

# V. Methods

## 52. Experimental methods in co-speech gesture research

1. Introduction
2. Can we capture co-speech gestural behaviour in experimental settings?
3. Some core questions in the field of co-speech gesture research
4. Experimental methods and paradigms
5. Some methodological shortcomings and limitations
6. Conclusion
7. References

### Abstract

*This chapter provides an introductory overview of some of the basic experimental paradigms traditionally employed in the field of gesture studies to investigate both comprehension and production in adult and child populations. With respect to gesture production, the chapter taps into paradigms used for exploring both intra-psychological and inter-psychological functions of co-speech gestures. At the same time, the present chapter aims to shed light on some of the core questions researchers have been addressing in using the described paradigms, concluding with a reflection on some of the methodological shortcomings and limitations of the respective paradigms and methods used.*

### 1. Introduction

Co-speech gestures occur in all cultures (Kita 2009) and in a wide variety of conversational contexts. This includes more formal settings, such as doctor-patient/therapist-client interaction (Duncan and Niederehe 1974; Heath 1989, 2002), teacher-pupil interaction (Roth 2001), work contexts (Mondada 2007) and official gatherings (Streeck 1994), as well as more informal conversational contexts, for example in interactions with acquaintances, friends and family (Efron 1941; Goodwin 1986; Kendon 1980, 1985; Müller 2003; Seyfeddinipur 2004; Streeck 1994). The kinds of gestures used in these contexts and the functions they fulfil are manifold. Explorations of co-speech gestures occurring in natural contexts have been the origin of gesture studies and they remain a prime focus in the field of gesture studies.

### 2. Can we capture co-speech gestural behaviour in experimental settings?

While analyses of gestures “in the real world” yield important insights in their own right, they are also an important source of inspiration for experimental research on gesture. This chapter focuses on the latter, in particular the experimental techniques

and paradigms that have been employed to find answers to some of the central questions in the field of co-speech gesture (mainly of a psychological nature). Before discussing these in detail, it is important to emphasise that one fundamental assumption underlying this research is that the behaviour we elicit in the laboratory is representative of what we observe outside of it. Of course, one possibility is that, in any given experiment, the chosen stimulus material influences the number and nature of gestures used; therefore results have to be considered in their particular context. Largely, however, the things participants are asked to talk about in gesture experiments tend to also feature frequently in everyday talk, including spatial relations, actions, objects and persons. One potentially critical issue which remains, though, is the common use of cartoon pictures or videos. The semantics of a cartoon world are radically different to the world we live in – literally anything can happen, even physical impossibilities. It is therefore possible that speakers use gestures differently in talk about more mundane events, especially if we consider that one use of gesture may be to channel and influence addressees' inferences; these, of course, could be crucially different when trying to process talk about rather unpredictable cartoon worlds (cf. Holler 2003; Holler and Beattie 2003a). However, because, to the best of my knowledge, no study to date has systematically investigated to what extent gestural behaviour in- and outside the lab are the same or different, we currently have no reason to discount experimental research on these grounds (but it is certainly an issue requiring future research).

Further, participants in experimental settings are providing us with insight into *spontaneously* produced gestural behaviour (sometimes, bodily behaviour may be slightly inhibited initially since research ethics require us to inform participants when they are video-recorded, but warm up conversations tend to get around this problem). Moreover, we know that we observe at least some of the same phenomena in experimental and non-experimental gesture data. For example, imagistic gestural representations are common in everyday conversation (e.g., Kendon 1985), and they occur frequently in laboratory-based communication, too (e.g., McNeill 1992); similar parallels can be claimed for interactive gestures (these involve the addressee in the interaction and are often associated with handing over a turn or keeping the floor) which have been observed both in the lab (Bavelas et al. 1995; Bavelas et al. 1992) as well as in everyday talk (Duncan and Niederehe 1974; Kendon 2004; Streeck and Hartge 1992). Further examples include the so-called “return gesture” (de Fornel 1992) where one participant in a conversation repeating another's gesture, which has also been observed in experimental contexts (Holler 2003; Holler and Wilkin 2011; Kimbara 2006, 2008; Parrill and Kimbara 2006). The parallels mentioned here are but a few and although no hard and fast evidence they serve to illustrate the point that gestural behaviour can be observed in experimental settings which, at least in some important aspects, is like that occurring outside the laboratory.

Of course, all this is altogether less of an issue if we assume that co-speech gestures are largely independent from the interactive processes happening between the people talking. The basic requirement is here that the experimental tasks participants engage in appropriately model the cognitive demands encountered by participants in communication. This brings us to the questions gesture researchers have been trying to answer.

### 3. Some core questions in the field of co-speech gesture research

Of course, the number of questions researchers interested in co-speech gestures have tackled is vast. One of the major debates which has dominated the field in recent years focuses on whether co-speech gestures are indeed an integral part of language, a notion put forward by Bavelas and Chovil (2000), Clark (1996), Kendon (1980, 2000), and McNeill (1985, 1992), amongst others. One aspect of this debate focuses on the function(s) of co-speech gestures and the idea that they may not necessarily be communicatively intended, but, rather, benefit the speaker him or herself (such as through the facilitation of lexical access (e.g., Krauss, Chen, and Gottesman 2000; Rauscher, Krauss, and Chen 1996) or conceptual planning (e.g., Hostetter, Alibali, and Kita 2007; Kita and Davies 2009)). A more overarching question, then, is why we gesture when we speak – which, in addition to the discussion about inter- and intra-personal functions of gesture, also addresses the evolutionary roots and development of co-speech gestures and language (Corballis 2003; Kelly et al. 2002; Rizzolatti and Arbib 1998; Tomasello 2008).

### 4. Experimental methods and paradigms

The paradigms that have been employed to answer these questions experimentally are based on a wide range of methods and techniques. The following sections will provide a general overview of these (rather than in-depth discussions of individual paradigms) – however, due to limitations on space, this overview cannot be completely exhaustive in scope.

#### 4.1. Co-speech gesture comprehension

How we comprehend and process co-speech gestures has been explored experimentally to a large extent using “play-back paradigms”. Here, the participant takes on the role of an observer, decoding the information they are presented with in the form of a video stimulus. Researchers have used this kind of paradigm primarily to test whether co-speech gestures communicate or not. To do so, they have often combined this basic paradigm with many variations regarding the conditions under which the video clips are generated and presented.

One common method is to recruit a first set of participants who describe a range of stimuli (for example landscapes, buildings and people (Krauss, Morrel-Samuels, and Colasante 1991) or cartoon stories (Beattie and Shovelton 1999a, 1999b, 2001)) to a confederate (usually the experimenter). These spontaneous narrations or descriptions have been shown to elicit a great amount of co-speech gestures. Video clips showing isolated gestures from this footage are then played to a new set of participants in a second stage of the study who view gesture and speech together, just the gesture (in absence of speech) or who hear the speech (in absence of gesture); this method allows researchers to evaluate the individual and combined contributions of the two modalities to the decoders’ message comprehension and information take-up. The measures these studies have used to identify whether the gestures have communicated information to the decoder-participants (both in the absence as well as over and above speech) vary. Krauss, Morrel-Samuels, and Colasante (1991) techniques required decoders, amongst

other things, to identify the lexical affiliates of gestures, the semantic interpretation and categorisation of gestures, and the recollection of individual gestures. Beattie and Shovelton (1999a, 1999b, 2001) used what they called a “semantic feature approach”, which involved quizzing participants about the kinds of information they had received regarding a range of detailed semantic categories. This was done in various forms, using either open-ended or forced-choice questionnaires which participants completed for each clip. Feyereisen, van de Wiele, and Dubois (1988) used a similar method; however, they filmed people delivering lectures rather than describing imagistic stimuli and then played video clips of the gestures to decoders. Rather than measuring the amount the gestures communicated, their focus was on how well the decoders could differentiate gesture types (iconic and batonic). These judgements were made either with or without speech to see whether access to the verbal message content would modulate the perception (and communicativeness) of the gestures.

Krauss et al. (1995) also used video footage of speakers communicating, but they included a condition in which participants exchanged information via an intercom (i.e., where addressees could not see the speakers’ gestures). They played these videos back to a set of decoders to compare the communicativeness of gestures which appeared to be produced for addressees and those which did not (measured in terms of the accuracy of decoders’ stimulus selection based on the speakers’ descriptions). Also, their study introduced a slightly different set of stimuli bearing more abstract features, such as synthesized sounds, tea flavours and abstract shapes.

Studies by Rogers (1978) and Riseborough (1981), too, used the basic play-back paradigm to test the communicativeness of gestures, but by introducing conditions in which just the speaker’s face was visible or the face was blanked out they managed to filter out the contribution of facial information accompanying gestural representations (thus contrasting with the studies above). Another variation is the presentation of noise at different levels of intensity to determine the importance of gestures when speech is more or less intelligible. A further important difference to the studies above is that the video footage played back to decoders stemmed from spontaneous interactions between two “naïve” interlocutors, rather than from interactions involving a confederate (with the exception of Riseborough 1981, experiments 2 and 3). This is a crucial point, as speakers in these experiments may have produced more natural gestures than when talking to a confederate – I will come back to this issue in section 5. The measure employed by Rogers (1978) bears similarity to the semantic feature approach used by Beattie and Shovelton (1999a, 1999b, 2001), as individual questions (with multiple choice answers) tapped different semantic aspects of the actions and objects described by the participants in the stimulus videos (an approach based on Fillmore 1971). Riseborough’s (1981) measure, in contrast, was based on participants’ guesses about the objects the gestures represented, their recall of gestures, and the information they inserted into blank fields in a transcript of the original narrative.

Apart from adult to adult communication, it has also been tested whether adults can glean information from children’s gestures, motivated by the idea that co-speech gestures can reveal something about children’s cognitive development (Alibali and Goldin-Meadow 1993; Church and Goldin-Meadow 1986; Broaders et al. 2007; Goldin-Meadow 2000, 2003). In particular, gestures can reveal whether children are at a so-called transitional stage (a period of time just before their implicit knowledge is about to advance by a significant step). Because children may benefit a great

deal from instruction and input from the environment during such periods, it is an important question whether adults (e.g., in the role of parents and teachers) are sensitive to this information in the child's gestural communication. A large number of experimental studies has explored this issue, using a paradigm in which adults decode information from children's gestures, extracted from videos of spontaneous interactions between the child and an experimenter (e.g., Alibali, Flevares, and Goldin-Meadow 1997; Goldin-Meadow and Sandhofer 1999; Goldin-Meadow, Wein, and Chang 1992). During these interactions, children were asked to explain mathematical equations or traditional Piagetian conservation problems, which children tend to grasp only at certain developmental stages. The adult decoders were presented with clips of either just the speech, the speech accompanied by a "matching" gesture (the gesture represents the same information as the speech) or a "mismatching" gesture (the gesture represents different, supplementary information to that contained in speech). They were then asked to check questionnaire answers relating to the video vignettes tapping the information the children had provided, or to talk about the children's explanations, with their own speech and gestures subsequently being analysed for content to see what information the adults had picked up.

Another question is whether children are also able to glean information from co-speech gestures. Kelly and Church (1997) employed a paradigm very similar to that used by Goldin-Meadow and colleagues (e.g., Goldin-Meadow, Wein, and Chang 1992), adapted to test the gesture comprehension of 7 year olds. To do so, they employed three measures, a recall task (children describing, in their own words, the responses given by the children in the video vignettes), a questionnaire testing for the information the children thought had been given in the videos, and a task requiring children to assess whether they thought the children in the videos were just about ready to understand the concepts they were explaining. Other studies have directly compared the decoding abilities of children and adults using the same basic paradigm, combined with comprehension and memory measures appropriate for the different age groups (Church, Kelly, and Lynch 2000; Kelly and Church 1998; Thompson and Massaro 1986). Also, some studies have started to investigate comprehension of gestures in very small children (around 1 year of age) which have mainly focused on the understanding of intentionality associated with gestures. These have used quite different paradigms. For example, Gliga and Csibra (2009) measured children's looking times in response to objects appearing at locations indicated by pointing gestures or at the opposite side to that indicated by the gesture.

Paradigms testing the communicativeness of co-speech gestures have been widely applied to children and healthy young adults; some studies have adapted these paradigms also to other populations, such as older adults and aphasics (for examples, see Cocks et al. 2009; Feyereisen, Seron, and de Macar 1981; Feyereisen and van der Linden 1997; Thompson 1995).

Apart from researching whether co-speech gestures communicate semantic information, studies have also focused on the comprehension of the pragmatic aspects of messages, in particular indirect requests. For example, Kelly et al. (1999) used a playback paradigm to present observers with clips of an actor expressing indirect requests accompanied by gesture (or not), where the gesture provided additional information relevant to interpreting the speaker's communicative intent. They asked participants to predict the response of the person who acted as addressee in the stimulus

video, thus measuring information uptake from the gestures and whether this information was integrated with the interpretation of the speaker's intended meaning. Kelly (2001, experiment 1) investigated the role of gesture for pragmatic understanding in children (3–5 year olds) using a similar paradigm. Children watched video-recorded interactions in which one person uttered an indirect request accompanied by gesture or not, with children being asked what the speaker in the video had referred to.

In addition to experiments presenting video clips to participants acting as observers/decoders, some studies have tested the communicativeness of gestures in live interactions. Graham and Argyle (1975) asked individuals to describe abstract shapes (of high and low verbal encodability) to a group of addressees present in the same room. In one condition, describers were allowed to gesture freely, in the other they were asked to fold their arms. Addressees then drew the shapes, followed by an evaluation of the accuracy of their drawings in the two conditions to measure gestural communication. Holler, Shovelton, and Beattie (2009) asked an actor to provide a scripted cartoon narrative (based on spontaneously produced narratives) to addressees, including the production of gestures which accompanied the original narratives. After the narrations, addressees answered questions about the stories which were then scored by the experimenters for the information they contained according to individual semantic features (some of which were only represented in the gestures). The communicativeness of the gestures in the face-to-face condition was compared to video (gesture + speech and gesture only), as well as to an audio only condition (speech without gesture). With regard to children's gestures, Goldin-Meadow and Sandhofer (1999) have shown that adults can glean significant amounts of information from them when observing the children communicate live with an experimenter, using the same paradigm as with their video-based play-back conditions. Kelly (2001, experiment 2) tested the communicative role of gesture in children's pragmatic understanding live by engaging them in interaction with the experimenter who uttered indirect requests (using just speech, gesture and speech, or just gestures to make the request, such as by pointing at an object). The children's success at understanding was reflected in their response to the indirect requests. Behne, Carpenter, and Tomasello (2005) and Gräfenhain et al. (2009) showed that gestures are communicative in a live context even to very small children (14 months of age). Their studies tested children's interpretation of the communicative intent associated with gestures produced by an adult. For example, in the task used by Gräfenhain et al. (2009), one adult pointed towards one of two locations combined with either averted gaze or gaze directed at another adult looking for a toy. Children who observed this scene were then allowed to look for the toy themselves, with their choice of location providing insight into their comprehension of gesture and gaze cues.

Studies testing the communicativeness of gestures in a live, face-to-face context advance our knowledge of gesture considerably, as they eradicate some of the potential limitations of studies using video play-back techniques. For example, in case of the latter, video clips of individual gestures are presented to decoders often without the natural context in which they occur, thus isolating them from any other contextual cues, and in some studies the clips were even played repeatedly. However, video play-back paradigms do offer the advantage that gestures from spontaneous interactions can be used as the stimuli whereas in most of the studies using a face-to-face context reviewed here (with the exception of the studies by Graham and Argyle as well as

Goldin-Meadow and Sandhofer described above), confederates/experimenters produced the gestures; this issue will be addressed in more detail in section 5.

Yet another alternative is to base the decision about whether the information from a gesture has been received and understood on the addressee's behaviour – such as in response to gestures with an interactive function which are known to elicit certain addressee responses (cf. Bavelas et al. 1995), as well as in cases where participants mirror their interactants' gestures (Holler 2003; Holler and Wilkin 2011; Kimbara 2006, 2008; Parrill and Kimbara 2006). Whereas the amount of detailed insights we can glean from such paradigms (e.g., exactly how the gesture was perceived/interpreted by the addressee, or exactly how much information was received), this sort of paradigm preserves most of the natural interaction in which co-speech gestures are used.

Other paradigms measuring the communicativeness of co-speech gesture do not rely on the use of questionnaires or other pen and paper recordings of participants' answers. Eye-tracking studies, for example, have investigated recipients' overt attention to gestures by measuring the amount and duration of recipients' eye fixations on speakers' gestural movements presented on video or in live conditions (Gullberg 2003; Gullberg and Holmqvist 1999, 2006). Although these eye-tracking data can provide useful insights into when and for how long participants overtly attend to gesture, the tool is not sensitive enough to capture covert attention processes and is not suitable for measuring information uptake from gestures (neither amount nor type) as there appears to be no clear association with direct fixations (Gullberg and Kita 2009). Reaction time measurements, however, are a suitable method for tapping into more covert processes of gesture comprehension (e.g., Kelly, Özyürek, and Maris 2010).

In addition to the behavioural measures reviewed above, at least two types of techniques from cognitive neuroscience have been used to measure the brain's response to gestures. They are suitable for providing insight into information uptake from gestures, the relationship between gesture and speech and the way in which the brain processes information from the two modalities. More precisely, studies using ERP (Event Related Potentials; the measurement of the brain's electrophysiological response as an indication of its activity following stimulus presentation) are suitable to answer questions about the time course of the processing and integration of different signals (including semantic integration, typically captured by the N400 component). The first ERP studies explored the semantic integration of speech and gesture using matching and mismatching gestures either as primes to subsequently presented words (Kelly, Kravitz, and Hopkins 2004), within a sentence context presented simultaneously with speech (Özyürek et al. 2007), and in association with imagistic information (cartoon images) and matching or mismatching words (Wu and Coulson 2007). ERP studies have also been used to investigate if and when the brain picks up information from co-speech gestures representing information that is not contained in the speech at all but semantically relevant for the interpretation of the verbal message (e.g., in the context of ambiguous speech, Holle and Gunter 2007). And, recently, study by Kelly, Creigh, and Bartolotti (2010) has used ERPs to gain insight into how voluntary or automatic gesture-speech integration is.

fMRI techniques (Functional Magnetic Resonance Imaging; a technique used to measure the brain's neural activity based on changes in blood flow, providing insight into brain area-specific activity in response to a stimulus or task) have been used to

find out where in the brain gesture and speech are integrated and which neural networks are involved in their processing. For example, Willems, Özyürek, and Hagoort (2007) used a paradigm in which they varied the difficulty of gesture-speech integration (with matching versus mismatching gestures) to explore this issue. In another study, they compared co-speech gestures with those that are less strongly tied to speech (pantomimes) to see whether they activate different or overlapping brain areas (Willems, Özyürek, and Hagoort 2009). Other researchers have focused on gesture-speech integration when gesture provides supplementary information which disambiguates speech (Holle et al. 2008), and for the involvement of the human mirror system in co-speech gesture processing (Skipper et al. 2007). Further, paradigms have manipulated the degree of perceived communicative intent associated with gestures to investigate pragmatic aspects of gesture-speech integration (e.g., by creating gesture-speech mismatches produced by the same versus different persons (Kelly et al. 2007), or by varying the speaker's gaze direction (Holler, Kelly, Hagoort, and Özyürek 2012), or their body orientation as being oriented either towards the participant or towards a third person (Straube et al. 2010)).

In both ERP and fMRI studies exploring co-speech gesture processing, it is often necessary to work with video stimuli of a highly controlled nature, as, otherwise, it is difficult to attribute observed effects to the intended experimental manipulation. The stimuli used in these studies tend to be video clips of individual gestures presented on their own, accompanied by speech (words or sentences), or preceded by it. Due to the strong need for careful control, the stimuli usually involve a trained actor carrying out scripted hand movements. (Also, ERP and fMRI studies often incorporate additional tasks requiring participants to answer questions or make some other kind of decision (e.g., using a push-button device). This results in additional datasets of reaction times (RTs) and response accuracy, for example, which provide further insight into the comprehension of co-speech gestures.)

## 4.2. Co-speech gesture production

A paradigm that has become widely established is that first used by David McNeill (1985, 1992), involving the use of cartoon videos (famously, Sylvester and Tweety cartoons) watched by one participant who then tells it to another while being video recorded. This paradigm was originally used without any further experimental manipulations and McNeill (1985, 1992) used the footage, rich in spontaneously produced co-speech gestures, to analyse the semantic relationship between gesture and speech. These analyses provided the basis for him to make the important argument that thought is externalised by, and that language consists of, both speech and co-speech gestures, and to model the kind of mental representations underlying speakers' gesture-speech utterances.

Some later studies used the same basic paradigm. Holler and Beattie (2002, 2003a) used it to investigate and quantify the semantic interplay of gesture and speech using a fine-grained semantic feature analysis (albeit with static rather than moving cartoon images), as well as a host of studies exploring cross-linguistic differences, specifically, how speakers of different languages package information in gesture and speech when describing the same stimuli (e.g., Allen et al. 2007; Kita and Özyürek 2003; McNeill 2001; McNeill and Duncan 2000; Özyürek et al. 2008; Özyürek et al. 2005).

The idea that co-speech gestures can provide us with a greater insight into speakers' underlying mental representations has also become of great relevance in developmental psychology. Here, particularly the work by Susan Goldin-Meadow and colleagues (e.g., Alibali and Goldin-Meadow 1993; Church and Goldin-Meadow 1986; Broaders et al. 2007; Goldin-Meadow, Alibali, and Church 1993; Goldin-Meadow 2003; Perry, Church, and Goldin-Meadow 1988) (see also Pine, Lufkin, and Messer 2004) has shown that children often externalise knowledge in co-speech gesture before they are ready to communicate verbally about the same concepts, such as in their explanations of conservation, maths and balance problems. In these kinds of studies, children are given problems of the aforementioned kind and are simply asked to provide their explanation of it. Both gesture and speech can then be analysed for the semantic information they represent.

Because co-speech gestures bear a very close relationship to speech, researchers have been intrigued by the nature of this relationship, the role of gesture in the process of speaking and communicating and the exact functions they fulfil in talk. Different experimental paradigms have been used to test different hypotheses; these can be broadly classed into those postulating cognitive functions (thus benefiting mainly the speaker) and those postulating communicative functions (thus benefiting primarily the addressee). However, although contrasted here and discussed separately, these approaches are not necessarily mutually exclusive.

Goldin-Meadow et al. (2001) have argued that co-speech gestures may reduce a speaker's cognitive load and thus free up cognitive capacities. In their paradigm, participants explained their solutions to a series of maths tasks, which they frequently accompanied with gestures, while trying to remember a sequence of letters. This was combined with a standard memory test (tapping the letter sequences) to see whether those who gestured more would perform better, assuming that gesturing enabled participants to allocate more resources to the memory task.

Other researchers have claimed that gestures maintain representations in spatial working memory, thus indirectly influencing speech production (Morsella and Krauss 2004; Wesp et al. 2001). Both Morsella and Krauss (2004) and Wesp et al.'s (2001) paradigms required participants to describe stimulus objects either from memory (stimulus absent) or while looking at them (stimulus present). A similar procedure was used by de Ruiter (1998, experiment 3) to test the lexical retrieval theory against the theory that gestures facilitate the encoding of imagery in speech.

Co-speech gestures have also been postulated to facilitate conceptual planning during the speech production process. To investigate this hypothesis, researchers have used paradigms which compare conditions under which conceptual planning is easy versus difficult. For example, Alibali, Kita, and Young (2000) used traditional Piagetian conservation tasks and asked children to either *explain* why they thought two vessels held the same or different amounts of liquid, or *describe* how the two vessels looked differently. Other studies have asked participants to describe a range of shapes made up from lines connecting a number of dots to another person; to create a conceptually more difficult condition, they removed the lines, leaving just dot patterns less suggestive of a particular shape (Hostetter, Alibali, and Kita 2007). Another study created conditions where participants had to describe geometrical shapes with or without distracting lines creating competing conceptualisations (Kita and Davies 2009). Melinger and Kita (2007) increased conceptual planning load by asking

participants to complete a secondary, competing task (either similar or different to the primary task).

Lexical access is another core component of the speech production process, happening at a later stage than the conceptual planning of messages. Some researchers have argued that it is at this point that co-speech gestures fulfil a facilitating function (e.g., Krauss, Chen, and Gottesman 2000; Rauscher, Krauss, and Chen 1996). Two main paradigms have been used to test this particular theory. One involves preventing speakers from gesturing followed by a subsequent analysis of the effects on verbal encoding; researchers have used various methods to restrict speakers' gestures, such as asking them to press desk-mounted hand switches (Lickiss and Wellens 1978), hold objects in their hands (Frick-Horbury and Guttentag 1998, experiment 1), or to keep their arms folded (Beattie and Coughlan 1999; Graham and Argyle 1975); however, this procedure may require the speaker to divide their attention by concentrating not only on the experimental task but also on the fact that they should not move their hands. Other studies have therefore used methods which meant that speakers were not physically able to move their hands, for example by fastening their forearms to arm rests (Rime et al. 1984), by immobilising their hands in special apron pockets (Frick-Horbury and Guttentag 1998, experiment 2) or by placing electrodes on their palms while pretending that the experiment focused on the psychophysiological recordings made during the task (Rauscher, Krauss, and Chen 1996).

A second paradigm used to investigate the function of gesture and test the theory of lexical access involves the elicitation of tip-of-the-tongue (ToT) states. For example, researchers have tried to get participants thinking about certain words by providing them with the dictionary definitions (and the first letter) of a range of words (Beattie and Coughlan 1999; Frick-Horbury and Guttentag 1998) or with pictures of objects when studying tip-of-the-tongue states in children (Pine, Bird, and Kirk 2007; Yan and Nicoladis 2009). The aim was to then analyse the frequency and type of gestures accompanying tip-of-the-tongue states, and to compare the number of tip-of-the-tongue states resolved with and without gesture. Some researchers have combined this paradigm with that of gesture prevention described above (e.g., Beattie and Coughlan 1999; Frick-Horbury and Guttentag 1998).

In addition to linking gesture use to cognitive, intra-personal functions, researchers have also developed paradigms to investigate their communicative, inter-personal ones. One well established paradigm involves the manipulation of visibility between the speaker and the addressee, usually by separating both participants, present in the same room, with an opaque screen (Alibali, Heath, and Myers 2001; Gullberg 2006). Cohen and Harrison (1973), who were amongst the first to experimentally investigate the communicative functions of gestures, used a combined manipulation of both visibility and co-presence; instead of being separated by an opaque screen, participants were located in different rooms and communicated via an intercom (they compared this to a face-to-face condition). In 1977, Cohen published a follow-up study and introduced a third condition in which participants talked into a tape-recorder, thus removing the addressee completely (speakers were told they were just practicing the task). This allowed him to compare the influence of visibility and co-presence on gestures with the influence of a completely absent addressee. Mol et al. (2009) compared four different conditions, participants communicating face-to-face, separated by an opaque screen, and via a web cam (here the participant did not see the addressee but was told that

the addressee could see them via a video link); the fourth condition was set up exactly like the latter but participants were told that their communication (both audio and visual) would be fed into a computer. This manipulation allowed the authors to compare the previous three different communicative contexts as well as human-human and human-machine communication.

Bavelas et al. (2008) introduced another important manipulation to tease apart the influence of visibility and dialogue on gesture use. In addition to visibility and co-presence, they varied dialogic interaction. This was done by comparing a face-to-face and a screen condition, in which interactants were free to engage in dialogue, with a tape recorder condition, in which participants believed they were recording their message for another person who would listen to the recording later – thus, neither did these speakers see their addressees, nor did they engage in dialogue with them. This work builds on a series of other studies manipulating monologue and dialogue and investigating the role of the addressee's involvement in gesture and language use (Bavelas et al. 1995; Bavelas, Coates, and Johnson 2000; Bavelas et al. 1988; Bavelas et al. 1986). In addition to research on gesture use in dyadic interaction, manipulating visibility, co-presence and dialogic interaction, researchers have investigated the influence of another contextual factor on co-speech gestures – that of addressee location (Özyürek 2002). Here, speakers talked to either one or two addressees who were located directly opposite or towards the side. Speakers' use of gesture when representing spatial information was compared between these conditions to provide insight into recipient design in gesture use. Further, because this research involved multi-party interactions, it expands our knowledge from gesture use in dyadic interactions to that in triads.

Apart from the influence of the degree of interactivity and physical contextual factors (such as co-presence, visibility, number of addressees and their location), researchers have investigated the influence of more cognitive, covert processes of conversation. One variable that has been manipulated in this context is the common ground between speakers and their addressees (i.e., the knowledge, beliefs and assumptions mutually shared by participants in an interaction (Clark 1996)). Common ground has been experimentally induced in a variety of ways. Gerwing and Bavelas (2004) asked participants to play with either the same (common ground) or a different (no common ground) set of toys and then asked one person to tell another about their experiences with the toys. The gestures used to refer to the toys in the two groups were compared for differences in their form (precision). Apart from creating common ground based on shared action-based experiences, researchers have also used paradigms to induce it visually by presenting stimuli to the speaker and the addressee or just to the speaker (who then talks to an unknowing addressee). Holler and Stevens (2007) used images showing particularly large entities amongst smaller ones and focused their analysis on the effect of common ground on the encoding of size information in both gesture and speech. Holler and Wilkin (2009) used a similar method, but instead of pictures used a short video, allowing their analysis to focus on a wider range of semantic features (relating to actions, objects and persons, as well as their attributes). Parrill (2010) also used video stimuli to experimentally manipulate common ground, but instead of a longer video (telling a whole story) she used a short clip showing a single event and, similar to Holler and Stevens (2007), focused her analysis on one semantic aspect of it (here, the ground element). In addition, she combined this with the manipulation of “information salience”,

i.e., whether the ground element had been mentioned by an experimenter previously to the participant referring to it or not. Holler (2003) and Jacobs and Garnham (2007) manipulated common ground by asking participants to relay the same description of events represented in cartoon pictures to the same addressee repeatedly (thus accumulating common ground) in order to then compare the speakers' gesture rate across the trials. Jacobs and Garnham (2007) also used joint visual availability of the stimulus to induce common ground, by providing both speaker and addressee with the view of the stimulus while it was being described.

Other studies investigating the link between communicative intent and co-speech gestures have manipulated verbal ambiguity to find out whether speakers would draw on the gestural modality to clarify their speech for the interlocutor (Holler and Beattie 2003b). Further, Melinger and Levelt (2004) investigated whether co-speech gestures encode what they defined as "necessary" information, and whether in such cases speakers were less likely to also represent this information in speech.

Although not manipulating communicative intent directly, studies focusing on gestural mimicry (Holler and Wilkin 2011; Kimbara 2006, 2008; Parrill and Kimbara 2006) provide insight into the collaborative use of co-speech gestures and add further to our knowledge of communicative uses of co-speech gestures in communication.

Finally, many of the paradigms reviewed above have been adapted (and in some cases special paradigms have been newly created) to investigate gesture production in populations other than children and the "healthy student adult", such as in older adults (Feyereisen and Havard 1999), split-brain patients (Kita and Lausberg 2008; Lausberg and Kita 2002; Lausberg et al. 2003), aphasic patients (Cocks, Hird, and Kirsner 2007; Hadar et al. 1998) and Alzheimer's patients (Carlomagno et al. 2005; Glosser, Wiley, and Barnoski 1998).

## 5. Some methodological shortcomings and limitations

One very debatable issue is the use of confederates in production (but also comprehension) studies of gesture. The obvious reason is that the verbal and nonverbal behaviour of confederates may seem unnatural as it is non-spontaneous. Of course, confederates may be able to control some behaviours quite well, such as whether to ask a question at a certain point or not. But this may not be the case for others, especially quick, fleeting micro-behaviours which are under much less voluntary control (movements of the facial muscles, for example) and behaviours which it is difficult to produce consistently across experimental trials (e.g., the exact intonation with which we utter something). What enhances the problem further is that in most cases the same confederate is "used" in more than one experimental trial. This means that when listening to descriptions or narratives of certain stimuli, latest on trial number 2 the confederate has pre-existing knowledge about what the speaker is telling (i.e., it is given information, without the speaker knowing this) and hence may respond to it differently than when being provided with new information. This, in turn, may of course affect the participant's behaviour. An additional problem is that in many cases the experimenter takes on the role of the confederate. This means that they are familiar with the experimental manipulations and in most cases probably also with the exact hypotheses. Potentially, this can have a huge impact on the confederate's behaviour which may be influenced by their particular expectations. The participant's verbal and/or gestural behaviour may, as a result, be biased

into a certain direction (e.g., the experimenter may, unconsciously, respond more enthusiastically or encouragingly (verbally or nonverbally) in cases where the participant has displayed gestural behaviour in line with the experimental predictions (or sanction behaviour going against them, such as with a lack of positive feedback)).

Of course, there may sometimes be good reasons as to why researchers want to use confederates in their studies. In comprehension studies, it is important to isolate a single manipulation or difference to test a particular hypothesis and obtain clear results. Especially in ERP and MRI studies, a tightly controlled, carefully constructed stimulus (optimising the signal/noise ratio) is necessary for the signal to pick up any meaningful and unequivocally interpretable responses from the brain. Other reasons are that confederates producing scripted behaviour allow researchers to examine recipients' responses to these behaviours – which may be useful when the natural occurrence of such behaviours is rather rare (meaning that an unmanageably huge number of hours of recordings and participants would be needed to obtain large enough a dataset), or when the social context in which it occurs creates too much noise for a clear analysis. Yet another reason of for using confederates, at least in production studies, is the availability of resources, including the size of the participant pool, financial means for compensating participants, and the greater effort and difficulty associated with recruiting unacquainted participants as pairs. Although regarding this latter reason scientific rigour and validity should certainly weigh stronger, much of the research using confederates in production studies was carried out quite a few years ago, when the strong influences social-interactional contexts can have on gesture use was not all that well known. Researchers nowadays benefit from this awareness and where future studies need to employ confederates as addressees or stimuli-actors for the above named (or other) reasons, one way of reducing methodological limitations is to complement the analyses with a second, smaller dataset using spontaneous interactions between “naïve” participants in the same respective context. This helps to demonstrate that similar behaviour occurs in a more natural context. Another (or better, additional) option is to have the consistency and naturalness of the confederate's behaviour established by a separate set of independent observers.

Another controversial issue is the manipulation of the interaction between speaker and addressee. In many of the production studies cited in this chapter, the participant taking on the role of the addressee was asked not to interrupt the speaker with questions (while still delivering back-channel responses though). It appears that one of the reasons researchers choose to limit the amount of dialogic exchange is the possibility of experimental confounds. Studies often measure the influence of various cognitive and social variables on gesture by focusing on gesture frequency or gesture rate. However, we also know that verbal interaction itself (as compared to monologue) influences gestures rate, independent of any additional manipulation (Bavelas et al. 1995; Beattie and Aboudan 1994). Thus, when manipulating, for instance, common ground or conceptual load, participants may interact more with their addressee in one of the experimental conditions than in another (e.g., participants may feel more rapport with the other participant when mutually sharing certain knowledge, or they may seek more help or feedback from their addressee when finding communication conceptually more difficult). In such a case, a higher gesture rate in one of the conditions could be due to a difference in dialogic interaction *per se* as well as due to the experimental manipulation.

However, considering that other studies have shown that dialogical involvement of the addressee impacts crucially on gestural behaviour (Bavelas et al. 1995; Beattie and Aboudan 1994) studies restricting interaction may be fundamentally limited in the extent to which their findings can be generalised to dialogue. Because dialogue is one of the most common forms of everyday conversation this is a serious potential limitation. While researchers certainly need to be aware of this limitation (and take it into account when drawing their conclusions), those studies based on restricted interactions are certainly not without value. This is because everyday talk constitutes a continuum, ranging from monologue to dialogue (Pickering and Garrod 2004). People talk in monologue when delivering lectures, conference talks or other oral presentations, and in conversation, individual speakers often take extended turns to tell stories and anecdotes, jokes, describe how someone gets from A to B, what procedure to follow to achieve a certain goal, or about other complex contexts whose explanation stretches over several sentences. During such extended turns it is not rare that addressees provide mainly backchannel responses rather than take the floor. In other cases, some interlocutors may simply be more dominant, vocal or extrovert and therefore talk considerably more than others, possibly leaving no opportunity at all for turn contributions from other participants for much of the conversation. Moreover, in almost all of the gesture production studies reviewed here, one participant is assigned the role of the speaker who has all the information (i.e., who has seen the stimuli) and who tells it to their addressee. This sort of situation leads, for obvious reasons, mainly to conversations dominated by one individual with a limited number of turns between speakers, even when these are completely free to interact. Considering the wide range of different forms of talk, it is important that our research reflects this spectrum, thus capturing human communication as the multi-faceted dimension that it is. At the same time, though, it is vital that researchers recognise the particular facet that individual datasets and analyses are representative of and be wary of over-generalisation.

Alternatively, researchers may choose to explore free interaction as a default, and in contexts where differences in dialogic interaction could confound results, undertake steps to tackle these unwanted influences. For example, experimental groups could be compared for the number of turns used/the number of questions asked, and so on. If differences on these dimensions are found, statistical procedures that partial out the respective influences could be employed. This would allow researchers to carry out experimental studies in order to exert some degree of control over aspects such as content of talk (narration/description of set stimuli) but without compromising spontaneous social interaction and running the risk of unnecessary reductionism; only approaches using a social unit of analysis offer the opportunity to capture those processes that cannot be captured by simply “summing the parts” (cf. Bavelas 2005). Considering we still know relatively little about gesture as a social behaviour and its use in dialogic interaction, experimental paradigms based on spontaneous, free interaction between non-confederates is certainly one main avenue researchers in this field need to pursue.

## 6. Conclusion

In this chapter, I have tried to provide an overview of the range of basic paradigms (and their variations) employed in experimental co-speech gesture research, combined with

some degree of critical reflection on aspects of these procedures. Due to the scope of this article, this overview remains selective and limited in many ways, but I hope to have been able to provide some starting point here, especially to scholars new in the field of co-speech gesture research.

Ultimately, in choosing between different experimental methods and weighing up their pros and cons, it depends on the researcher's exact aim to decide what is gained and lost by opting for a particular paradigm. With respect to the interpretation of research findings, it is important to recognise that differences in research results may in fact be rooted in differences between experimental paradigms used, even if these may seem small (such as regarding the degree of dialogic interaction). Further, it is important to be careful with the generalisation of findings and with distinguishing, for example, whether results tell us something about gesture use in dialogue or in more monologue-type contexts; or whether they tell us nothing about gesture use in interaction at all but useful things about the gesture-speech relationship nevertheless (i.e., something that Bavelas 2005 has referred to as studying the mind, or individuals' thinking, as opposed to social interaction).

In trying to make a choice between different paradigms in the light of their methodological advantages and limitations, the most fruitful approach may still be one that combines less with more experimentally controlled methods (given there are good reasons for employing the latter). This way, we might throw light on the phenomena we aim to investigate from a range of different angles, capturing partly different aspects, and obtaining the most comprehensive answers. In my view, different experimental methods and techniques complement, similar to laboratory-based research of co-speech gesture complementing observations of gesture in non-experimental contexts – both in terms of the methods used and the questions answered.

## 7. References

- Alibali, Martha W., Lucia M. Flevaras and Susan Goldin-Meadow 1997. Assessing knowledge conveyed in gesture: Do teachers have the upper hand? *Journal of Educational Psychology* 89: 183–193.
- Alibali, Martha W. and Susan Goldin-Meadow 1993. Gesture speech mismatch and mechanisms of learning: What the hands reveal about a child's state of mind. *Cognitive Psychology* 25: 468–523.
- Alibali, Martha W., Dana C. Heath and Heather J. Myers 2001. Effects of visibility between speaker and listener on gesture production: Some gestures are meant to be seen. *Journal of Memory and Language* 44: 169–188.
- Alibali, Martha W., Sotaro Kita and Amanda J. Young 2000. Gesture and the process of speech production: We think, therefore we gesture. *Language & Cognitive Processes* 15: 593–613.
- Allen, Shanley, Ash Özyürek, Sotaro Kita, Amanda Brown, Reyhan Furman, Tomoko Ishikuza and Mihoko Fujii 2007. Language-specific and universal influences in children's syntactic packaging of manner and path: A comparison of English, Japanese, and Turkish. *Cognition* 102: 16–48.
- Argyle, Michael and Jean A. Graham 1975. A cross-cultural study of the communication of extra-verbal meaning by gestures. *International Journal of Psychology* 10: 57–67.
- Bavelas, Janet B. 2005. The two solitudes: Reconciling social psychology and language and social interaction. In: Kristine L. Fitch and Robert E. Sanders (eds), *Handbook of Language and Social Interaction*, 179–200. Mahwah, NJ: Lawrence Erlbaum.
- Bavelas, Janet B., Alex Black, Nicole Chovil, Charles R. Lemery and Jennifer Mullett 1988. Form and function in motor mimicry topographic evidence that the primary function is communicative. *Human Communication Research* 14: 275–299.

- Bavelas, Janet B., Alex Black, Charles R. Lemery and Jennifer Mullett 1986 "I show how you feel": Motor mimicry as a communicative act. *Journal of Personality and Social Psychology* 50: 322–329.
- Bavelas, Janet B. and Nicole Chovil 2000. Visible acts of meaning: An integrated message model of language in face-to-face dialogue. *Journal of Language and Social Psychology* 19: 163–194.
- Bavelas, Janet B., Nicole Chovil, Linda Coates and Lori Roe 1995. Gestures specialized for dialogue. *Personality and Social Psychology Bulletin* 21: 394–405.
- Bavelas, Janet B., Nicole Chovil, Douglas A. Lawrie and Allan Wade 1992. Interactive gestures. *Discourse Processes* 15: 469–489.
- Bavelas, Janet B., Linda Coates and Trudy Johnson 2000. Listeners as co-narrators. *Journal of Personality and Social Psychology* 79: 941–952.
- Bavelas, Janet B., Jennifer Gerwing, Chantelle Sutton and Danielle Prevost 2008. Gesturing on the telephone: Independent effects of dialogue and visibility. *Journal of Memory and Language* 58: 495–520.
- Beattie, Geoffrey and Rima Aboudan 1994. Gestures, pauses and speech: An experimental investigation of the effects of changing social context on their precise temporal relationship. *Semiotica* 99: 239–272.
- Beattie, Geoffrey and Jane Coughlan 1999. An experimental investigation of the role of iconic gestures in lexical access using the tip-of-the-tongue phenomenon. *British Journal of Psychology* 90: 35–56.
- Beattie, Geoffrey and Heather Shovelton 1999a. Do iconic hand gestures really contribute anything to the semantic information conveyed by speech? *Semiotica* 123: 1–30.
- Beattie, Geoffrey and Heather Shovelton 1999b. Mapping the range of information contained in the iconic hand gestures that accompany spontaneous speech. *Journal of Language and Social Psychology* 18: 438–462.
- Beattie, Geoffrey and Heather Shovelton 2001. An experimental investigation of the role of different types of iconic gesture in communication. *Gesture* 1(2): 129–149.
- Behne, Tanya, Malinda Carpenter and Michael Tomasello 2005. One-year-olds comprehend the communicative intentions behind gestures in a hiding game. *Developmental Science* 8: 492–499.
- Broaders, Sara C., Susan Wagner Cook, Zachary Mitchell and Susan Goldin-Meadow 2007. Making children gesture brings out implicit knowledge and leads to learning. *Journal of Experimental Psychology: General* 136: 539–550.
- Carlomagno, Sergio Maria Pandolfi, Andrea Marini, Gabriella Di Iasi and Carla Cristilli 2005. Coverbal gestures in Alzheimer's type dementia. *Cortex* 41: 535–546.
- Church, Ruth Breckinridge and Susan Goldin-Meadow 1986. The mismatch between gesture and speech as an index of transitional knowledge. *Cognition* 23: 43–71.
- Church, Ruth Breckinridge, Spencer D. Kelly and Katherine Lynch 2000. Multi-modal processing over development: The case of speech and gesture detection. *Journal of Nonverbal Behavior* 24: 151–174.
- Clark, Herbert H. 1996. *Using Language*. Cambridge: Cambridge University Press.
- Cocks, Naomi, Kathryn Hird and Kim Kirsner 2007. The relationship between right hemisphere damage and gesture in spontaneous discourse. *Aphasiology* 21: 299–319.
- Cocks, Naomi, Laetitia Sautin, Sotaro Kita, Gary Morgan and Sally Zlotowitz 2009. Gesture and speech integration: An exploratory study of a man with aphasia. *International Journal of Language and Communication Disorders* 44: 795–804.
- Cohen, Akiba A. 1977. The communicative functions of hand illustrators. *Journal of Communication* 27: 54–63.
- Cohen, Akiba A. and Randall P. Harrison 1973. Intentionality in the use of hand illustrators in face-to-face communication situations. *Journal of Personality and Social Psychology* 28: 276–279.
- Corballis, Michael 2003. *From Hand to Mouth: The Origins of Language*. Princeton, NJ: Princeton University Press.
- de Fornel, Michel 1992. The return gesture: Some remarks on context, inference, and iconic gesture. In: Peter Auer and Aldo Di Luzio (eds.), *The Contextualisation of Language*, 159–176. Amsterdam: John Benjamins.

- de Ruiter, Jan-Peter 1998. *Gesture and speech production*. Ph.D. dissertation, MPI Series in Psycholinguistics, Catholic University of Nijmegen, the Netherlands.
- Duncan, Starkey and George Niederehe 1974. On signalling that it's your turn to speak. *Journal of Experimental Social Psychology* 10: 234–247.
- Efron, David 1941. *Gesture and Environment*. New York: King's Crown Press.
- Feyereisen, Pierre and Isabelle Havard 1999. Mental imagery and production of hand gestures while speaking in younger and older adults. *Journal of Nonverbal Behavior* 23: 153–171.
- Feyereisen, Pierre, Xavier Seron and M. de Macar 1981. L'interpretation de differentes categories de gestes chez des sujets aphasiques. *Neuropsychologia* 19: 515–521.
- Feyereisen, Pierre and Martial van der Linden 1997. Immediate memory for different kinds of gestures in younger and older adults. *Cahiers de Psychologie Cognitive/Current Psychology of Cognition* 16: 519–533.
- Feyereisen, Pierre, Michèle van de Wiele and Fabienne Dubois 1988. The meaning of gestures: What can be understood without speech? *Cahiers de Psychologie Cognitive* 8: 3–25.
- Fillmore, Charles 1971. Types of lexical information. In: Danny D. Steinberg and Leon A. Jakobovits (eds.), *Semantics. An Interdisciplinary Reader in Philosophy, Linguistics and Psychology*, 370–392. New York: Cambridge University Press.
- Frick-Horbury, Donna and Robert E. Guttentag 1998. The effects of restricting hand gesture production on lexical retrieval and free recall. *American Journal of Psychology* 111: 43–62.
- Gerwing, Jennifer and Janet B. Bavelas 2004. Linguistic influences on gesture's form. *Gesture* 4(2): 157–195.
- Gliga, Teodora and Gergely Csibra 2009. One-year-old infants appreciate the referential nature of deictic gestures and words. *Psychological Science* 20: 347–353.
- Glosser, Guila, Mary J. Wiley and Edward J. Barnoski 1998. Gestural communication in Alzheimer's disease. *Journal of Clinical and Experimental Neuropsychology* 20: 1–13.
- Goldin-Meadow, Susan 2000. Beyond words: The importance of gestures to researchers and learners. *Child Development* 71: 231–239.
- Goldin-Meadow, Susan 2003. *Hearing Gesture: How Our Hands Help Us Think*. Cambridge, MA: Harvard University Press.
- Goldin-Meadow, Susan, Howard Nusbaum, Spencer D. Kelly and Susan Wagner 2001. Explaining math: Gesturing lightens the load. *Psychological Science* 12: 516–522.
- Goldin-Meadow, Susan and Catherine Sandhofer 1999. Gestures convey substantive information about a child's thoughts to ordinary listeners. *Developmental Science* 2: 67–74.
- Goldin-Meadow, Susan, Martha Wagner Alibali, and Ruth Breckinridge Church 1993. Transitions in concept acquisition: Using the hand to read the mind. *Psychological Review* 100: 279–297.
- Goldin-Meadow, Susan, Debra Wein and Cecilia Chang 1992. Assessing knowledge through gesture: Using children's hands to read their minds. *Cognition and Instruction* 9: 201–219.
- Goodwin, Charles 1986. Gesture as a resource for the organization of mutual orientation. *Semiotica* 62: 29–49.
- Gräfenhain, Maria, Tanya Behne, Malinda Carpenter and Michael Tomasello 2009. One-year-olds' understanding of nonverbal gestures directed to a third person. *Cognitive Development* 24: 23–33.
- Graham, Jean A. and Michael Argyle 1975. A cross-cultural study of the communication of extra-verbal meaning by gestures. *International Journal of Psychology* 10: 57–67.
- Gullberg, Marianne 2003. Eye movements and gestures in human face-to-face interaction. In: Jukka Hyönä, Ralph Radach and Heiner Deubel (eds.), *The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research*, 685–703. Oxford: Elsevier.
- Gullberg, Marianne 2006. Handling discourse: Gestures, reference tracking, and communication strategies in early L2. *Language Learning* 56: 155–196.
- Gullberg, Marianne and Kenneth Holmqvist 1999. Keeping an eye on gestures: Visual perception of gestures in face-to-face communication. *Pragmatics & Cognition* 7: 35–63.

- Gullberg, Marianne and Kenneth Holmqvist 2006. What speakers do and what addressees look at: Visual attention to gestures in human interaction live and on video. *Pragmatics & Cognition* 14: 53–82.
- Gullberg, Marianne and Sotaro Kita 2009. Attention to speech-accompanying gestures: Eye movements and information uptake. *Journal of Nonverbal Behavior* 33: 251–277.
- Hadar, Uri, Dafna Wenkert-Olenik, R. Krauss and Nachum Soroker 1998. Gesture and the processing of speech: Neuropsychological evidence. *Brain and Language* 62: 107–126.
- Heath, Christian 1989. Pain talk: The expression of suffering in the medical consultation. *Social Psychology Quarterly* 52: 113–125.
- Heath, Christian 2002. Demonstrative suffering: The gestural (re)embodiment of symptoms. *Journal of Communication* 52: 597–616.
- Holle, Henning and Thomas C. Gunter 2007. The role of iconic gestures in speech disambiguation: ERP evidence. *Journal of Cognitive Neuroscience* 19: 1175–1192.
- Holle, Henning, Thomas C. Gunter, Shirley-Ann Rüschemeyer, Andreas Hennenlotter and Marco Iacoboni 2008. Neural correlates of the processing of co-speech gestures. *NeuroImage* 39: 2010–2024.
- Holler, Judith 2003. Semantic and pragmatic aspects of representational gestures: Towards a unified model of communication in talk. Ph.D. dissertation, Department of Psychology, University of Manchester, Manchester (UK).
- Holler, Judith and Geoffrey Beattie 2002. A micro-analytic investigation of how iconic gestures and speech represent core semantic features in talk. *Semiotica* 142: 31–69.
- Holler, Judith and Geoffrey Beattie 2003a. How iconic gestures and speech interact in the representation of meaning: Are both aspects really integral to the process? *Semiotica* 146: 81–116.
- Holler, Judith and Geoffrey Beattie 2003b. Pragmatic aspects of representational gestures: Do speakers use them to clarify verbal ambiguity for the listener? *Gesture* 3(2): 127–154.
- Holler, Judith, Spencer D. Kelly, Peter Hagoort and Asli Özyürek 2012. When gestures catch the eye: The influence of gaze direction on co-speech gesture comprehension in triadic communication. In: Naomi Miyake, David Peebles and Richard D. Cooper (eds.), *Proceedings of the 34th Annual Conference of the Cognitive Science Society*, 467–472. Austin, TX: Cognitive Society.
- Holler, Judith, Heather Shovelton and Geoffrey Beattie 2009. Do iconic hand gestures really contribute to the communication of semantic information in a face-to-face context? *Journal of Nonverbal Behavior* 33: 73–88.
- Holler, Judith and Rachel Stevens 2007. The effect of common ground on how speakers use gesture and speech to represent size information. *Journal of Language and Social Psychology* 26: 4–27.
- Holler, Judith and Katie Wilkin 2009. Communicating common ground: How mutually shared knowledge influences speech and gesture in a narrative task. *Language and Cognitive Processes* 24: 267–289.
- Holler, Judith and Katie Wilkin 2011. Co-speech gesture mimicry in the process of collaborative referring during face-to-face dialogue. *Journal of Nonverbal Behavior* 35: 133–153.
- Hostetter, Autumn B., Martha W. Alibali and Sotaro Kita 2007. I see it in my hands' eye: Representational gestures reflect conceptual demands. *Language and Cognitive Processes* 22: 313–336.
- Jacobs, Naomi and Alan Garnham 2007. The role of conversational hand gestures in a narrative task. *Journal of Memory and Language* 56: 291–303.
- Kelly, Spencer D. 2001. Broadening the units of analysis in communication: speech and nonverbal behaviours in pragmatic comprehension. *Journal of Child Language* 28: 325–349.
- Kelly, Spencer D., Dale Barr, Ruth Breckinridge Church and Katheryn Lynch 1999. Offering a hand to pragmatic understanding: The role of speech and gesture in comprehension and memory. *Journal of Memory and Language* 40: 577–592.
- Kelly, Spencer D. and Ruth Breckinridge Church 1997. Can children detect conceptual information conveyed through other children's nonverbal behaviors? *Cognition and Instruction* 15: 107–134.
- Kelly, Spencer D. and Ruth Breckinridge Church 1998. A comparison between children's and adults' ability to detect conceptual information conveyed through representational gestures. *Child Development* 69: 85–93.

- Kelly, Spencer D., Peter Creigh and James Bartolotti 2010. Integrating speech and iconic gestures in a stroop-like task: Evidence for automatic processing. *Journal of Cognitive Neuroscience* 22(4): 683–694.
- Kelly, Spencer D., Jana M. Iverson, Joseph Terranova, Julia Niego, Michael Hopkins and Leslie Goldsmith 2002 Putting language back in the body: Speech and gesture on three time frames. *Developmental Neuropsychology* 22: 323–349.
- Kelly, Spencer D., Corinne Kravitz and Michael Hopkins 2004. Neural correlates of bimodal speech and gesture comprehension. *Brain and Language* 89: 253–260.
- Kelly, Spencer D., Asli Özyürek and Eric Maris 2010. Two sides of the same coin: Speech and gesture mutually interact to enhance comprehension. *Psychological Science* 21: 260–267.
- Kelly, Spencer D., Sarah Ward, Peter Creigh and James Bartolotti 2007. An intentional stance modulates the integration of gesture and speech during comprehension. *Brain and Language* 101: 222–233.
- Kendon, Adam 1980. Gesticulation and speech: Two aspects of the process of utterance. In: Mary Ritchie Key (ed.), *The Relationship of Verbal and Nonverbal Communication*, 207–228. The Hague: Mouton.
- Kendon, Adam 1985. Some uses of gesture. In: Deborah Tannen and Muriel Saviile-Troike (eds.), *Perspectives on Silence*, 215–234. Norwood, NJ: Ablex.
- Kendon, Adam 2000. Language and gesture: Unity or duality. In: David McNeill (ed.), *Language and Gesture*, 47–63. Cambridge: Cambridge University Press.
- Kendon, Adam 2004. *Gesture: Visible Action as Utterance*. Cambridge: Cambridge University Press.
- Kimbara, Irene 2006. On gestural mimicry. *Gesture* 6(1): 39–61.
- Kimbara, Irene 2008. Gesture form convergence in joint description. *Journal of Nonverbal Behavior* 32: 123–131.
- Kita, Sotaro 2009. Cross-cultural variation of speech-accompanying gesture: A review. *Language and Cognitive Processes* 24: 145–167.
- Kita, Sotaro and Thomas S. Davies 2009. Competing conceptual representations trigger co-speech representational gestures. *Language and Cognitive Processes* 24: 761–775.
- Kita, Sotaro and Hedda Lausberg 2008. Generation of co-speech gestures based on spatial imagery from the right-hemisphere: Evidence from split-brain patients. *Cortex* 44: 131–139.
- Kita, Sotaro and Asli Özyürek 2003. What does cross-linguistic variation in semantic coordination of speech and gesture reveal? Evidence for an interface representation of spatial thinking and speaking. *Journal of Memory and Language* 48: 16–32.
- Krauss, Robert M., Yihsiu Chen and Rebecca Gottesman 2000. Lexical gestures and lexical access: A process model. In: David McNeill (ed.), *Language and Gesture*, 261–283. New York: Cambridge University Press.
- Krauss, Robert M., Robert A. Dushay, Yihsiu Chen and Frances Rauscher 1995. The communicative value of conversational hand gesture. *Journal of Experimental Social Psychology* 31: 533–552.
- Krauss, Robert M., Palmer Morrel-Samuels and Christina Colasante 1991. Do conversational hand gestures communicate? *Journal of Personality and Social Psychology* 61: 743–754.
- Lausberg, Hedda and Sotaro Kita 2002. Dissociation of right and left hand gesture spaces in split-brain patients. *Cortex* 38: 883–886.
- Lausberg, Hedda, Sotaro Kita, Eran Zaidel and Alain Ptito 2003. Split-brain patients neglect left personal space during right-handed gestures. *Neuropsychologia* 41: 1317–1329.
- Lickiss, Karen P. and A. Rodney Wellens 1978. Effects of visual accessibility and hand restraint on fluency of gesticulation and effectiveness of message. *Perceptual and Motor Skills* 46: 925–926.
- McNeill, David 1985. So you think gestures are nonverbal? *Psychological Review* 92: 350–371.
- McNeill, David 1992. *Hand and Mind*. Chicago: University of Chicago Press.
- McNeill, David 2001. Analogic/Analytic representations and cross-linguistic differences in thinking for speaking. *Cognitive Linguistics* 11: 43–60.
- McNeill, David and Susan Duncan 2000. Growth points in thinking-for-speaking. In: David McNeill (ed.), *Language and Gesture*, 141–161. Cambridge: Cambridge University Press.

- Melinger, Alissa and Willem J. Levelt 2004. Gesture and the communicative intention of the speaker. *Gesture* 4: 119–141.
- Melinger, Alissa and Sotaro Kita 2007. Conceptualisation load triggers gesture production. *Language and Cognitive Processes* 22: 473–500.
- Mol, Lisette, Emiel Krahmer, Alfons Maes and Marc Swerts 2009. The communicative import of gestures: Evidence from a comparative analysis of human-human and human-machine interactions. *Gesture* 9(1): 97–126.
- Mondada, Lorenza 2007. Multimodal resources for turn-taking: Pointing and the emergence of possible next speakers. *Discourse Studies* 9: 194–225.
- Morsella, Ezequiel and Robert M. Krauss 2004. The role of gestures in spatial working memory and speech. *American Journal of Psychology* 117: 411–424.
- Müller, Cornelia 2003. On the gestural creation of narrative structure: A case study of a story told in a conversation. In: Monica Rector, Isabella Poggi and Nadine Trigo (eds.), *Gestures: Meaning and Use*, 259–265. Porto: Universidade Fernando Pessoa.
- Özyürek, Asli 2002. Do speakers design their cospeech gestures for their addressees? The effects of addressee location on representational gestures. *Journal of Memory and Language* 46: 688–704.
- Özyürek, Asli, Sotaro Kita, Shanley Allen, Amanda Brown, Reyhan Furman and Tomoko Ishizuka 2008. Development of cross-linguistic variation in speech and gesture: Motion events in English and Turkish. *Developmental Psychology* 44: 1040–1054.
- Özyürek, Asli, Sotaro Kita, Shanley Allen, Reyhan Furman and Amanda Brown 2005. How does linguistic framing of events influence co-speech gestures? Insights from cross-linguistic variations and similarities. *Gesture* 5(1/2): 219–240.
- Özyürek, Asli, Roel M. Willems, Sotaro Kita and Peter Hagoort 2007. On-line integration of semantic information from speech and gesture: Insights from event-related brain potentials. *Journal of Cognitive Neuroscience* 19: 605–616.
- Parrill, Fey 2010. The hands are part of the package: Gesture, common ground, and information packaging. In: John Newman and Sally Rice (eds.), *Empirical and Experimental Methods in Cognitive/Functional Research*, 285–302. Stanford, CA: Center for the Study of Language and Information.
- Parrill, Fey and Irene Kimbara 2006. Seeing and hearing double: The influence of mimicry in speech and gesture and observers. *Journal of Nonverbal Behavior* 30: 157–166.
- Perry, Michelle, Ruth Breckinridge Church and Susan Goldin-Meadow 1988. Transitional knowledge in the acquisition of concepts. *Cognitive Development* 3: 359–400.
- Pickering, Martin J. and Simon Garrod 2004. Toward a mechanistic psychology of dialogue. *Behavioural and Brain Sciences* 27: 1–57.
- Pine, Karen, Hannah Bird and Elizabeth Kirk 2007. The effects of prohibiting gestures on children's lexical retrieval ability. *Developmental Science* 10: 747–754.
- Pine, Karen, Nicola Lufkin and David Messer 2004. More gestures than answers: Children learning about balance. *Developmental Psychology* 40: 1059–1067.
- Rauscher, Frances H., Robert M. Krauss and Yihsiu Chen 1996. Gesture, speech, and lexical access: The role of lexical movements in speech production. *Psychological Science* 7: 226–231.
- Rime, Bernard, Loris Schiaratura, Michel Hupet and Anne Ghysseleinx 1984. Effects of relative immobilization on the speaker's nonverbal behavior and on the dialogue imagery level. *Motivation and Emotion* 8: 311–325.
- Riseborough, Margaret G. 1981. Physiographic gestures as decoding facilitators: Three experiments exploring a neglected facet of communication. *Journal of Nonverbal Behavior* 5: 172–183.
- Rizzolatti, Giacomo and Michael Arbib 1998. Language within our grasp. *Trends in Neuroscience* 21: 188–194.
- Rogers, William T. 1978. The contribution of kinesic illustrators toward the comprehension of verbal behavior within utterances. *Human Communication Research* 5: 54–62.
- Roth, Wolff-Michael 2001. Gestures: Their role in teaching and learning. *Review of Educational Research* 71: 365–392.
- Seyfeddinipur, Mandana 2004. Meta-discursive gestures from Iran: Some uses of the 'Pistol Hand'. In: Cornelia Müller and Roland Posner (eds.), *The Semantics and Pragmatics of Everyday*

- Gestures. Proceedings of the Berlin Conference April 1998 (Körper Zeichen Kultur 9)*, 205–216. Berlin: Weidler.
- Skipper, Jeremy I., Susan Goldin-Meadow, Howard C. Nusbaum and Steven L. Small 2007. Speech-associated gestures, Broca's area, and the human mirror system. *Brain and Language* 101: 260–277.
- Straube, Benjamin, Antonia Green, Andreas Jansen, Anjan Chatterjee and Tilo Kircher 2010. Social cues, mentalizing and the neural processing of speech accompanied by gestures. *Neuropsychologia* 48: 382–393.
- Streeck, Jürgen 1994. Gesture as communication II: The audience as co-author. *Research on Language and Social Interaction* 27: 239–267.
- Streeck, Jürgen and Ulrike Hartge 1992. Previews: Gestures at the transition place. In: Peter Auer and Aldo di Luzio (eds.), *The Contextualisation of Language*, 135–157. Amsterdam, NL: John Benjamins.
- Thompson, Laura A. 1995. Encoding and memory for visible speech and gestures: A comparison between young and older adults. *Psychology & Aging* 10: 215–228.
- Thompson, Laura A. and Dominic W. Massaro 1986. Evaluation and integration of speech and pointing gestures during referential understanding. *Journal of Experimental Child Psychology* 42: 144–168.
- Tomasello, Michael 2008. *Origins of Human Communication*. Cambridge: Massachusetts Institute of Technology Press.
- Wesp, Richard, Jennifer Hesse, Donna Keutmann and Karen Wheaton 2001. Gestures maintain spatial imagery. *American Journal of Psychology* 114: 591–600.
- Willems, Roel M., Asli Özyürek and Peter Hagoort 2007. When language meets action: The neural integration of gesture and speech. *Cerebral Cortex* 17: 2322–2333.
- Willems, Roel M., Asli Özyürek and Peter Hagoort 2009. Differential roles for left inferior frontal and superior temporal cortex in multimodal integration of action and language. *NeuroImage* 47: 1992–2004.
- Wu, Ying Choon and Seana Coulson 2007. How iconic gestures enhance communication: An ERP study. *Brain and Language* 101: 234–245.
- Yan, Stephanie and Elena Nicoladis 2009. Finding le mot juste: Differences between bilingual and monolingual children's lexical access in comprehension and production. *Bilingualism: Language and Cognition* 12: 323–335.

Judith Holler, Manchester (UK)

## 53. Documentation of gestures with motion capture

1. Introduction
2. Tracking technologies
3. Representation formats and tools for analysis
4. Examples of motion capture studies
5. Best practices for study design
6. Conclusion
7. References

### Abstract

*For the scientific observation of non-verbal communication behavior, video recordings are the state of the art. However, everyone who has conducted at least one video-based*