10.2478/topling-2021-0001

The relationship between speech and gestures in persons with aphasia: Evidence from the Czech perspective

Martin Janečka*

Charles University in Prague, Czech Republic

Abstract

In my research, I replicate two fundamental hypotheses established by Jakob et al. (2011): 1) Persons with aphasia (PWA) produce more gestures than healthy control persons (HCP) during interpretation of texts; 2) The more speech-restricted a person with aphasia is, the more gestures he/she produces during the interpretation of a text.

I work with 6 persons with diagnosed aphasia and 10 healthy control persons (or persons with no evident speech deficiency). From a methodological point of view, I point out the necessity to include a description of non-verbal elements in language description and, at the same time, to describe the data of the damage in persons with aphasia. I also introduce some possible perspectives for exploring the categories and the extent of speech damage in persons with aphasia and various ways in which they compensate for verbal deficiency with the aid of gestures. From the viewpoint of data processing methods, on the one hand, I explore the speech parameters: among others, quantity of words, and, on the other hand, the gesture parameters: quantity of gestures, diversity of gestures, etc.

I find that Czech aphasic persons do use gestures to support their restricted verbal production and to substitute for verbal production where they do not have access to any given lexical items. My data also correlate with the general assumptions on speech production when considering different types of aphasia.

Keywords

aphasia, gestures, speech, non-verbal communication, linguistic experiment, trade-off hypothesis, hand-in-hand hypothesis

1. Introduction

The necessity of exploring speech together with gestures has been stated for decades,¹ see e.g. Birdwhistell (1970) with his hierarchical framework of units describing non-verbal ‘language’ consisting of kinems, kinemorphs and kinemorphic complexes, and Pike, who claimed that “verbal and non-verbal activity is a unified whole, and theory and methodology should be organized to describe it as such” (see Pike, 1967, p. 26).

The mutual interconnection of verbal and non-verbal expressions (and their elements) is indisputable. This has recently been illustrated e.g. by Fricke (2012) with the example of nominal groups. In this area, she points out that gestures belong to syntax as well as to semantics. They can influence the core noun of a nominal group (known as “functional integration”). In addition, it has also been proven that gestures can substitute for some constituents of nominal groups and that specific manifestations of substituting gestures are influenced through the pronounced grammatical context (known as “structural

* Address for correspondence: Martin Janečka, Charles University in Prague, Faculty of Education, Magdalény Rettigové 47/4, Prague, Czech Republic, E-mail: martin.janecka@pedf.cuni.cz.

¹ A detailed description of how we use gestures in the process of everyday communication is found in the famous book by A. Kendon (2004): *Gesture: Visible action as utterance*, which is one of the basic pillars of gesture studies.

integration”). Gestures can even grammaticalize in those positions, in the same way as expressions of verbal language do.

Although the information conveyed in gestures can, at times, supplement the information conveyed in speech, there are situations when gesture and speech convey information that appears to be redundant: the gesture contributes information that is already fully expressed in the speech (Abner, Cooperrider and Goldin-Meadow, 2015, p. 442). We would presume that speakers use their gestures primarily to disambiguate ambiguities in spoken language (see de Ruiter, Bangerter, and Dings, 2012, p. 238). There are basically two contradictory viewpoints: people with aphasia, i.e. with a language impairment affecting the production or comprehension of speech, use gestures vs. they do not use gestures to intentionally compensate for their verbal deficiency. These approaches are described in Sections 1.2 and 1.3.

1.1 Aphasia

Aphasia is defined as a language disorder that results from damage to the specific area of the brain involved in language processing. There are specifically two main disorders: i) language production and ii) language comprehension. The core of aphasic disability is specifically based on grammar, lexicon and semantics, and in all areas of production and perception – speaking, listening, reading, writing, etc.

The causes of aphasia in particular are cerebrovascular accidents (CVAs, commonly known as strokes) and haemorrhage, which occurs in various ways. Other causes of aphasia include different types of cerebral tumour, brain disease and traumatic damage (Crystal, 2010, p. 280). In general, comprehension can be improved more rapidly than production. However, it is important to mention that these improvements are often only partial.

There are various classifications of aphasia based on different criteria. The most common is probably the Boston classification of aphasia (see Table 1 below). It is important to mention that change in aphasic symptoms might occur in the process of recovery and that aphasic symptoms are also often blended, to a certain extent, so that a totally clear diagnosis is often not possible.

Two main types of aphasia are Broca’s and Wernicke’s aphasia. Considering Broca’s aphasia, language is usually described as markedly non-fluent – slow, laboured, with great difficulty in articulation. Sentences are usually very short, with little use of grammatical constructions. Comprehension is quite standard, but Broca’s aphasics often repeat individual words (usually non-semantic words). In Wernicke’s aphasia, language is usually described as (excessively) fluent, with almost no articulatory difficulty. However, there may be unpredictable pauses.

The comprehension of an aphasic is often quite impaired. The speech shows circumlocutions and unintelligible sentences, and mistakes in choosing phonemes and words. The aphasic also has problems with object naming. Although the two abovementioned types of aphasia are the most commonly known, it is important to mention that there are other types of aphasia e.g. conduction aphasia, transcortical aphasia, global aphasia, primary progressive aphasia, anomic aphasia, etc. These types are often found in combination with another type. Table 1 describes the different types of aphasia according to four parameters – fluency, repetition, comprehension and naming. With reference to my research to date as described in this article, two males with Broca’s aphasia, two males² with Wernicke’s aphasia, one male with transcortical-motor aphasia and one female with transcortical-motor aphasia have been involved in this research.

² One of them shows a tendency towards conduction aphasia.

Table 1. Boston classification of aphasia³

Aphasia type	Fluency	Comprehension	Repetition	Naming
Broca's aphasia	non-fluent	impaired	relatively intact	impaired
Transcortical motor aphasia	non-fluent	intact	relatively intact	impaired
Wernicke's aphasia	fluent	impaired	impaired	impaired
Conduction aphasia	fluent	impaired	relatively intact	impaired
Transcortical sensory aphasia	fluent	intact	impaired	impaired
Global aphasia	impaired	impaired	impaired	impaired

1.2 Trade-off hypothesis vs. hand-in-hand hypothesis

According to the cross-modal compensation hypothesis (de Ruiter, 2006 cited in So et al., 2009, p. 2) “speakers should use gesture to identify a referent particularly when speech fails to uniquely specify the referent – they should use gesture to compensate for their under-specification in speech.”

Another opinion, called the “interface hypothesis”, is found in Kita and Özyürek (2003). They claim “that gesture originates from the interface between speaking and thinking, where spatio-motoric imagery is packaged into units that are suitable for speaking. Under this view, when speech fails to uniquely specify a referent, gesture should also fail to identify the referent” (So et al., 2009, p. 2).⁴ In this study, I am not concerned with the opposition of cross-modal vs. interface hypotheses, but there is also another (more recent) dichotomy of views involving the aforementioned authors.

De Ruiter et al. (2012, p. 233) claim “that there is a trade-off relation between gesture and speech in terms of their communicative load. The trade-off hypothesis assumes that if speech becomes more difficult, the likelihood of a gesture occurring, to take over some of the communicative load, is higher.” They also claim, on the basis of empirical evidence, that “[a]lternatively, when gesturing becomes harder, the trade-off hypothesis predicts that speakers will rely relatively more on speech.”

The “hand-in-hand hypothesis” by Kita et al. (2009, p. 5) is in opposition to the previous hypotheses: they claim that “gesture goes hand-in-hand with speech, identifying referents only when speech does” and vice versa. De Ruiter et al. (2012, p. 233) explored the relationship between gesture and speech in situations where people refer to something in the shared visual environment. They focus on two types of gesture that are often used in referring and are closely synchronized with the affiliated speech: (a) pointing (or deictic) gestures and (b) iconic gestures. At the end of that study, de Ruiter et al. (2012, p. 244) evaluated the trade-off and hand-in-hand hypotheses. Only one result was concordant with the trade-off hypothesis: the rate of pointing decreased when the directors repeated a referring expression.

In addition, they found evidence supporting the hand-in-hand hypothesis: The rate of pointing gestures was positively related to the quantity of locative descriptions in speech, and the rate of iconic gestures with the quantity of feature descriptions in speech.

³ Teasell, 2016, p. 6.

⁴ To test these competing views, So et al. (2009, p. 2) manipulated lexical specificity in referential expressions in speech. They asked speakers to describe two stories, the Man-Woman (M-W) story, involving protagonists of different genders, and the Man-Man (M-M) story, involving protagonists of the same gender.

This suggests (as also claimed by So et al., 2009) that if you have standard speakers in your research, the hand-in-hand hypothesis is more relevant, and there may be a trade-off if you have non-standard speakers (children, or people with a cognitive restriction, which is also compatible with the results in de Ruiter, 2006).

1.3 Recent research on gestures in PWA

Sekine and Rose (2013) explored whether aphasia type and speech fluency have an impact on gesture production in American speakers. A higher rate of persons with a lower degree of speech fluency were found to use concrete deictic gestures and mime in their utterances. According to their results, persons with Broca's and conduction aphasia were inclined to produce gestures that were more iconic, specified by an illustration of concrete images. Persons with Wernicke's aphasia, on the contrary, used more abstract gestures, such as metaphoric or referential gestures. Those with anomic and transcortical motor aphasia displayed a gesture profile like that of healthy control subjects.

Participants in the research by Kong et al. (2015, p. 88) were native Cantonese speakers. They found that the severity of aphasia and verbal-semantic impairment were related to a higher quantity of co-verbal gestures. The aim of their research (Kong et al., 2015, p. 93–94) was to examine how the use of gestures differed between healthy persons and PWA. Among others, they examined different gestures and their functions in the group of healthy persons and the PWA group. They also compared the frequency of gestures used between the two groups and evaluated whether the use of gestures differed, depending on the severity of aphasia. They found that about 35% of healthy persons produced no gestures within the discourse tasks. Many more gestures were produced by PWA – only about 10% of them did not gesture. Aphasics significantly used iconic, metaphoric, deictic gestures and symbols (emblems) to improve their communication, providing additional information to the verbal expression.

De Beer et al. (2017, p. 487) examined a differential effect of various gesture types on the comprehensibility of expressions by PWA, using a listener experiment (similarly to Hogrefe et al., 2013). They concentrated on gestures produced in spontaneous conversation, in order to ensure the validity of their findings. This study (de Beer et al., 2017, p. 488) attempted to answer two basic questions: 1) Does gesture production augment communicative effectiveness for PWA presenting with a primary production deficit across a continuum of severity? 2) Which gesture types hold the highest potential to add information to the verbal message?

De Beer et al. (2017, p. 494) found that the production of gestures by PWA had a serious impact on the comprehensibility of communication by PWA. These findings contributed to the communicative value of gesture for PWA, even for those who are unfamiliar with persons with aphasia. The results of this study support the view that there is a mutual origin of gestures and speech. In other words, parts of the meaning that PWA cannot communicate verbally are produced through gestures, because this modality remains relatively intact. In this research, listeners also confirmed that when a verbal expression was difficult to decode, it was also difficult to interpret the meaning of a gesture, although the information was more understandable when gestures were used. This fact confirms that gestures can transmit important parts of information, but are also largely dependent on speech.

Preisig et al. (2018) explored Swiss PWA and the main question of their study (2018, p. 9) concerned the question of how PWA perceive and produce co-speech gestures during face-to-face interaction. They examined the impact of co-speech gestures at the level of perception by the eye-tracking method (using voxel-based lesion-symptom mapping, VLSM) in order to connect the production of co-speech gestures and the localization of brain injury. They found that meaningful gestures can attract more visual attention than abstract gestures, and that PWA are able to fix co-speech gestures more than healthy persons. They also discovered that persons with more severe aphasia (but not with more severe apraxia) produced more meaningful gestures than only mildly affected persons.

Jakob et al. (2011) claim that PWA compensate for their verbal deficiency by using gestures intentionally. Currently this approach is, in general, more accepted than the former attitude represented by Cicone, et al. (1979), who claim that PWA do not compensate for their verbal deficiency by the intentional use of gestures.⁵ The origins of the approach by Jakob et al. are clearly based on the de Ruiter (2000) Sketch model. In this model, gesture and speech production systems are linked with the aid

⁵ If we consider the hypotheses mentioned at the beginning of this paper, it is possible to compare the hand-in-hand hypothesis to Cicone's approach and the trade-off hypothesis to Jakob's approach.

of a conceptualizer. The next assumption is that a “gesture planner” provides the information to a message generation component of the conceptualizer. Hence gesture planning can again activate some features of the lexical concept. According to this model, gestures do not facilitate concrete lexical access (lemma selection and word form retrieval), but a concept before word formation.

The hypotheses by Jakob et al. are the following:

- 1) PWA produce more gestures than HCP during text reproduction.
- 2) The more speech-restricted a PWA is, the more gestures he/she produces when he/she retells a story.

From the viewpoint of data-processing methods, on the one hand they explored the speech parameters, including (among others) the quantity of words, length of phrases and their complexity and lexical diversity, and, on the other hand, the parameters of the gestures: quantity of gestures, rate of words matched to a gesture, diversity of gestures, etc.

Regarding hypothesis 1) PWA produce more gestures than HCP during the interpretation of texts, there are also two sub-hypotheses exploring whether A) PWA possess a higher rate of words matched to a gesture than the HCP group and whether B) PWA use more complex gestures than the HCP group. Among other things, they compared the two groups of people from the viewpoint of the rate of words connected to a gesture.

Regarding hypothesis 2) The more speech-restricted a PWA is, the more gestures he/she produces during the interpretation of a text, there are also two sub-hypotheses exploring whether A) PWA producing long or complex phrases use fewer gestures than PWA producing short and less complex phrases and whether B) PWA with lower lexical diversity use more gestures than PWA with higher lexical diversity. This means that the relationship between the rate of words connected to a gesture and the length of a phrase was explored.

In my research, I replicate the abovementioned hypotheses by Jakob et al. (2011). In addition, in the discussion, I also compare my results with all the other cited research, except for Cicone et al. (1979). The reason is that all the aforementioned research illustrates the necessity to explore not only the verbal aspect of aphasics’ communication, but their gestural production as well. Similar methods are used in comparing PWA and HCP regarding their use of gestures.

2. Methodology

I explore, if (and how) persons with aphasia compensate for verbal deficiency through gestures. I compare how these two groups differ, considering the quantity and typology of the used gestures regarding their verbal production. I do not describe paralinguistic phenomena, such as laughter, intonation, pauses, etc. Under specific circumstances, facial expressions can convey or modify the meaning of the information. Nevertheless, I restrict my research and analyses to the field of gestures (in the narrow sense of the word).

At present, I am collaborating with a non-profit organization in Prague called Club Aphasia, which provides secondary therapy to interested clients. Thus, these people always have their own primary speech therapist, with Club Aphasia only providing supplementary services. Clients of this organization were addressed by a speech therapist in a collective session, and those who were interested were addressed by me afterwards. Every participant was asked to sign an ethical statement that their participation within this recording was voluntary, that they could cancel their participation at any time and could also make a request for the deletion of their data from my database.

2.1 Gesture classification

Within the data analysis, I work with two fundamental groups of gestures: gestures with a communicative function and gestures with a primarily non-communicative function. Communicative gestures concern mainly hand movements, which are carried out physically, then head movements (e.g. nodding), shoulder movements (e.g. shrugging). Gestures with a non-communicative function include e.g. touching oneself. It is necessary to emphasize that, from the viewpoint of the potential relationship to linguistic expression, it is adequate to explore only those gestures with a communicative function, not gestures with a non-communicative (i.e. autostimulative) function, which cannot convey or modify the meaning of an utterance.

As a basic typology of gestures, I adopt the classification by Hografe (2009): in the broad group of what are called pictographs (i.e. semantic gestures), which can illustrate various objects, on the one hand, are iconographs (object drawing in the air), and, on the other hand, kinetographs, which can represent the method or speed of a movement. Then, mime can be integrated into this group, i.e. simulation of action through an imaginary object. However, mime comprises complex, sequential movements; gestures themselves are not bound (as in mime) to a concrete displayed content, so the exploration of mime is not included within the aims of this study.

Another independent group of gestures is deictic gestures. We can further differentiate between concrete deictic gestures, which can be used to point out a concrete object in a space, and abstract deixis, which can be defined as a situation in which one points at the empty space in front of the body when describing an imaginary situation. The last group of semantic gestures are known as emblems (symbols), i.e. gestures that are specialized formally and with a meaning which is conditioned by culture and language. Besides hand gestures, nodding, head motion and head shaking, and shoulder shrugging are also included in this group.

My own temporary classification consists of semantic gestures (pictographs, deictics and emblems together) and what are called “processual” (or sometimes known as “metaphoric”⁶) gestures, where the meaning is not so obvious. However, these gestures are often related to a non-semantic verb (a verb with low semantics e.g. *work*, *think*, *process*, etc.). In the final chapter, when summarizing the verifications of Jakob’s hypotheses, I count them all as communicative gestures.⁷

Considering the classification of individual gestures in the categories described above, it is necessary to mention that there has always been agreement of at least two out of three annotators (the author of this article and two trained student assistants), so the condition of inter-rater reliability should be fulfilled.

2.2 Gesture coding

Gesture form is described in terms of the parameters used to describe sign languages – shape and placement of the hand, trajectory of motion. A change in any of these parameters marks the end of one gesture and the beginning of another as well. Each gesture was assigned a meaning, indicating what was represented in the gesture (see So et al. 2009, p. 4).

It is also necessary to differentiate that “[t]he preparation phase is the movement of the hand as it readies itself for the gestural stroke. The stroke phase is the most effective and most meaningful phase of the gesture.” There are three possible options considering the last phase: “It may then be followed by a retraction phase, where the hand returns to resting position, or it may be followed by the preparation or stroke phase of a subsequent gesture” (Abner, Cooperrider and Goldin-Meadow, 2015, p. 438).

2.3 Description of PWA and HCP

In Table 4, the description of the PWA presents the information of their age, gender, aetiology, education, aphasia duration and type of aphasia. With reference to HCP (healthy control persons), they are all aged between 20 and 40 years and all have a university degree.

⁶ e.g. McNeill (1992). He claims that metaphoric gestures are similar to iconic gestures. They are idiosyncratic in their production, but they differ from iconic gestures by referring to abstract concepts.

⁷ Gullberg (2006) uses the term “referential gestures” to describe gestures referring to the entity of referents (objects, places and characters).

Table 2. Description of persons with aphasia

Patient	Gender	Age	Education	Aphasia duration	Aetiology and lesio	Type of aphasia
1	M	69	college	9 years	iCMP (ACM sin.), central	Broca
2	M	67	high school	20 years	hCMP	Broca
3	W	56	vocational school	3 years	iCMP (ACM sin), FTP	Transcortical motor
4	M	79	college	3 years 8 months	iCMP, TP	Wernicke/conductive
5	M	46	college	5 years 6 months	iCMP (ACA, ACM sin)	Transcortical motor
6	M	71	vocational school	3 years 7 months	hCMP, T	Wernicke

List of aetiologies: iCMP = ischemic cerebrovascular accident, ACM sin. = arteria cerebri media, hCMP = hemorrhagic cerebrovascular accident, FTP = frontotemporoparietal, TP = temporoparietal, ACA = arteria cerebri anterior, T = temporal.

2.4 Experimental setup

Every person (aphasic or healthy) participating in the creation of my corpus of audiovisual data (i.e. a multimodal corpus) was asked to sign an ethical statement that they agreed with the recording and that they had the possibility to cancel their participation in this research at any time in the future. The participants all watched the cartoon “Shaun the Sheep” with a duration of approximately 24 minutes. The subsequent conversation was related to this film and the procedure was always carried out in the following way:

1) At first, the person retells the story, i.e. everything that he/she is capable of remembering; 2) Next, he/she completes a monologue (without any interventions and with minimal prompts, such as “What happens next?” or “What else?”), and answers the questions e.g. “What is the character like of individual characters in this film?” or “What does the major theme of the film symbolize?” etc.

Part 1) represents a controlled experiment with clearly defined conditions – in contrast with:

Part 2), which is not an experiment with regulated conditions, from the viewpoint of observational objectivity for every participant equally, but is more like natural, spontaneous, unprepared communication.

To date, 6 PWA and 10 HCP have been involved in this research. Regarding sociolinguistic parameters, there is a gender balance in HCP. Moreover, all speakers in my research sample are native speakers of what is called “obecná čeština”.⁸

With reference to the number of words, a method of naive tokenization with the aid of the MaWaTaTaRaD⁹ program was used. This means that every single segment from space to space is counted. Since some of the aphasic persons (and healthy control persons as well) correct themselves when trying to express a word (e.g. *ko-ko-kolečko*), I have decided to erase all these preparatory phases for the purposes of this article. I have also decided to count every single word, even if it is repeated many times in one phrase. I think that the erasure of repetitive words would mean a significant modification of my data.¹⁰ Considering words that were not understandable, there were obvious differences between two situations. On the one hand, there were only hesitation sounds used (*ehm, hmm, eee*) and these sound chains were not counted. On the other hand, there were clear neologisms used (particularly verbs, adjectives or nouns with crashed phonological structure, at least partially supported

⁸ Interdialect of Czech spoken in the western part of the country.

⁹ Free statistical software developed by Jiří Milíčka, see <http://milicka.cz/mawatatarad/>.

¹⁰ I consider type/token ratio in another article, more statistically oriented (now in preparation).

by their location in a phrase), which were counted. There was always agreement by at least two out of three annotators.

Table 3: Persons with aphasia: communication gestures to words in total ratio

	Words	Semantic gestures		Processual gestures		Individual gestures in total	Communication gestures to words ratio (%)
		GwgW	GwaW	GwgW	GwaW		
Mtm	1086	18	6	11	5	40	3.7
Wtm	818	12	10	0	0	22	2.7
Mb2	750	34	18	0	1	53	7.1
Mw1	733	8	2	8	1	19	2.6
Mw2	580	33	19	5	1	68	11.7
Mb1	578	22	94	0	0	119	20.6

Explanatory note:

GwgW: a gesture with a given word (e.g. a person showed me a gesture for gun/shooting together with the word ‘gun’); GwaW: a gesture with another word (e.g. a person showed me a gesture for gun/shooting before the word ‘gun’); GtpnW: a gesture related to the previous or next word (e.g. a person showed me a gesture for gun/shooting before or after a word, but there is no word for gun/shooting within the given context – s/he said only something e.g. a pronoun such as it / this / that, etc); GcrW: a gesture completely replaces a word (e.g. a person showed me only a gesture for gun/shooting – without any verbal accompaniment).

Determination of these categories is based on my own methodological contribution.

Figure 1. Proportion of semantic and processual gestures by PWA

Table 4. Healthy control persons: communication gestures to words in total ratio

	Words	Semantic gestures		Processual gestures		Individual gestures in total	Communication gestures to words ratio (%)
		GwgW	GwaW	GwgW	GwaW		
W1	3563	34	4	0	0	38	1.1
M1	3368	103	5	4	0	112	3.2
W2	3056	51	7	1	0	59	1.9
M2	3010	117	14	2	0	133	4.4
W3	2923	124	15	11	0	150	5.1
M3	2720	36	8	7	0	51	1.9
M4	2376	27	6	1	2	36	1.5
W4	2151	64	5	6	0	75	3.5
M5	2104	25	2	5	1	33	1.6
W5	1903	21	0	12	1	34	1.8

Explanatory note: M1–M5: men 1–5; W1–W5: women 1–5.

Figure 2. Proportion of semantic and processual gestures by HCP

3. Results

Two males with Broca's aphasia, two males with Wernicke's aphasia, one male with transcortical-motor aphasia and one female with transcortical-motor aphasia have been involved in my research to date. PWA were recorded for an average time of 23 minutes.¹¹

¹¹ Except for PWA Mw1, because he saw only three episodes of the cartoon "Shaun the Sheep" (instead of four) and his recording lasted for only about 18 minutes. This PWA was in an extremely bad psychological mood and wanted to stop the recording immediately. This request obviously had to be granted.

The only male diagnosed with transcortical-motor aphasia produced a total of 1,086 words. He used 24 semantic gestures and 16 processual gestures, which is quite a high number, considering his ability to express himself in speech. There were 16 semantic gestures with a given word and 6 with another word, then 11 processual gestures with a given word and 5 with another word and 2 semantic gestures without words, but these gestures were produced by the previous or next word in both cases.

The only female involved in my research is diagnosed with transcortical-motor aphasia. She produced 818 words in total. She used 19 semantic gestures, of which 11 gestures were with a given word and 8 with another word. It is quite interesting that she did not use any processual gesture or any non-semantic gesture. The same situation occurred when considering processual and non-semantic gestures expressed without words. She used 3 semantic gestures without words, where 1 gesture was related to the previous or next word and 2 gestures completely replaced the words. That means that she used 22 gestures altogether, all of which were semantic gestures. In this case, it is also possible that psychological factors could have played a role – this female was quite nervous, and when she finally used a gesture, she was very focused on producing only very concrete gestures.

The PWA Mb2 used 750 words during his speech, but used many more gestures than Mw1; there were even 13 semantic gestures without verbal accompaniment (8 of them were related to the previous or next word and 5 completely replaced verbal expressions). There were also 5 non-semantic gestures without verbal accompaniment. We also identified 39 semantic co-speech gestures by this PWA, of which 26 gestures were with a given word and 13 gestures with a word with another meaning than what was transmitted through the given gesture. There was also 1 processual gesture related to a word other than a word with the anticipated processual meaning.

Despite the shorter time of the recording process, the recording of PWA Mw1 contains 733 words, which corresponds with the fact that the speech of Wernicke's aphasics is relatively fluent, but contains a lot of neologisms¹² and with a significantly chaotic structure of their speech in general.

This PWA did not use gestures to compensate for his verbal deficiency, so I did not note any gesture without verbal accompaniment. With regard to the fact that this PWA always used only “co-speech gestures”, their more detailed classification is as follows: PWA Mw1 used 10 semantic gestures and 9 processual gestures, of which 8 were semantic gestures with the given word and only 2 with another word; considering processual gestures, there were also 8 gestures with a given word and only 1 gesture with another word.

There are two possible factors that could have an influence on the very low frequency of gestures in his speech: 1) the number of words in his speech (733 words during nearly 18 minutes) and, together with that fact, the corresponding assumption that he was able to transmit a significant amount of information without the necessity of using gestures to complete (or even substitute for) something; 2) psychological factors could also have played a role, because this PWA was very nervous, not very co-operative and not relaxed during the entire time of the recording process, which also might have had an influence on the less notable production of non-verbal expressions. He also did not use any gesture without verbal accompaniment.

PWA Mw2 used only 580 words during his speech, although the non-problematic fluency of speech is to be expected of Wernicke's aphasics¹³ – that was confirmed during the recording. However, the fundamental problem consisted of his very low comprehension ability of the given tasks, i.e. retelling the story in the way that was chronologically presented in the video. It was necessary to question him minutely about individual situations in the video. This was much easier for him and his speech became more fluent.

Nevertheless, he used a surprisingly high number of semantic gestures, completely replacing the verbal part – 22 altogether (5 of them were related to the context of the previous or next uttered word, 17 were totally without verbal accompaniment). PWA Mw2 also used a considerable quantity of semantic co-speech gestures, altogether 40, where 28 gestures were related to a given word and 12 to another word. He further expressed 5 processual gestures related to a given word.

¹² It is important to differ between the term “neologism” in lexicology (a new word in a given language, created based on an existing word of another language with the aid of certain suffixes, etc.) and in aphasiology (a new word, but with no sense – the sequential order of phonemes is often destroyed).

¹³ In his case, it is more likely a tendency towards conduction aphasia.

With regard to very limited speech fluency, PWA Mb1 expressed only 578 words. Considering his speech restriction, he used only semantic gestures (119) – he did not use any processual gestures (but quite a high number of non-semantic gestures). It was presumed that he would use more gestures without verbal accompaniment. Nevertheless, he used only 10, where 2 gestures were linked to something which was uttered sooner or later, and 8 gestures totally replaced the verbal constituent.

PWA Mb1 used altogether 109 semantic gestures during his speech: 23 of them were expressed with a word carrying the meaning corresponding to the implemented gesture, and 86 gestures were used in instances other than the intended meaning expressed by words. This could relate to the fact that PWA Mb1 was able to represent very concrete (mostly iconic) gestures that could enable him to remember individual words (or even phrases), which he was able to express afterwards – that fact is concordant with the interface hypothesis (So et al., 2009, 2).

4. Discussion

To date, I have verified two main hypotheses and one sub-hypothesis within my data analysis, i.e. three of the six hypotheses established by Jakob, et al. (2011) in total.

1) PWA with aphasia produce more gestures than HCP during text reproduction. Regarding the number of uttered words, three out of five PWA produce more communicative gestures than any from the group of HCP. To be more specific, the ratio of the most speech-restricted PWA (Mb2) ratio is 20.6% communicative gestures to words. Thereafter, the dependency continues, because the ratio of the second most speech-restricted PWA (Mw2) is 11.7%, followed by Mb2 at 7.1%. There is an obvious difference when comparing these data to HCP: the highest ratio of communicative gestures to words is by W3 (5.1%, 5th place in word production), followed by M2 (4.4%, 4th place in word production), then follows PWA Mtm with 3.7%, then W4 (3.5%, 8th place in word production) and M1 (3.2%, 2nd place in word production). Then follow the two remaining PWA, Wtm and Mw1 (2.7% and 2.5%), and then the rest of 6 HCP with the communicative gestures-to-words ratio from 1.1 to 1.9%. Kong et al. (2015) also found that aphasic persons use more gestures than HCP. What is interesting is the fact that Czech aphasics do not use emblems (symbols) at all, in contrast with the Cantonese speakers in Kong's research.

So far, I have described hypothesis 1) in general. I focus more on sub-hypothesis 1A) in the following part, i.e. whether the PWA group shows a higher rate of words matched to communicative gestures (i.e. semantic and processual together) than the HCP group.

Two PWA show a noticeable higher ratio of words influenced by communicative gestures to words in total than all HCP – three HCP show the ratio of approx. 9%, then the ratio significantly decreases. To be more precise, Mb1 shows a ratio of 38.4%, i.e. more than 38% of his speech is influenced by a communicative gesture. In 2nd place is Mw2 with 15.5%. Then follow the three aforementioned HCP: M2 (9.2%), W3 (9.1%) and M1 (9%). The third PWA has the ratio of 7.7% (Mtm) and the fourth PWA (Mb2) has the ratio of 7.1%, then follows W4 from HCP (5.9%). The two remaining PWA, Mw1 and Wtm, (4.1% and 3.4%) follow, and the remaining 6 HCP are at the lower end, with ratios from 1.5 to 3.2% (see Tables 5 and 6).

Table 5. Persons with aphasia: words influenced by communication gestures to words in total ratio

Person	Words	Words influenced by semantic gestures	Words influenced by processual gestures	Words influenced by communication gestures to words ratio (%)
Mtm	1086	61	23	7.7
Wtm	818	28	0	3.4
Mb2	750	52	1	7.1
Mw1	733	18	12	4.1
Mw2	580	84	6	15.5
Mb1	578	222	0	38.4

Figure 3. Words influenced by semantic and processual gestures by PWA

Table 6. Healthy control persons: words influenced by communication gestures to words in total ratio

Person	Words	Words influenced by semantic gestures	Words influenced by processual gestures	Words influenced by communication gestures to words ratio (%)
W1	3563	64	0	1.8
M1	3368	296	8	9
W2	3056	95	2	3.2
M2	3010	270	6	9.2
W3	2923	255	12	9.1
M3	2720	55	8	2.3
M4	2376	32	3	1.5
W4	2151	116	10	5.9
M5	2104	48	7	2.6
W5	1903	25	16	2.2

Figure 4. Words influenced by semantic and processual gestures by HCP

It is possible to claim that there is an obvious dependency between two facts: 1) three PWA produce more gestures to words than HCP, and 1A) a significant amount of words by PWA are influenced by communicative gestures – the first three places are the same in both indices. The connection between 1) and 1A) can also be observed in HCP – 1st and 2nd places change mutually, as well as 3rd and 4th places, but differences in the measured values are also minimal.

2) The more speech-restricted a PWA is, the more gestures he/she produces when retelling a story. This means that the fewer words a PWA uses, the more gestures he/she uses in his or her speech. My data show that this is valid for almost all observed people with aphasia, except for Mtm, who used the highest number of words (1,086) and is in 4th place when considering the communicative gestures used (40). This accords with Rose and Sekine (2013) regarding their finding that persons with transcortical-motor aphasia have a similar gesture profile to healthy persons – they do not use so many gestures, because they can express meaning verbally. The dependency does not involve Mb2 and Mw1, but I have to take into account a mild distortion, because the recording of Mw1 lasted only about 18 minutes. I would therefore expect that the number of words and also the number of gestures would definitely be higher in more than 20 minutes of recording, as in the rest of the cases. PWA Mb1 produced 578 words and 119 communicative gestures, Mw2 produced 580 words and 68 communicative gestures, Mb2 used 750 words and 53 communicative gestures, Mw1 used 733 words and 19 communicative gestures and Wtm produced 818 words and 22 communicative gestures. My results are also concordant with those of Preisig (2018), who found that persons with more severe aphasia (but not with apraxia) produce more meaningful gestures than mildly affected people.

However, nothing like the abovementioned dependency is visible in HCP. Although W1, with the highest number of words (3,563), used only 38 gestures (second lowest place), the smallest number of gestures in total was used by W5 (34) and M5 (33), who also produced the lowest number of words (1,903 and 2,104), probably because they were very nervous and non-communicative in general. In contrast to that fact, the third highest number of gestures (125) was used by M1, who at the same time produced the second highest number of words (3,368), because he was very communicative in general. My data show that the three HCP who used communicative gestures most actively are also in the top 5 when considering the words produced.

Primary observations show that my data correlate with those of Jakob et al. (2011). However, we could be more certain by the use of statistical approaches and this will be the aim of our future work in this field of research, together with a more detailed classification of communicative gestures and those occurrences where different types of gestures are combined.

My data correlate with the general assumptions about different types of aphasia: Broca's aphasics have tendencies to use fewer words (and mostly non-semantic words, such as pronouns) than Wernicke's and transcortical-motor aphasics, who compensate with quite a high quantity of communicative gestures. But there is at least one exception, because PWA Mw2 inclines towards Broca's symptoms with regard to his use of gestures: he used the second highest number of gestures, which neatly correlates

with the second lowest number of words. A reason for this could be the fact that his comprehension is severely damaged and he is not able to reflect the questioner's requests (to retell a story), but reflects his speech malfunction very frequently (as did PWA, Mw1, but he was not as cooperative as Mw2, so he practically did not try to help himself with gestures). It is also possible to claim that PWA with more distorted speech use gestures particularly as pro-speech gestures and that co-speech gestures are used by HCP or PWA with relatively fluent speech.

My results also accord with de Beer, et al. (2017), who claim that information transmitted by PWA not only by speech, but also by communicative gestures are much more understandable to the recipient of the message. This also corresponds with So, et al. (2009) who claim that, if standard speakers are involved in the research, then the hand-in-hand hypothesis is more relevant, whereas the trade-off hypothesis can function if non-standard speakers (e.g. PWA) are involved. My results also correspond with the findings of de Beer et al. (2017) that emblems (symbols) have the potential to convey meaning when replacing speech, but this does not mean that PWA actually do use emblems to replace speech.

Considering sub-hypotheses 2A) PWA producing long or complex phrases use fewer gestures than PWA producing short and less complex phrases and 2B) PWA with lower lexical diversity use more gestures than PWA with higher lexical diversity, preliminary observations suggest that these assumptions are relevant for Czech PWA. The detailed verification of these assumptions will be the subject of future research as well.

Considering sub-hypothesis 1B), it is also necessary to make a more detailed classification of gestures, probably based on HamNoSys (Hamburg Sign Language Notation System¹⁴), which means a set of units of non-verbal communication that can participate in the creation of meaning. HamNoSys consists of roughly 200 initial hand configurations (shape and position of hands, localization), with a set of possible actions included there.

There are possible problems of computer tools (e.g. automatic coding of gestures in OpenPose¹⁵), which could be solved within research like this, e.g. if one person makes a totally identical gesture for two different meanings (as Mb2 in my research, who made the same gesture for the number 2 as for a gun, with his thumb and pointed finger, etc.). The possibilities and limitations of these tools are also to be discussed within the future research.

References

- Abner, N., Cooperrider, K. and Goldin-Meadow, S., 2015. Gesture for Linguists: A Handy Primer. *Language and Linguistics Compass*, vol. 9, no. 11, pp. 437–451.
- de Beer, C., Carragher, M., van Nispen, K., Hogrefe, K., de Ruiter, J. P. and Rose, M. L., 2017. How Much Information Do People with Aphasia Convey via Gesture? *American journal of speech-language pathology*, vol. 26, no. 2, pp. 483–497.
- Birdwhistell, R. L., 1970. *Kinesics and Context. Essays on Body Motion Communication*. Philadelphia: University of Pennsylvania Press.
- Cicone, M., et al., 1979. The relation between gesture and language in aphasic communication. *Brain and Language*, vol. 8, no. 3, pp. 324–349.
- Crystal, D., 2010. *The Cambridge encyclopedia of language*. Cambridge: Cambridge University Press.
- Fricke, H., 2012. *Grammatik multimodal: Wie Wörter und Gesten zusammenwirken*. Berlin: De Gruyter.
- Gullberg, M., 2006. Handling discourse: Gesture, reference, tracking, and communication strategies in early L2. *Language Learning*, vol. 56, pp. 155–196.
- Hogrefe, K., Ziegler, W., Wiesmayer, S., Weidinger, N. and Goldenberg, G., 2013. The actual and potential use of gestures for communication in aphasia. *Aphasiology*, vol. 27, 1070–1089.
- Hogrefe, K., 2009. *Aphasie, Apraxie und Gestik: Zur Produktion von Handgesten bei Patienten mit linkhemisphärischer Hirnschädigung*. Dissertation, Universität Potsdam.
- Jakob, H. et al. 2011. Zusammenhang von Spontansprachproduktion und Gesten bei Patienten mit Aphasie. *Aphasie und verwandte Gebiete*, vol. 30, no. 3, pp. 20–38.

¹⁴ It was specially designed to be applicable in research and should be usable for every sign language in the world <https://www.sign-lang.uni-hamburg.de/dgs-korpus/index.php/hamnosys-97.html> [Accessed 10 November 2019].

¹⁵ A real-time multi-person system for detecting human body, foot, hand and facial key points (in total 135 key points).

- Kendon, A., 2004. *Gesture: Visible Action as Utterance*. Cambridge: Cambridge University Press.
- Kita, S. and Özyürek, A., 2003. What does cross-linguistic variation in semantic coordination of speech and gesture reveal? Evidence for and interface representation of spatial thinking and speaking. *Journal of Memory and Language*, vol. 48, no. 1, pp. 16–32.
- Kong, A. P.-H., Law, S.-P., Wat, W. K.-C. and Lai, C., 2015. Co-verbal gestures among speakers with aphasia: Influence of aphasia severity, linguistic and semantic skills, and hemiplegia on gesture employment in oral discourse. *Journal of Communication Disorders*, vol. 56, pp. 88–102.
- McNeill, D., 1992. *Hand and mind: What gestures reveal about thought*. Chicago: University of Chicago Press.
- Pike, K. L., 1967. *Language in Relation to a Unified Theory of the Structure of Human Behaviour*. The Hague: Mouton.
- Preisig, B. C., 2018. Multimodal Communication in Aphasia: Perception and Production of Co-speech Gestures During Face-to-Face Conversation. *Frontiers in Human Neuroscience*, vol. 12, article 200.
- de Ruiter, J. P., Bangerter, A. and Dings, P., 2012. The Interplay Between Gesture and Speech in the Production of Referring Expressions: Investigating the Trade-off Hypothesis. *Topics in Cognitive Science*, vol. 4, no. 2, pp. 232–248.
- de Ruiter, J. P., 2006. Can gesticulation help aphasic people speak, or rather, communicate? *Advances in Speech-Language Pathology*, vol. 8, no. 2, pp. 124–127.
- de Ruiter, J. P., 2000. The production of gesture and speech. In D. McNeill (Ed.), *Language and gesture*. Cambridge, England: Cambridge University Press, pp. 284–311.
- Sekine, K. and Rose, M. L., 2013. The relationship of aphasia type and gesture production in people with aphasia. *American Journal of Speech-Language Pathology*, vol. 22, no. 4, pp. 662–672.
- So, W. Ch., Kita, S. and Goldin-Meadow, S., 2009. Using the Hands to Identify Who Does What to Whom: Gesture and Speech Go Hand-in-Hand. *Cognitive Science*, vol. 33, no. 1, pp. 115–125.
- Teasell, R., 2016. *Aphasia and Apraxia*. London, Ontario: Parkwood Institute.