Linguistic reflexes of matching vs. non-matching iconic gestures

Researchers Involved

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Background and general aim

It is by now an established fact that gestures may help children to learn, be that with a vocabulary learning task (Macedonia & von Kriegenstein 2012), or a mathematical equation task (Goldin-Meadow et al. 2009). Interestingly, it has also been pointed out that gestures may identify children as ready to learn and thus predict whether one child will be more likely to benefit from instructions than another (Goldin-Meadow at al. 1993; Church & Goldin-Meadow 1986 for a Piagetian conservation task; Perry et al. 1988 for mathematical equations). In numerous studies it could be shown that children who produce many speech-gesture mismatches in their spontaneous explanations of their solution to a given problem were more likely to benefit from instruction than children who produced only few speech-gesture mismatches. For example, in a Piagetian liquid quantity conservation task, children that were not yet able to complete this task were asked to explain why they thought the amount of liquid was not the same in the two containers and the explanations were videotaped. The finding was that some children consistently produced a lot of non-matching gestures, while others used none or only very few. An example of a matching gesture case would be the following: a child talks about the different heights of the liquid in the two containers and at the same time indicates these heights via gesture. A mismatching gesture would be one produced by a child who talks about the height of the liquid in the containers in speech, but focuses on the width of these containers in gesture. Children who produced more of these mismatching gestures were shown to be more ready to learn.

This fact was interpreted as showing that children who produce a lot of mismatching gestures are less consistent in their beliefs. They are in a transitional state and entertain multiple hypotheses about the concept under discussion, here the liquid quantity conservation task. In other somewhat simplifying words one could say that the children make use of two conflicting strategies, one incorrect one, which they express in speech, and one (partly) correct one, which seems to be expressed via gesture. Apparently this strategy that is expressed via gesture is not yet ready to be reflected and expressed via speech.

In our project *PSIMS*, we investigate the iconic means of language, and one major part is dedicated to gestures, in particular so-called *iconic* gestures such as a ,round' gesture, for example, and their iconic potential. An iconic gesture that matches speech is straightforwardly iconic to what is expressed in speech, e.g. by indicating the shape of a window with a 'round' gesture while uttering the NP *round window*. These gestures are then iconic to speech and also to an aspect of the object that is referred to. A non-matching iconic gesture, however, is obviously not iconic concerning the

corresponding speech, but then it must be iconic to some other aspect of the object talked about that is not verbalized. In the example above, the child who gestures the width of the containers, but talks about the height, seems to anticipate the significance of this dimension, but is not able to verbalize this knowledge yet.

In collaboration with Prof. Susan Goldin-Meadow and Heather Mangelsdorf from the University of Chicago, Psychology Department & Center for Gesture, Sign, and Language, we want to find out more about the nature of these matching and non-matching gestures, their significance for predicting the readiness to learn, their actual impact on learning, and their iconic character. As part of her project *Harnessing gesture and action to improve pre-algebra instruction (NSF DRL-1561405, 2016-2019)*, Susan Goldin-Madow (PI) investigates how gesture instructions affect children's ability to learn, in particular concerning mathematical equivalence tasks. Our joint work aims at detecting the linguistic reflections of matching vs. non-matching gestures. Can we find systematic linguistic differences between these two types and what does this tell us about the origin of these? For example, we are interested in timing effects, i.e. whether gesture types (matching vs. non-matching) correlate with linguistic categories such as VP, IP, etc., or whether preparation or retraction phases differ (e.g. systematically start earlier with one type or are more often omitted). Furthermore, there may be systematic differences in the general timing, thus finding one type more often realized as a post-speech gesture, for example, as opposed to the other type, which may occur more likely as a co-speech gesture. Depending on the results, the findings may allow conclusions to be drawn on the underlying processes guiding the production of matching and non-matching gestures, the iconic nature of these gestures, and on iconicity in general.

Project description, planned method, and goals

Heather Mangelsdorf has video-taped over 100 participants (7-9 years old children) in a study using a math equivalence paradigm along the lines of the study described in Goldin-Meadow at al. (2009): Children solve 6 math problems (e.g., 3+4+5= __+5), and then explain at a whiteboard how they arrived at each of their answers. Most of the children produced many spontaneous gestures during this explanation, including some gesture-speech mismatches. All of the children's spontaneous speech has been transcribed in Excel, and it has been coded both the speech and gesture for what mathematical strategy they express (in order to determine mismatches). While the kinds of gestures (hand, handshape, and referent) have been annotated, no timing has been coded so far. There exist videos from four different angles: over the child's right shoulder, directly to the child's side, looking down at the child's gestures from the ceiling, and a close-up of each child's face. Most of the children did not know how to solve the problems, but there are also some children who got all the pretest problems correct and still explained their solutions.

In addition to the spontaneous speech and gesture at pretest (and again at posttest), there exist also videos of the children in a training phase. Here, the children were instructed to say a certain phrase („*I want to make one side equal to the other side*"), while producing a certain grouping gesture, namely, in the above example, point with V-hand to 3+4, and point with index finger to the blank. If the two numbers that are marked by the V-gesture are added, they generate the result that has to be inserted for the blank. Perry et al. (1988) point out that this grouping gesture is a gesture that is often spontaneously produced by children who can solve this type of problem.

On grounds of the video material and the annotations that have been made already, we plan to convert and enrich these annotations by using the annotation software *ELAN* so that we can track the speech-gesture alignment in all detail that is needed. We will start out with 4-6 videos, transcribe

the speech, and annotate the most important parts of speech (VP, DP, IP, ...), the type of gesture (iconic, deictic, emblematic, discourse, ...), and the gesture phases (preparation, stroke, retraction as well as holds). For the linguistic and general gesture annotations, we will stick to the annotation guidelines of the SaGA corpus, University of Bielefeld (Lücking et al. 2013). Then we will investigate whether the gestures align with speech (co-speech) or not (post-/pre-speech), which parts of speech they align with (VP, IP, ...?), and search out for more such correlations. We hereby hope to find interesting dependencies and significant differences between matching and non-matching gestures[1].

Up to this moment, we have only just started with the transcriptions of 3 videos. A yet to be confirmed primary observation we made is that with mismatching gestures there are more (alleged) preparation phases which are followed by a direct retraction phase without an actual stroke in between. This could be interpreted as reflecting an instability on the side of the speaker due to the two underlying conflicting strategies that could be at place.

This work is mostly exploratory. However, as no studies on the linguistic reflections of matching and mismatching gestures in general and the temporal speech-gesture alignment of these kinds of gestures in particular exist, we are convinced that this is a valuable contribution to gesture research within theoretical linguistics and we are positive that it has the potential to have great impact on the treatment and understanding of matching and mismatching gestures and gesture semantics at large.

Literature

Church, R. B. & S. Goldin-Meadow (1986): The mismatch between gesture and speech as an index of transitional knowledge, Cognition 23, 43-71.

Ebert, C., S. Evert, & K. Wilmes (2011): Focus marking via gestures, in I. Reich, E. Horch and D. Pauly (eds.), Sinn & Bedeutung 15. *Proceedings of the 2010 annual conference of the Gesellschaft für Semantik*. Saarbrücken: universaar.

Goldin-Meadow, S., S. Wagner Cook, & Z. A. Mitchell (2009): Gesturing Gives Children New Ideas About Math, *Research Report, University of Chicago*, Association for Psychological Science.

Goldin-Meadow, S., Alibali, M.W., & Church, R.B. (1993). Transitions in concept acquisition: Using the hand to read the mind. *Psychological Review*, 100, 279–297.

Lücking, A., K. Bergmann, F. Hahn, S. Kopp & H. Rieser (2013): Data-based analysis of speech and gesture: the Bielefeld Speech and Gesture Alignment corpus (SaGA) and its applications. *Journal on Multimodal User Interfaces* 7(1-2): 5-18. Special issue on multimodal corpora.

M. Macedonia & K. von Kriegstein (2012): Gestures Enhance Foreign Language Learning, *Biolinguistics* 6.3–4: 393–416.

Perry, M., Church, R.B., & Goldin-Meadow, S. (1988). Transitional knowledge in the acquisition of concepts. *Cognitive Development* 3, 359–400.

Short CVs of the researchers involved

Cornelia Ebert

CE is a postdoctorial researcher at the Leibniz-ZAS, Berlin and one of the PIs of the project *PSIMS*. She received her PhD from the University of Potsdam in 2007. As a postdoc, she worked at the Universities of Osnabrück and Stuttgart.

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[1] In Ebert, Evert, & Wilmes (2011), we could demonstrate with a similar technique that there is a systematic alignment of gesture phrases with focus phrases.

Susanne Fuchs

SF received a PhD from Queen Margaret University College Edinburgh in 2005, she then went for a postdoc to GIPSA-lab Grenoble. She is now a group leader of the Laboratory Phonology Group at ZAS in Berlin and one of the PIs of *PSIMS*.

Susan Goldin-Meadow

SGM got her Ph.D. in Psychology University of Pennsylvania in 1975. Since 1976, she is a professor of the University of Chicago, 1992-2001 Full Professor of the Department of Psychology, Committee on Human Development, Department of Education, The Center for East Asian Studies, and the College University of Chicago, 2001-2005 Irving B. Harris Professor, and since 2006 Beardsley Ruml Distinguished Service Professor. She is one of the founders and faculty directors of the *Center for Gesture, Sign, and Language*, University of Chicago. She is PI of the project *Harnessing gesture and action to improve pre-algebra instruction (NSF DRL-1561405, 2016-2019)*.

Manfred Krifka

MF got his Ph.D. at the University of Munich in 1986. After research and teaching positions in Konstanz and Tübingen, he was appointed professor of linguistics at the University of Texas at Austin in 1990. In 2000, he took up a professorship at Humboldt Universität zu Berlin, and since 2001 he is, in addition, director of the Leibniz- ZAS, Berlin. He is one of the PIs of *PSIMS*.

Heather Mangelsdorf

HM is a Ph.D. Candidate in Cognitive Psychology at the University of Chicago. She graduated from Haverford College in 2011 with Honors in Psychology and a minor in Dance. In 2015 she completed her Master's thesis, which investigated changes in children's speech and gestures over the process of learning a new mathematical concept. She is currently writing her dissertation on physiological mechanisms underlying transitions in knowledge and individual differences in learning from gesture.