $\eta^2= .18$. The left-side bias was higher during metaphor explanations ($M = -.11$, $SE = .08$) compared to the concrete ones ($M = -.24$, $SE = .09$), thus suggesting a reduced right-sided mouth asymmetry during explanation of metaphorical expressions. More importantly, we assessed the relationship between the left-side bias in mouth openings and the left-hand gesturing advantage during metaphor explanation. The range on the mouth asymmetry measurement was -0.90 to 0.77, where positive scores indicate a right-hemispheric lateralization (= that is participants open their left side of the mouth wider than the right whilst explaining metaphors). The range on the left-hand gesture advantage index was -0.30 to 0.83, where higher positive scores 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. Note further that the mouth asymmetry during explanation of concrete expressions did not significantly correlate with the left-hand gesture advantage ($r(29)= .32$, $p> .05$).

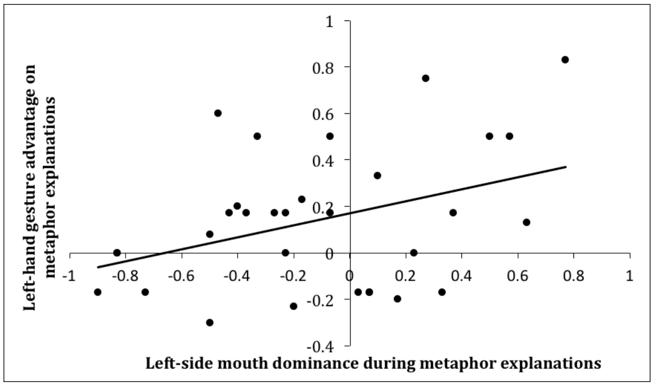

Figure 4: The scatter plot for the correlation between the left-side mouth dominance and left-hand gesture advantage during metaphor explanations.

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, no hands. We found that speakers produced more metaphoric verbal responses when they gestured with either hand compared to not gesturing at all, and when they gestured with the 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, Kita, & Young, 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 the 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 the hand used 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 metaphor explanations compared to concrete or abstract 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 there are several studies, which manipulate gesturing in order to assess gestures' effect on cognitive processes (e.g., Alibali & Kita, 2010; Rauscher et al., 1996), as far as we know, this is 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 left-hand gesture advantage for metaphoricity significantly correlated with the left-side dominance in mouth openings for metaphorical expressions, but not for concrete expressions. That is, the left-hand gesture advantage is stronger 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.

But, how exactly this neural mechanism works? We may speculate *how* based on our current findings, and also in light of metaphor theories. Metaphor is considered as a matter of conceptualizing one conceptual domain in terms of another (Lakoff & Johnson, 1980), and specifically the metaphorical mapping requires speakers to map a concrete concept on to a more abstract one. In addition, this mapping requires the conceptualization of a distant semantic relationship between the source and target domains of the metaphor, and it is considered to be predominantly computed in the right hemisphere, which processes coarse grained semantic information (Jung-Beeman, 2005). For example, in the expression to "spill the beans" participants had to represent the abstract concept of IDEAS (target) in terms of the distant concrete concept of OBJECTS (source). 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 make the distant semantic relationship between target and source domains of the metaphor to become closer, and then speakers can represent the metaphorical mapping in speech, thus become more metaphoric. It seems 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.

The present study did not account for what aspects of gestural hand movement influences metaphorical thinking. More specifically, our findings cannot address the question, "is it the gesture or the arm movement *per se* which activates the processes in the contra-lateral hemisphere?" Previous studies (Ravizza, 2003) have shown that meaningless arm movements, such as tapping, may facilitate lexical retrieval. However, this is only in tasks where lexical items have been selected by automatic spreading activations but not sufficiently so, and not in tasks where words have to be strategically searched. We may assume that metaphorical mapping requires strategic search of semantic fields, thus arm movement *per se* may not facilitate the process. Thus, it is the depictive nature of the gestural movement as described above that enhanced participants' performance rather than merely the arm movement. Moreover, even when the analysis included trials with representational gestures only, the results remained significant and demonstrated the same pattern (= left-hand gesture advantage). Thus, it provided implicit support for the effect of the depictive nature of representational gestures. However, future research to compare the effect of meaningless versus meaningful arm movements on metaphorical thinking would directly assess this issue.

In conclusion, the current study has advanced our knowledge of and enhanced theoretical accounts on a neural mechanism for gestures' self-oriented functions, which have received little attention so far. We propose 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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