Neuropsychologia 93 (2016) 176–188

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

Co-speech hand movements during narrations: What is the impact of right vs. left hemisphere brain damage?

Katharina Hogrefe[a,*], Robert Rein[b,c], Harald Skomroch[d], Hedda Lausberg[d]

[a] Clinical Neuropsychology Research Group (EKN), Institute of Phonetics and Speech Processing (IPS), Ludwig-Maximilians-Universität München, Schellingstr. 3, 80799 Munich, Germany
[b] Institute of Cognitive and Team/Racket Sport Research, German Sport University Cologne, Am Sportpark Müngersdorf 6, 50933 Köln, Germany
[c] Institute of Sport Sciences, Goethe University, Ginnheimer Str. 39, 60487 Frankfurt / Main, Germany
[d] Department of Neurology, Psychosomatic Medicine, and Psychiatry, Institute of health promotion and clinical movement science, German Sport University Cologne, Am Sportpark Müngersdorf 6, 50933 Köln, Germany

ARTICLE INFO

Keywords:
Hand movement behaviour
Non-verbal communication
Gesture
Aphasia
Right brain damage
Left brain damage

ABSTRACT

Persons with brain damage show deviant patterns of co-speech hand movement behaviour in comparison to healthy speakers. It has been claimed by several authors that gesture and speech rely on a single production mechanism that depends on the same neurological substrate while others claim that both modalities are closely related but separate production channels. Thus, findings so far are contradictory and there is a lack of studies that systematically analyse the full range of hand movements that accompany speech in the condition of brain damage. In the present study, we aimed to fill this gap by comparing hand movement behaviour in persons with unilateral brain damage to the left and the right hemisphere and a matched control group of healthy persons. For hand movement coding, we applied Module I of NEUROGES, an objective and reliable analysis system that enables to analyse the full repertoire of hand movements independent of speech, which makes it specifically suited for the examination of persons with aphasia.

The main results of our study show a decreased use of communicative conceptual gestures in persons with damage to the right hemisphere and an increased use of these gestures in persons with left brain damage and aphasia. These results not only suggest that the production of gesture and speech do not rely on the same neurological substrate but also underline the important role of right hemisphere functioning for gesture production.

1. Introduction

1.1. Gesture, speech, and laterality of hand movements

During communication we produce spontaneously hand movements. These hand movements comprise irregular, continuous self-touching behaviour as well as gestures with a phase structure that are based on conceptual processes. Hand movements have been studied in different fields of research. Most attention was dedicated to the relationship of gesture, speech and communication. To date, it is widely acknowledged that gesture production interacts with speech production. The precise nature of this relationship however remains unclear. Whereas some authors argue that gesture and speech originate from the same representation and are inseparable throughout the production process (Butterworth and Hadar, 1989; McNeill, 1992, 2005), others claim that gesture and speech production are separate but closely coordinated processes (De Ruiter, 2000; Feyereisen, 1987; Kita and Özyürek, 2003; Krauss et al., 2000). In this respect, the question whether language and gesture originate from the same neural substrate is of great interest. Kimura (1973) observed that healthy speakers with right hand preference produced more communicative gestures (“free movements” in her terminology, including all movements of the hands or arms which did not result in touching the body or coming to rest) with the right hand, also regardless of the speaking topic. It was also reported that self-touching behaviour, i.e. movements that resulted in touching the person's own body or clothing, was produced equally often with the left and the right hand (Lavergne and Kimura, 1987). These findings led to the conclusion that the generation of gestures is obligatory tied to linguistic processes and that speech and gesture originate from a common neural system (compare Lausberg

* Correspondence to: Clinical Neuropsychology Research Group (EKN), Institute of Phonetics and Speech Processing, Ludwig-Maximilians-Universität München, Schellingstr. 3, 80799 Munich, Germany.
E-mail address: K.Hogrefe@ekn-muenchen.de (K. Hogrefe).

http://dx.doi.org/10.1016/j.neuropsychologia.2016.10.015
Received 10 April 2016; Received in revised form 18 October 2016; Accepted 24 October 2016
Available online 27 October 2016
0028-3932/

and Kita (2003) for a detailed critical review of Kimura's experiments).

More recent research investigating handedness contradicts Kimura's notion of a right hand preference for communicative hand gestures. An equal use of the right and left hands was reported for iconic gestures (Blonder et al., 1995; Lausberg and Kita, 2003) and self-touching behaviour (Blonder et al., 1995) in healthy speakers. Furthermore, a range of studies with healthy speakers as well as split-brain patients indicate that hand preference for gesturing is tied to gesture type in that specific gesture types are predominantly produced with either the right or the left hand (for an overview compare Lausberg, 2013, p. 33 ff). There seems to be evidence for a specialization of the left hemisphere for iconic, pantomimic, and deictic gestures as well as for self-touching behaviour that involves the manipulation of objects. In contrast, the right hemisphere seems to play an important role in the generation of rhythmic gestures, i.e. batons, and continuous self-touching behaviour of the speaker. These findings support a bilateral system responsible for gesture production and self-touching behaviour.

Studies investigating persons with unilateral left hemisphere damage (LBD) or right hemisphere brain damage (RBD) support the thesis that both hemispheres contribute to hand movement behaviour. Most of these studies investigated persons with LBD following the rationale that knowledge about the impact of aphasia on gesture use may indicate the precise relationship of gesture and speech, whereas some studies also focused on persons with RBD. At present, only a few studies have compared the two groups with each other.

1.2. Gesture production in persons with left hemisphere damage

Investigating the impact of aphasia on gesture production can reveal more insights into the relationship of gesture and speech (for an overview compare Rose (2006)). Results so far do not show a straightforward relationship between language disorder and gesture use: Some authors argue that gesture and speech break down together in persons with aphasia (PWA; e.g. Cicone et al., 1979; Glosser et al., 1986; McNeill, 1985) – a finding that supports Kimura's hypothesis – whereas other studies suggest that PWA may compensate with gestural communication for their reduced verbal output (e.g. Ahlsen, 1991; Behrmann and Penn, 1984; Beland and Ska, 1992; Herrmann et al., 1988; Hogrefe et al., 2013; Le May et al., 1988). According to the first view, gesture production is disturbed and reflects type (Cicone et al., 1979) and severity of aphasia (Glosser et al., 1986). Hence, the language impairment leads to a parallel impairment of the two modalities with gesture displaying the same characteristics as the verbal output. This view is in line with the classical concept of "asymbolia" which was introduced by Finkelnburg (1870). Finkelnburg claimed that aphasia is one particular manifestation of a general disability to display concepts by means of signs. In contrast to this view, some studies argue for a compensatory use of gestures in PWA who have been shown to produce more communicative gestures or specific gestures types than healthy speakers (Herrmann et al., 1988; Le May et al., 1988; Sekine and Rose, 2013). In a recent study, Sekine and Rose (2013) classified gestures of persons with differing degrees of aphasia severity according to twelve different gesture types. The authors analyzed if a gesture type appeared at least once in the discourse sample and found that – in contrast to the healthy control persons – PWA used the full range of gesture types. Interestingly, the only person with global aphasia included in the sample produced two gesture types only, namely deictic and emblematic gestures. This finding is in line with the study of Herrmann et al. (1988), who showed that in comparison to healthy speakers, persons with severe aphasia produce more emblematic gestures including head shakes, nods, and shoulder shrugs in conversations.

These results indicate that persons with left hemisphere damage may use the full range of the gestural repertoire. However, the data further suggest that individuals with more severe language disturbances that are probably caused by greater lesions may primarily make use of a reduced set of gestures.

Other studies investigated the expression of meaning via gesture in PWA: Some individuals with severe aphasia convey more information via gesture than via speech (Hogrefe et al., 2013) and gesture contributes to the expression of meaning in PWA (De Beer et al., in press). These studies lend empirical support to the notion that persons with aphasia use gestures as a communicative device as compensation for their reduced language expression.

Further, neuropsychological disorders that have been attributed to LBD have been shown to have an impact on gesture production. Limb apraxia may lead to a disturbed production of pantomimes to command (e.g. Goldenberg, Hermsdörfer, Glindemann, Rorden, and Karnath, 2007; Goldenberg and Randerath, 2015; Tarhan et al., 2015). Furthermore, limb apraxia may impact on the intelligibility of spontaneously produced gestures in persons with severe aphasia (Feyereisen et al., 1988; Hogrefe et al., 2012). Additionally, non-verbal semantic disorders lead to a reduced diversity of gestures in this patient group (Hogrefe et al., 2012).

1.3. Gesture production in persons with right hemisphere damage

It is widely acknowledged that the right cerebral hemisphere plays – amongst others – an important role for the processing and production of emotions and pragmatic aspects of communication. Persons with damage to the right hemisphere usually do not display systematic linguistic deficiencies but often a communication disorder that may affect narrative-discourse abilities, the processing of metaphors or idioms as well as the processing of prosody (e.g. Brownell et al., 1995). Côté et al. (2007) estimated that approximately 50% of the persons with damage to the right hemisphere display subsequent communication disorders.

There are some descriptions of persons with RBD that deal with the display of emotions through non-verbal expression (Ross, 1981, 1996; Ross and Mesulam, 1979). Most of these studies focus on the specific characteristics of prosody, but some include also "body language". Ross and Mesulam (1979, p. 148) report two patients who "evidenced an inability to communicate emotions through the use of facial, limb, and body gestures". The authors use the term "agestural" for this state and claim that it accompanies the "aprosody" in patients with flattened affect. The observation that persons with RBD produce one type of communicative conceptual gestures, namely iconic gestures, at a lower rate than healthy or aphasic speakers has also been reported by Hadar et al. (1998). On the other hand, it has been described by Blonder et al. (1995) for a group and by Cocks et al. (2007) for two persons that RBD enhances the production of self-touching behaviour.

Reasons for these deviant gesture use patterns have been attributed to visuo-spatial deficits (Hadar et al., 1998; McNeill and Pedelty, 1995) or viewed in close relationship with disturbed prosody (Ross and Mesulam, 1979). However, these suggestions were not confirmed by more recent studies (Cocks et al., 2007; Hogrefe et al., 2011).

Taken together, even if the reported studies did not reveal very clear results with respect to hand movement behaviour, the majority supports findings from healthy speakers and split brain patients in that damage to the right hemisphere may lead to a reduction of iconic gestures and an increase in self-touching movements.

1.4. Comparisons of persons with left and right hemisphere damage

To date, only few studies have compared these two groups with each other. As mentioned above, Blonder et al. (1995) showed that persons with RBD produced more self-touching movements on their own body with their right hand than did persons with LBD and persons without neurological disorders. Hadar et al. (1998) found differing rates for the production for communicative gestures in two patient groups and a control group: The persons with RBD produced fewer communicative