The content of the message influences the hand choice in co-speech gestures and in gesturing without speaking

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Abstract

The present study investigates the hand choice in iconic gestures that accompany speech. In 10 right-handed subjects gestures were elicited by verbal narration and by silent gestural demonstrations of animations with two moving objects. In both conditions, the left-hand was used as often as the right-hand to display iconic gestures. The choice of the right- or left-hands was determined by semantic aspects of the message. The influence of hemispheric language lateralization on the hand choice in co-speech gestures appeared to be minor. Instead, speaking seemed to induce a sequential organization of the iconic gestures.
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1. Introduction

The present study investigates factors that influence the hand choice in gestures that spontaneously accompany speech. An important suggestion in the literature is Kimura's hypothesis (1973a, 1973b) that hand preference is determined by language lateralization in the two hemispheres. Kimura (1973a) noted that right-handers preferred the right-hand in free movements that accompany speech (left:right ratio 10:31). Among left-handers, those with right ear advantage and inferred left hemisphere language used both hands for speech-accompanying gestures with a slight left-hand preference (left:right ratio 48:42), and those with left ear advantage clearly preferred the left-hand (left:right ratio 83:29) (Kimura, 1973b). Kimura rejected the interpretation that language lateralization and handedness as independent additive factors would explain the patterns in the three groups. In her opinion, this assumption would not sufficiently explain the high number of right-hand gestures in

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left-handers with left ear advantage. Instead, she suggested that in left-handers, both hands are used for gesticulation because of bilateral language representation, "...where speech is not unilaterally organized, gesturing should also be manifested less unilaterally." (Kimura, 1973b, p. 54). Since Kimura further suggested that gestures and speech were controlled by a common system, her hypothesis concerning left-handers would, strictly speaking, imply that if a left-hander gestured with his left-hand he would rely on right hemisphere language and if he "spoke" with his left hemisphere he would use his right-hand for gestures that accompany speech. This proposition would require further investigation. In addition, in Kimura's interpretation of the data, the exclusion of handedness as an independent additive factor is not well-founded.

In a later experiment with manipulation of blocks (Hampson & Kimura, 1984), differences in hand preference were observed between verbal and non-verbal tasks. As compared to a neutral task, a right-hand preference for the manipulation of blocks was found in verbal tasks whereas non-verbal tasks produced a shift toward greater left-hand use. This finding lead to a generalization of Kimura's original hypothesis in the sense that shifts in hand preferences reflect the engagement of the cerebral hemisphere that is preferentially involved in performing a task. Based on this assumption, Lavergne and Kimura (1987) performed an experiment in which speakers talked about verbal, spatial, and neutral topics. The authors expected that talking about spatial topics, e.g., the description of a route or of a bedroom, would require greater right hemisphere processing and therefore induce more left-hand gestures. However, it is questionable if the task "*speaking about a spatial topic*" is adequate for testing specifically right hemisphere processing. The authors found a right-hand preference in all conditions but only the right-hand preference in the spatial topic reached considerable significance. Lavergne and Kimura concluded that the topic of speech and the presumed right hemispheric engagement in a spatial task has no influence on the hand preference in co-speech gestures.

Kimura's findings provided an essential contribution to understanding of the neuropsychological basis of gestures that accompany speech. However, as outlined above, her interpretation of the patterns of hand preference in co-speech gestures in left-handers shows some ambiguity. In addition, by more current standards, there are some methodological deficits: Kimura and colleagues did not distinguish different types of speech-accompanying gestures. They investigated only one broad gesture category, free movements, defined as "any motion of the limb which did not result in touching of the body or coming to rest" (Kimura, 1973a, p.46), and compared this category with self-touch. Meanwhile, studies that investigated different categories of speech-accompanying gestures, such as deictics, beats, or iconic gestures, have demonstrated different hand preferences for the specific gesture types (Lausberg, Davis, & Rothenhäusler, 2000). For example, equal use of the right- and left-hands was reported for 'beats' or 'nonrepresentational gestures' in both right- and left-handers (Sousa-Poza, Rohrberg, & Mercure, 1979; Stephens, 1983). For 'representational' or 'iconic' gestures, right-hand preference was reported in right-handers (Sousa-Poza et al., 1979; Stephens, 1983), and left-hand preference in left-handers (Stephens, 1983). Even for the group of iconic or representational gestures a further distinction is desirable, as iconic gestures with "character viewpoint" differ from iconic gestures with "observer viewpoint" (McNeill, 1992). In iconic gestures with character viewpoint, the speaker himself enacts the motion of a character in the narration, e.g., in order to represent someone throwing a ball, the speaker actually pantomimes throwing a ball. Iconic gestures with observer viewpoint depict a motion, location, or shape as if the event is observed from

outside, e.g., in order to represent a person running zigzag, the gesturing person moves his hand along a zigzag trajectory. If right-handers prefer their right-hands to produce character-viewpoint gestures only, handedness is the more likely explanation than the language dominance. Since Stephens (1983) and Sousa-Poza et al. (1979) collapsed the two types of iconic gestures in their analyses, their results cannot be interpreted as direct support for Kimura's hypothesis. Hence, the different nature of the gesture types demonstrates the necessity to test Kimura's hypothesis concerning hand preference with a more fine-grained analysis for the specific gesture types.

A further limitation of Kimura's hypothesis is the lack of an explanation for left-hand gesture in right-handers and for bimanual gestures. Percentages of left-hand gestures in unimanual gestures (L/R + L) reported in studies on right-handers range between 25% and 39% (Kimura, 1973a: 25%; Sousa-Poza et al., 1979: representational gestures: 31%; Dalby, Gibson, Grossi, & Schneider, 1980: 25%; Stephens, 1983: iconic gestures: 34%; Lavergne & Kimura, 1987: 39%). Percentages of bimanual gestures (bimanual / bimanual + unimanual) ranged between 24% and 34% of all gestures (Kimura, 1973a: 24%; Sousa-Poza et al., 1979: 34%; Dalby et al., 1980: Men 21–22%, Women 16–27%; Stephens, 1983: 22%; Lavergne & Kimura, 1987 excluded bimanual gestures). Hence, the question remains open what determines the production of left-hand and bimanual gestures in right-handers. Thus far, factors other than speech dominance or handedness that might influence the hand choice in gestures that accompany speech have rarely been investigated systematically. There is some evidence that the content of the verbal message influences the hand choice. Stephens (1983) reported that subjects whose narrations were structured tightly around a global theme preferred bimanual gestures, while subjects who simply gave a sequential listing of the events in the story displayed unimanual gestures.

In the present study, we investigate the hypothesis that the content of the verbal message influences the hand choice in gestures that accompany speech. As the analysis of one defined gesture type seems warranted, we focus on iconic gestures with observer-viewpoint. Per definition, iconic gestures depict the content of the message and, thereby, represent the most adequate type of gestures for comparing the influence of semantic aspects with the influence of language lateralization on hand choice. Iconic gestures with observer-viewpoint were preferred to iconic gestures with character-viewpoint because for the latter type the hand choice is expected to be influenced by handedness. We investigate our hypothesis on spontaneous gestures that accompany the verbal narration of animations which show two geometric objects moving on a horizontal line in relation to each other. We assume that the image of the scene that is verbally described determines the use of the right- and left-hands. Specifically, our hypotheses are that (1) the right- and left-hands are used iconically to reflect the right and left positions of the objects and (2) the right- and left-hands are used simultaneously if "global aspects" are described, i.e., in our design the spatial relation between the two objects. Further, we compare the effect of the semantic content of the message with the effect of language lateralization on hand choice. For this purpose, our design also included a silent condition, in which subjects had to communicate the content of the animation in gestural demonstrations without speaking. According to Kimura and colleagues, in the speech condition a right-hand preference should occur and consequently, the absence of speaking in the silent condition should induce a relative decrease of right-hand gestures. In contrast, if the content of the message influenced the hand choice, the two conditions should not differ concerning hand preference.

2. Methods

2.1. Subjects

Ten right-handed subjects, five females and five males, were chosen from a cohort of 122 healthy adults who are available for normative neuropsychological studies at the Montreal Neurological Institute. The mean age of the sample was 41 years ranging from 18 to 54. Eight of the subjects were English native speakers, and two were French native speakers (one female, one male). The subjects' IQs were distributed evenly within the average range. Because of the specific relevance for the study, handedness was scrutinised. As the classification of an individual's handedness depends on the choice of items (Geschwind & Galaburda, 1985; Oldfield, 1971; Salmaso & Longoni, 1985) and on the modalities in which handedness is examined (Barnsley & Rabinovitch, 1970; Salmaso & Longoni, 1985), two different questionnaires were applied, the one currently used at the Montreal Neurological Institute and Hospital and the modified Oldfield Inventory (Salmaso & Longoni, 1985). In addition, the items of the questionnaires were administered as pantomime tasks and as actual object use tasks, and the spontaneous hand preference was noted. For all subjects, right-handedness was established with the items of both questionaires in the three modalities, verbal response, pantomime, and object use. Sensorimotor testing was performed in order to exclude primary sensori-motor deficits that could affect the hand choice in spontaneous gesturing. The testing included passive movement of the fingers, simultaneous stimulation of the hands, pinch or grip strength, free and sequential tapping, and manual dexterity (Grooved or Purdue Pegboard). There were no relevant deficits in any subject.

2.2. Stimulus material

Subjects were presented 24 animations having an average duration of 30 s that show two geometric objects moving on a horizontal line. The animations were structured as follows: 1st phase: The first object appears in the middle of the screen on a horizontal line; 2nd phase: The second object appears on either the right (12 animations) or the left side (12 animations) of the screen and moves towards the object in the middle; 3rd phase: The second object either stops close to the object in the middle or touches it; 4th phase (four variations): The second object just remains in the stop position; the second object moves back; the first object in the middle moves to the other side of the screen, i.e., in direction opposite to the second object; both objects continue to move towards the other side of the screen.

In addition to the path of object motion, the manner of object movement and the object shapes varied. The objects could either simply slide or, they could move in a rolling or jumping manner. There were three variations of object shape and colour, a red ball, a blue square, and a green triangle. The 24 animations varied in their complexity, as the path(s) of the object(s) could be simple or complex, and a manner of movement could occur or not. Based on this differentiation, for each animation, a score was given that reflects the complexity. The complexity scores ranged from 3 (simple animation with two shapes, one one-way path) to 7 (complex animation with two shapes, two manners, three paths). The 24 animations were ordered in such a way that the first half of the animations were matched to the second half with regard to complexity, the frequencies of motion in the left and right spaces of the scene, and the frequencies of motion starting at the left and right sides of the scene.

2.3. Procedures

The experiment consisted of a speech condition and a silent condition that were tested in two separate sessions. In order to avoid potential influences on the spontaneous gestural behavior in the speech condition due to previous silent gestural demonstrations of the same animations, the speech condition was tested in the first session, and the silent condition in the second session. In the speech condition, the subjects were asked to narrate the content of each animation directly after its presentation. As people tend to gesture during narration especially if they talk about a spatial content (Lavergne & Kimura, 1987; Sousa-Poza et al., 1979), the speech condition was designed to elicit spontaneous speech-accompanying gestures. In the speech condition, subjects were not informed that their co-speech gestures were the focus of interest. In the second session, the silent condition was tested. The same 24 animations were presented again, and the subjects were asked to gesturally demonstrate the content of each animation without speaking, directly after its presentation. In order to motivate the subjects to be precise in their silent gestural demonstrations, verbal feed-back was given by the investigator for the first five animations, i.e. the investigator directly reported what she saw in the subjects' silent demonstrations.

The animations were presented on a TV-screen that was placed 2.5 m in front of the subject. Each subject's gestural demonstrations were taped in full shot with a video camera (sony DCR TRV900E miniDV camcorder) that was close to the TV screen.

2.4. Evaluation of the video material

The video tapes were digitized to MPEG 1 format. This procedure permitted use of the movement analysis program Media Tagger (Brugman & Kita, 1995) for the evaluation of the movie files. With this software, a segment of a movie can be selected and be tagged with a value. In this study, each coding unit contained the subject's gestural response to one animation. For each subject, 2×24 gestural responses for the speech and the silent conditions were evaluated by two independent trained raters. Only iconic gestures with observer viewpoint were coded systematically. The observations of other gesture types were noted. The coding of the videos was performed without sound in order to prevent the raters' evaluation of the co-speech gestures from being influenced by the verbal message. The first rater was blind to the research hypotheses, the second rater was the first author. The codings of the second rater were used only to establish interrater agreement. Hence, the statistical evaluation is based on the codings of the blind rater.

For the evaluation of the iconic gestures with observer viewpoint, a coding system was developed that consisted of four nominal variables: hand use, gesture laterality, object reference, and bimanual depiction. For all variables, the relevant coding unit was the gestural response given to one animation, i.e., the value of a variable refers to a whole gestural response and not to a single gesture. This approach has the advantage that meaningful units of gestural demonstrations are considered and that the interaction of the two hands within such a natural gesture unit can be observed.

A. *Hand use*. The following two variables note the hand use for iconic gestures in a response: (a) The right-hand displays an iconic gesture in a response and (b) the left-hand displays an iconic gesture in a response. Each variable was coded as 'yes' or 'no'. If a subject used the right- and left-hands in a response, each variable was coded as 'yes'.

B. *Gesture laterality*. This variable codes how the right- and left-hands co-act in a gestural response. The following categories were differentiated: (1) Bimanual simultaneous: both hands are used simultaneously in a response to display iconic gestures. (2) Alternating: both hands were used in a response to display iconic gestures, but only one hand at a time, i.e. one hand gestured while the other hand was resting, and then the two hands switched roles. (3) Only-right-hand: only the right-hand displayed iconic gestures in a response. (4) Only-left-hand: only the left-hand displayed iconic gestures. (5) No iconic gesture was performed in a response by any hand. The five categories were coded mutually exclusive.

C. *Object reference*. This variable describes for each hand to which object in the animation it refers with an iconic gesture. In the animations, there were always two objects simultaneously present that were positioned on a horizontal line. Hence, there was always a left object and a right object. For each gestural response, the use of each hand for object reference was categorised into the following five types: (1) The hand refers to the ipsilateral object, e.g., the right-hand refers to the right object. (2) It refers to the contralateral object, e.g., the right-hand refers to the left object. (3) It refers to both objects. (4) It refers to one of the objects or to both objects only as a part of two-handed representation, e.g., the two hands jointly shape a triangle with the two thumbs constituting one side of the triangle and the two indexes one side each. (5) The hand does not display an iconic gesture. The five categories were coded mutually exclusive.

D. *Bimanual depiction*. This variable refers to responses with bimanual simultaneous gestures only (see B(1)) and records if the spatial relation between the two objects is depicted in gesture. The point of reference for this evaluation is the 3rd phase of the animation, in which the two objects meet in the middle of the horizontal line and they either touch each other or remain at close distance without touching. The following categories were differentiated: (1) The two hands correctly display the spatial relation between the two objects, i.e. they show a touch or a close distance; (2) the two hands deficiently display the spatial relation between the two objects, e.g., no touch instead of touch; (3) the two hands gesture jointly depict one object shape, e.g., both hands together form a ball; (4) the two hands gesture simultaneously but independently, i.e., no shared iconic representation is recognizable. The four categories were coded mutually exclusive.

3. Results

In the speech condition, $70 \pm 38\%$ of the verbal responses (Group mean $\pm$ SD) were accompanied by spontaneous iconic gestures with observer viewpoint that represented or described the objects shown in the animations. Other gesture types such as batons, i.e. gestures that rhythmically accompany speech, shrugs, or emblems, i.e. conventionalized gestures with a specific meaning, that that were not focus of the present investigation were rarely observed. One subject did not gesture at all in the speech condition. In the silent condition, subjects displayed iconic gestures in all responses as required by the experiment task.

1. Use of the right- and left-hands in the speech and the silent conditions.

The interrater agreement (Spearman Correlation) was for right-hand use was $r = 1.00$, and for left-hand use $r = 1.00$. In the speech condition, the right-hand gestured in $53.3 \pm 39.2\%$ of the 24 responses and the left-hand in $47.1 \pm 36.9\%$ of the responses. In the silent condition, the right-hand gestured in $100.0 \pm 0\%$ of the responses and the left-hand in $91.3 \pm 26.2\%$ of the responses. The subjects' proportions

of responses with right-hand gestures in the 24 responses and of responses with left-hand gestures in the two conditions were submitted to a mixed ANOVA with two repeated factors (hand, condition) with two levels each (right-hand vs. left-hand; speech condition vs. silent condition). There was a significant effect of condition ($F = 19.17$, df $= 1$, $p = .002$) as more responses with gestures were performed in the silent condition than in the speech condition. There was no effect of hand ($p = .287$) and the interaction of hand and condition ($p = .878$). For comparison purpose, hand preference was also examined following the procedure by Lavergne and Kimura (1987) with an asymmetry ratio ($R - L/R + L$). The one-sample t test conducted on the difference of the subjects' ratios from zero, i.e. no hand preference, showed no preference for the right or left-hands in the speech condition ($p = .695$) nor in the silent condition ($p = .329$). There was also no significant difference between the asymmetry ratios in the two conditions ($p = .881$). To summarize, firstly, although there was a tendency to use the right-hand more often for iconic gestures, the effect was clearly not significant. Secondly, there was no difference in hand preference between the speech and silent conditions.

We were further interested in the distribution of right-hand and left-hand gestures in the course of the 24 trials in the speech and silent conditions. For each trial, the number of subjects who used the right hand for iconic gesture display, and the number of subjects who used the left-hand were counted. Subjects who used the right- and left-hands in a response were counted in each variable. Figs. 1 and 2 show the patterns of right- and left-hand use in the 24 trials in the speech and silent conditions.

In the speech condition (Fig. 1), there was change in the frequency of right-hand use in the course of the 24 trials. The regression analysis with the order of the 24 trials as the predictor variable yielded a significant decrease of right-hand use ($t = -2.86$; df $= 1.22$; $p = .009$). As the first 12 animations were matched with the
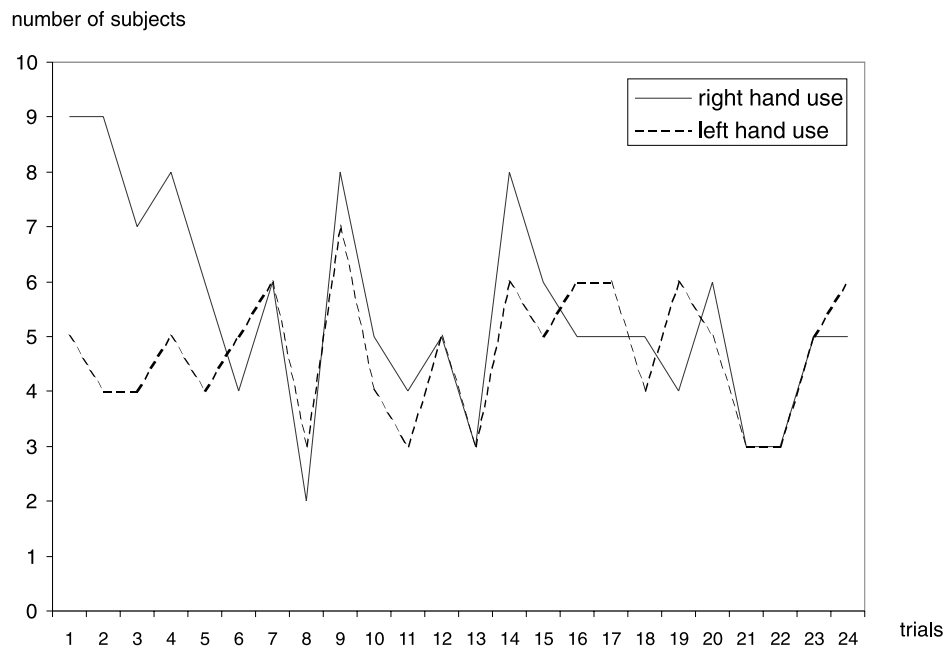

Fig. 1. For each trial in the speech condition, the numbers of subjects are shown who display iconic gestures with their right-hands and who display iconic gestures with their left-hands.
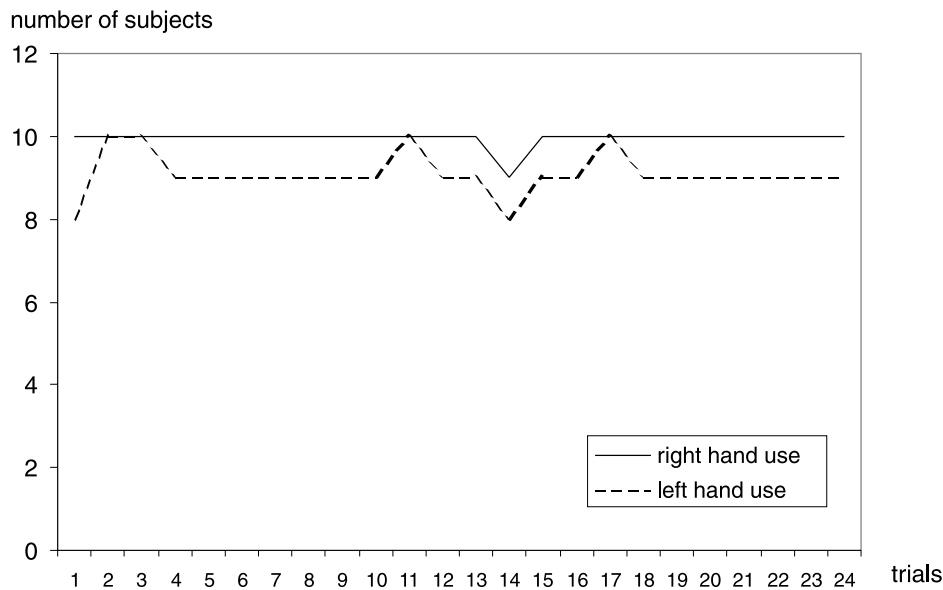
number of subjects

Fig. 2. For each trial in the silent condition, the numbers of subjects are shown who use their right-hands to display iconic gestures and who use their left-hands to display iconic gestures.

second 12 animations concerning complexity, the frequencies of motion in the left and right scene spaces, and the frequencies of motion starting at the left and right sides of the screen scene, the decrease of right-hand gestures cannot be secondary to changes in the content of the animations. No significant regression was found for left-hand use ($t = .350$; df $= 1.22$; $p = .729$). The decrease of right-hand gestures was mainly due to a higher rate of right-hand gestures in the first quartile of the speech experiment than in the other three quartiles. Consequently, the paired samples t tests comparing right-hand use and left-hand use in each quartile of the speech condition showed only for the first quartile a significantly higher frequency of right-hand use than left-hand use ($t = 3.16$; df $= 5$; $p = .025$). No significant differences occurred in the second, third, and fourth quartiles. Hence, the overall non-significant tendency for right-hand preference in the speech condition, described at the beginning of the section, resulted only from the high rate of right-hand use in the first quartile of the experiment. Fig. 2 shows that in the silent condition, the pattern of hand use was stable through the course of the experiment.

2. Gestural reference to the left and right objects in the scene

The following analysis investigates if the use of the right- and left-hands for iconic gestures reflects the right and left positions of the objects in the scene that is verbally or non-verbally described. The interrater agreement (Cohen's κ coefficient) was for right-hand object reference $r = .89$, and for left-hand object reference $r = .79$. Fig. 3 shows the proportions of responses in each object reference type separately for the right- and left-hands and the speech and silent conditions.

The subjects' proportions in each object reference type were submitted to a mixed ANOVA with two repeated factors (hand, condition) with two levels each (right-hand vs. left-hand; speech condition vs. silent condition). Reference by a hand only to the right object in a response was performed significantly more often by the right-hand than by the left-hand in both conditions ($F = 53.57$; $p = .000$). Reference by a hand only to the left object in a response was performed significantly more often by the left-hand than by the right-hand in both conditions ($F = 145.05$; $p = .000$). For
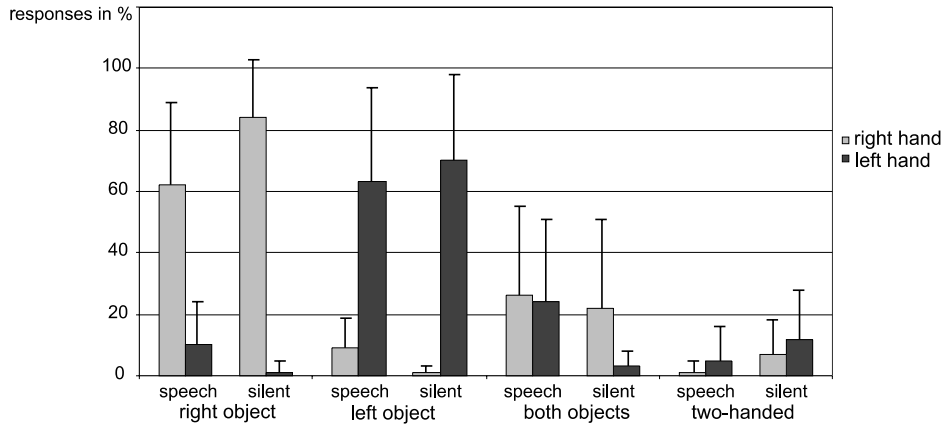
Fig. 3. Object reference by the right- and left-hands. Group means and SD of the proportions of each reference type in the right- and left-hands in the speech and silent conditions.

the left object reference, there was an additional significant effect of the interaction of hand and condition ($F = 9.37$; $p = .016$), as the left-hand preference for the left object was stronger in the silent condition than in the speech condition. For the reference to both objects by a hand, there was no significant difference between the two hands and between the two conditions. Object reference by a hand only as part of a two-handed presentation occurred significantly more often in the left-hand than in the right-hand ($F = 10.51$; $p = .012$), i.e. while the left-hand represented an object only together with the right-hand in a response, in the same response the right-hand in addition represented an object by itself. To summarize, the right object in the scene was predominantly represented by the right hand. Analogously, gestural reference to the left object was preferably performed by the left-hand.

3. Gesture laterality types

The following analysis investigates the different combinations of right hand use and left-hand use in the responses. The rater agreement (Cohen's κ coefficient) for gesture laterality was $r = .76$. In Fig. 4, the group means of the proportions of each gesture laterality category are shown separately for the speech and silent conditions.

Differences in the laterality type patterns between the two conditions were tested with a mixed ANOVA with one repeated factor (condition) with two levels (speech vs. silent). In the speech condition, there were significantly more responses with
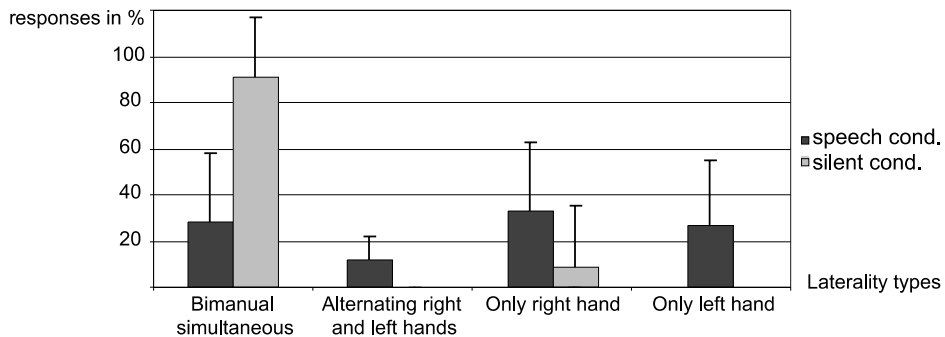

Fig. 4. Group means and SD of the proportions of responses with bimanual simultaneous hand use, alternating right- and left-hand use, only right-hand use, and only left-hand use for iconic gestures in the speech and silent conditions.

alternating gestures ($F = 12.32$; df $= 1$; $p = .008$) or with 'only left-hand' gestures ($F = 8.47$; df $= 1$; $p = .020$) than in the silent condition. In the silent condition, there were significantly more simultaneous bimanual responses than in the speech condition ($F = 33.85$; df $= 1$; $p = .000$). The frequencies of responses with only right-hand gestures did not differ significantly between the two conditions ($p = .118$).

4. Content of bimanual depiction

The interrater agreement (Cohen's κ coefficient) for bimanual depiction was $r = .89$. In the speech condition, in $69 \pm 24.3\%$ of the responses with bimanual gestures, the two hands were used simultaneously to depict the spatial relation between the two objects and the depiction of the spatial relation was precise. In $8.8 \pm 11.1\%$, the depiction of the spatial relation was given, but was deficient. In $22.3 \pm 20.7\%$, the two hands acted as a unit, i.e. they represented the shape of one object together. In the silent condition, a similar pattern occurred: In $75.1 \pm 18.1\%$ of the responses with bimanual gestures, the two hands demonstrated the spatial relation between the two objects correctly, and in $6 \pm 8.2\%$, they did so deficiently. In $18.9 \pm 17.6\%$, the two hands together depicted the shape of an object.

4. Discussion

4.1. Lack of evidence for Kimura's hypothesis

The present study investigated the effect of language lateralization on hand choice in iconic gestures with observer viewpoint that accompany the verbal descriptions of animations. In all our subjects right-handedness was established after detailed examination of handedness. As 95.5–99.67% of the right-handers have left hemisphere language (Borod, Carper, Naeser, & Goodglass, 1985; Bryden, 1982; Levy & Gur, 1980), we can assume that in our sample language competence is primarily localized in the left hemisphere. According to the original hypotheses by Kimura (1973a, 1973b) that hemispheric language lateralization induces a preference for the contralateral hand in free gestures that accompany speech, our subjects should have demonstrated a right clear right-hand preference in the speech condition. As a main result, in our study no significant right-hand preference during verbal narration was found.

A significant right-hand preference was observed only in the first quartile of the speech condition experiment; there was no hand preference in the other 3 quartiles. As the initial right-hand preference occurred only in the speech condition but not in the silent condition, we can assume that the initial right-hand preference is related to speaking rather than to handedness. Kimura's proposition that " The right–hand activity is related to left-hemisphere control of speech functions,..." (Kimura, 1973a, p. 45) could explain the right hand preference in the first quartile of the experiment. However, in the course of the speech experiment the influence of hemispheric language and speech lateralization on hand choice is obviously overridden by other factors. The language lateralization hypothesis fails to explain the fact that in the majority of responses, the right- and left-hands were used equally often to display iconic gestures. Also in the silent condition, lack of evidence was found for Kimura's proposition. If speaking induced a right-hand preference for gestures, the absence of speaking should result in a relative decrease of right-hand gestures. However, in our study, no differences were found between the two conditions concerning the frequencies of right- and left-hand use. Hence, the investigation of the two conditions together demonstrated that the relevance of language lateralization for hand choice in gestures that accompany speech is limited. Our data suggest that hand choice in

iconic gestures that spontaneously accompany speech is more likely to be influenced by factors other than hemispheric specialization for language.

4.2. Iconic use of the right- and left-hands in gesture

In the speech condition, subjects had to narrate the content of the animations. The striking result was that if subjects referred to the object that had been left in the animation scene, they spontaneously preferred their left-hands for the iconic gestures that accompanied speech. Analogously, they used their right-hands if they referred to the right object. It seems that the subjects 'chose' their left- and right-hands for the purpose of iconic representation. If the subjects gesturally depicted object features, e.g., manner of object motion or object shape, of an object in relative left position, they spontaneously used their left-hands for the iconic gestural demonstration of the relative spatial position.

It is noteworthy that the subjects did not only use their left-hands to represent the left object and their right-hands to represent the right object, if they presented both objects simultaneously and opposed them. Also in responses in which only one hand gestured at a time, i.e. alternating, right-hand only, and left-hand only responses, the use of the left-hand for the left object and of the right-hand for the right object was maintained. This indicates that the right- or left-hands were 'chosen' to depict the relative spatial position of the object of reference. The same pattern was found in the silent condition. Subjects predominantly used their right-hands to represent the right object and their left-hands to represent the left object. If the right- and left-hands were used simultaneously, in the majority of responses in both conditions, the spatial relation between the two objects was depicted. This finding can be linked to Stephens's observation (1983) that the frequency of bimanual gestures increased if global aspects were described in the narration. In about one fifth of the bimanual responses in both conditions, the two hands depicted the shape of an object together.

There was no difference between the speech and the silent conditions concerning the iconic use of the right- and left-hands for the representation of the relative spatial position of the object of reference, and for the depiction of the spatial relation between the two objects. Therefore, it could be argued that both forms of gestural demonstrations are based on the same, or at least, similar mental images of the scene. This interpretation can be further connected to propositions that both speech and gesture are grounded in the same imagery (de Ruiter, 2000; Kita, 1997; Krauss, Chen, & Chawla, 1996; McNeill, 1992).

4.3. Effects of speaking on gesture laterality types in iconic gestures

In our study, speaking did not induce a right-hand preference as compared to a non-speaking condition, in contrast to Kimura's hypothesis. However, other differences between gestures while speaking and gestures without speaking were observed. In the silent condition, the predominant gesture laterality type was the simultaneous use of the right- and left-hands. We assume that simultaneous bimanual expression was preferred because it enables the subjects to give a complete gestural depiction of the animation scene in which two objects are present all the time with a varying spatial relationship. In the speech condition, the use of the right- and left-hands showed a broader range of laterality types. Responses in which both hands acted simultaneously occurred significantly less frequent than in the silent condition. Instead, in the speech condition, a higher percentage of responses with unimanual gestures was noted, i.e., alternating right- and left-hands, only-left-hand and only right-hand gestures. In this respect, the subjects adopted a typical distri-

bution pattern of unimanual/bimanual gestures for speech-accompanying gestures which is comparable to previous studies (Dalby et al., 1980; Kimura, 1973a, 1973b; Sousa-Poza et al., 1979; Stephens, 1983). Hence, the subjects tended to gesture with only one hand at a time despite the fact that in the animations two objects were present all the time. Similarly, the verbal descriptions in the speech condition tended to focus on one object at a time. The following description was given for an animation, in which a square is in the centre and a triangle comes in from the left: "Floating triangle, floats towards the blue square. Stops, don't touch. The blue square floats off, to the right." (subject 1, speech condition). We assume that in the speech condition, the sequential nature of the information flow in speech makes the information flow in co-speech gesture also sequential (Kita & Özyürek, in press; Özyürek & Kita, 1999). This assumption also concurs with Stephens's report (1983) that speakers displayed unimanual gestures if they described sequential events, whereas descriptions of global aspects were accompanied by bimanual gestures.

5. Conclusion

To summarize, our data demonstrate that the effect of language laterality on hand choice in gestures that accompany speech has been overestimated. The present study shows that Kimura's proposition is only of limited value for iconic gestures with observer viewpoint. In our sample with presumed left hemisphere language no significant right-hand preference in co-speech gestures was found. In the verbal narration experiment, there was an initial right-hand preference that was overridden by other factors in the subsequent course of the experiment. The hand choice for iconic gestures that accompany speech was largely determined by the content of the message. The use of the right- or left-hands iconically reflected the relative spatial position of the object of reference. Simultaneous right- and left-hand use was found to depict in addition the spatial relationship between the two objects. The iconicity of right- and left-hand use in co-speech gestures did not differ from their iconic use in gestural demonstrations without speaking. It is plausible that co-speech and gestures without speaking are based on the same mental image of the scene that the speaker intends to convey. Gestures that accompanied speech differed from gestures in the silent condition, however, as they tended to be unimanual whereas gestures in the silent condition were predominantly bimanual. The preference for unimanual gestures in the speech condition might be related to the sequentiality of verbal narrations.

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