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Part of the message comes in gesture: how people with aphasia convey information in different gesture types as compared with information in their speech

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ABSTRACT

Background: Studies have shown that the gestures produced by people with aphasia (PWA) can convey information useful for their communication. However, the exact significance of the contribution to message communication via gesture remains unclear. Furthermore, it remains unclear how different gesture types and representation techniques impact message conveyance.

Aims: The present study aimed to investigate the contribution of gesture to PWA's communication. We specifically focussed on the degree to which different gesture types and representation techniques convey information absent in the speech of PWA.

Methods & Procedure: We studied the gestures produced by 46 PWA and nine non-brain-damaged participants (NBDP) during semi-structured conversation. For each of the different types of gestures and representation techniques we identified whether these conveyed essential information, that is information that was absent in speech. Rather than looking at information that was either similar to information in speech or additional to information in speech, we focused on the essential gestures only.

Outcomes & Results: For PWA, a fifth of their gestures were Essential. Despite individual differences between PWA, the majority produced more Essential gestures than NBDP, who produced limited amounts of Essential gestures. Essential information was mostly conveyed by specific gesture types: Pointing, Emblems and Iconic gesture. Within the group of iconic gestures, not only Handling and Enact but also Object and Shape gestures, were often Essential.

Conclusions: Our findings suggest that a great proportion of gestures produced by most PWA convey information essential for understanding their communication. In their communication advice, speech language therapists could draw attention to specific gesture types to make sure that interlocutors pay more attention to these gestures when communicating with PWA.

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Introduction

Studies addressing the use of gestures by people with aphasia (PWA) have used various perspectives. Most studies have looked at co-speech gestures, gestures that accompany speech and are produced spontaneously (Hogrefe, Ziegler, Weidinger, & Goldenberg, 2012; Hogrefe, Ziegler, Wiesmayer, Weidinger, & Goldenberg, 2013; Mol, Krahmer, & van de Sandt-Koenderman, 2013; Pritchard, Dipper, Morgan, & Cocks, 2015; Sekine & Rose, 2013; Sekine, Rose, Foster, Attard, & Lanyon, 2013). Of these studies, some have looked specifically at whether or not these gestures facilitate speech in case of word finding difficulties (e.g., Cocks, Dipper, Middleton, & Morgan, 2011; Lanyon & Rose, 2009). Results suggest that some PWA make more gestures during word finding difficulties and that these gestures may facilitate word production. A third perspective is the use of gestures in the absence of speech: pantomime. Studies have shown that PWA are able to produce pantomimes (Hogrefe et al., 2013; van Nispen, van de Sandt-Koenderman, Mol, & Krahmer, 2014, 2016) and that PWA can be trained to produce a set of pantomimes (Caute et al., 2013; Kroenke, Kraft, Regenbrecht, & Obrig, 2013; Marshall et al., 2012; Rose & Douglas, 2006; Rose, Raymer, Lanyon, & Attard, 2013). The present study focuses on all gestures that PWA produced during a semi-structured interview.

In addition, several studies have shown that PWA may produce various informative gesture types (Behrmann & Penn, 1984; Cocks, Dipper, Pritchard, & Morgan, 2013; Goodwin, 1995; Goodwin & McNeill, 2000; Kemmerer, Chandrasekaran, & Tranel, 2007; Kong, Law, Wat, & Lai, 2015; Rose & Douglas, 2003; Sekine & Rose, 2013; Sekine, Rose, Foster, Attard, and Lanyon, 2013) and representation techniques (Mol et al., 2013; van Nispen et al., 2016). However, the observation that PWA produce informative gestures, in itself, does not show that these gestures actually convey information that is not conveyed through the speech of PWA. Recently, various studies have therefore tried to explore *how* the information conveyed in PWA's gestures contributes to their communication (de Beer et al., *in press*; Hogrefe et al., 2013; Mol et al., 2013; Rose, Mok, & Sekine, 2017). Examining how information from gesture and speech is conveyed in PWA is complex. First, it can be difficult to determine the exact meaning conveyed in PWA's speech. In addition, it is also and maybe even more difficult, to determine the exact meaning of a gesture, especially in the context of spontaneous communication, where in contrast to picture description the referents are often not shared. To overcome these difficulties, the present study presents a new method to assess how information conveyed in gesture relates to information conveyed in speech. Based on a coding scheme developed by Colletta, Kunene, Venouil, Kaufmann, and Simon (2009) for analysing gestures produced by children, we developed a coding scheme which compares the information in gesture to the information in speech. Adding to previous studies, this method will enable us to quantify the contribution of gesture to PWA's communication. By determining how the information conveyed in gesture compares with the information conveyed in speech, we aimed to investigate how different gesture types and representation techniques contribute to PWA's communication.

Gesture types and representation techniques in aphasic communication

Gestures naturally co-occur with the production of speech (McNeill, 1992). Within these co-speech gestures, one can distinguish between two main gesture categories: gestures

that are meaning laden and gestures that are not. The latter category consists mainly of so-called beat gestures. These are repetitive single-stroke movements which do not present a discernible meaning and they often follow the intonation pattern in speech (Krahmer & Swerts, 2007; McNeill, 1992). Other gesture types are meaningful and therefore potentially useful for PWA to support their communication. Within the category of these meaning-laden gestures, the following gesture types are distinguished: emblems, deictics, iconic gestures, and metaphoric gestures. Emblems have a conventional meaning within a certain culture, such as the *thumbs up* gesture in the Dutch and English culture (McNeill, 1992). Deictics or pointing gestures can also be highly informative, indicating something in the environment (McNeill, 1992). Individuals can point to referents, *pointing to their arm* or *pointing to something on the table*, and also distant referents, for instance, *pointing to the wall* to indicate the neighbours or something outside, or abstract referents, for instance *pointing to the sky* to refer to “heaven”. Iconic gestures have an iconic or form relationship to the concept they refer to (McNeill, 1992; Müller, 1998; Perniss, Thompson, & Vigliocco, 2010). For instance, the iconic gesture of *pretending to drink* is very similar to the real activity of drinking. Metaphoric gestures are iconic as well but these refer to abstract concepts (McNeill, 1992). For instance, *two fists bouncing against each other* can refer to “clashing arguments” in a heated discussion. Among these gesture types, iconic gestures could be particularly useful for PWA’s communication. Whereas, for instance, emblems are limited to the available emblems within a culture, iconic gestures can potentially be created freely and understood in the absence of a spoken context (McNeill, 1992; Müller, 1998; Perniss & Vigliocco, 2014). Sekine & Rose (2013); Sekine, Rose, Foster, Attard & Lanyon, (2013) have given an extensive description of the different gesture types produced by 98 PWA. They reported, for example, that individuals with Wernicke’s aphasia produced a low number of meaning-laden gestures, such as emblems and iconic gestures, and a high number of beats and metaphoric gestures, which are less meaningful. By contrast, they found that individuals with Broca’s and conduction aphasia produced high levels of meaning-laden gestures (concrete deictic, iconic gestures, emblems, and number gestures). These findings are in line with findings of earlier small-scale studies in which parallels were observed between PWA’s linguistic impairment and the type of gesture produced (e.g., Carlomagno & Cristilli, 2006; Cicone, Wapner, Foldi, Zurif, & Gardner, 1979). Considering the communicative properties of different gesture types and techniques, it is important to determine the degree to which they contribute to PWA’s communication.

Within the category of iconic gestures, Müller (1998) makes a sub-classification of various representation modes. For example, the hands can imitate the performance of an everyday activity, which can be a transitive action or an intransitive action, for instance, *pretending to drink* or *pretending to dance*. One could also mould or draw the shape or size of a referent. Finally, one could use the hands to portray a certain entity, such as *moving the index finger in front of one’s mouth* to represent a toothbrush. Various techniques can be used to depict a certain referent (van Nispen et al., 2016), but the communicative value of these techniques may differ. For instance, *drawing the outline of the shape of a toothbrush* might be less informative or more difficult to interpret correctly by an interlocutor than *pretending to use a toothbrush*. Mol et al. (2013) found that in the co-speech gestures produced by 25 PWA during responses to a

communicative scenario, relatively many shape techniques occurred, whereas people without brain damage more often also produced other techniques, such as imitation of the performance of everyday activities. Similar findings were reported by van Nispen et al. (2016) in a study of 38 PWA who used gestures in absence of speech to name a set of pictures. Differently from NBDP, some of these PWA relied only on shape gestures to convey what was in a picture. Also, Cocks et al. (2013) looked at the gestures produced by 29 PWA during word finding difficulties. They found that semantic knowledge related positively to the use of shape gestures and gestures depicting the manner of an action during word finding difficulties.

In summary, PWA produce different gesture types and representation techniques. However, some may use these differently from NBDP, and their use of gestures may be related to their patho-linguistic profiles. These different gesture types and different representation techniques vary in the type of information they can convey. Therefore, it is important to know how these different gesture types may contribute to communication of PWA.

Information in aphasic gesture

Pritchard et al. (2015) showed that PWA produced gestures that were similar in frequency and form to those produced by NBDP. Because PWA produced less information in speech, relatively more information was present in gesture. Although studies such as this one and those by Sekine & Rose (2013), Sekine et al. (2013) have shown that PWA produce gesture types in conversation that can be informative, it remains unknown what the exact contribution is of gesture to PWA's communication, particularly for spontaneous communication. Studies that have examined the information conveyed by PWA showed that judges derived more information from stimuli in which speech and gesture were presented combined as compared with speech only conditions (de Beer et al., *in press*; Mol et al., 2013; Rose et al., 2017). These studies, however, mostly looked at specific scenarios and judges could rely on very specific contexts regarding the meaning of the utterances. For example, judges had to choose between a limited number of scenarios for determining the meaning of communication (Hogrefe et al., 2013; Mol et al., 2013). Although communicative context can help in determining the meaning of a gesture, the settings in these studies are not particularly akin to real-life communication, as during daily conversation interlocutors would not have such options to choose from to identify the meaning of a gesture. In the studies by de Beer et al. (*in press*) and Rose et al. (2017), the researchers first identified the meaning of a gesture based on its communicative context. They did this for gestures for which the context disambiguated the meaning. Then in their experiments they showed the gestures to naïve judges with limited additional context, and determined whether these judges were able to correctly identify the ambiguous meaning in different conditions (speech only or gesture and speech combined). They found that PWA's communication was best understood when both speech and gesture were available to the judges.

The difficulty that arises when addressing spontaneous communication is that the meaning of gesture is not standardised and there are no validated tools to investigate spontaneous gesture use. For analysing speech, there are some validated measures

available, such as the spontaneous speech analysis of the Akense Aphasia Test (AAT, Graetz, de Bleser, & Wilmes, 1991) or Western Aphasia Battery (WAB, Kertesz, 1982). Such a measure does not yet exist for analysing the spontaneous gesture use of PWA. It would be useful to investigate whether a similar approach could also work for determining the communicativeness of gestures.

One early attempt to determine the information contained in gesture was by Herrmann, Reichle, Lucius-Hoene, Wallesch, and Johannsen-Horbach (1988). They determined the communicative functions of non-verbal behaviours (including hand gestures, but also other body movements) of seven PWA with global aphasia in an interaction with their partners. They found that PWA employed non-verbal behaviour significantly more often in the absence of speech than their partners. Their analysis focused mainly on the balance between communication modes: whether speech and gesture were used simultaneously, separately, or consecutively and less on the information conveyed in each modality. In a more recent study, Kong et al. (2015) determined the communicative value of various gesture types produced by 48 Cantonese PWA and showed that PWA's content-carrying gestures, including iconic, metaphoric, deictic gestures, and emblems, served the function of enhancing language content and providing information additional to the language content. They found a significant correlation indicating that PWA with more severe aphasia produced more co-speech gestures than PWA with less severe aphasia. They did not report whether these gestures were also more informative than speech.

The coding scheme of Colletta et al. (2009), that was originally developed to code information in gestures produced by typically developing children, could potentially be useful to determine how information in PWA's gestures adds to their communication. The six codes in this coding scheme can be combined into three main categories that show how information in gesture relates to information in speech: gestures that convey information that is "Similar" to information in speech, "Additional" to speech, or convey information that was not clear from speech, but "Essential" for understanding that message (also see Bergmann & Kopp, 2006; Özçalışkan & Goldin-Meadow, 2005; for other categorisations of how information in gesture compares to information in speech). Consider the speech and accompanying gestures in the following fictional example in which a man discusses an accident that happened to him (underlined speech and gestures with the same number are aligned together):

Speech: "1 went up the stairs² and boom³"

Gesture: 1 point at self,

2 point index finger upwards and makes circular upwards movement,

3 tilts hand palm facing the body to palm facing upwards

These gestures all convey information, but their communicative value differs. First, while the speaker says "1", he *points at himself*. This gesture conveys information that is similar to the information in speech. During the next part of his expression, "went up the stairs", he *points his index finger upwards and makes a circular movement upwards*. This gesture conveys information about the shape of the stairs, namely that it is a spiral, and specifies the upwards movement. This information is not present in speech. Considering that the speaker intends to explain an accident, this information is not necessary to understand his message, rather it conveys information that is additional to the spoken context.

Finally, the man says “boom” and accompanies this with a final gesture: he *holds his hand palm facing the body and tilts it to hand palm facing upwards*, representing a falling motion. This gesture is essential for understanding that the man fell down the stairs, as without this information the complete message about the accident would not be understood. For the present study, we are interested in finding out whether this way of coding information in gesture can be useful to assess the information conveyed in PWA’s gestures.

Present study

Gestures produced by PWA can convey information absent in their speech. It remains unclear how important this contribution of gesture is for aphasic communication. Furthermore, PWA as well as NBDP produce various gesture types and representation techniques. The latter though has not been studied for the spontaneous communication of PWA. These different gesture types and representation techniques can differ in the type of information they convey. Thus, the present study examined two things. First, we investigate the use of different representation techniques by PWA in semi-spontaneous communication. Second, we investigated which gesture types are most communicative, by determining to what degree these gestures convey information that is not conveyed in speech. The present study adds to the existing literature by showing how PWA use gesture representation techniques spontaneously and shows the communicative value of PWA’s gesture, specifically for different gesture types and representation techniques.

Method

Participants

This study used data from an online database AphasiaBank (MacWhinney, Fromm, Forbes, & Holland, 2011). Participant details and test scores were downloaded on 1 February 2016. AphasiaBank is a database with, among other things, interviews with PWA and non-brain-damaged people (NBDP). The interviews were all conducted following a strict protocol in which an experimenter asked four questions about the participants’ recovery and an important event in their lives. Questions for the NBDP were comparable. Here, the interviewer asked the participants to tell her about an illness or medical condition that they had and whether they had experience with people with language difficulties. The database contains PWA’s demographic data and results of the WAB (Kertesz, 2007), as well as various other tests not used for the present study. Unfortunately, no information on limb apraxia is available in the database. Individuals in the database are labelled with the name of the experimenter who contributed their data to the database and a number (for instance Adler01).

The present article reports on 46 PWA (28 male, age 36–84) and 9 NBDP (4 male, age 34–77). These were, except for one, the same as described in Sekine, Rose, Foster, Attard, and Lanyon, (2013). Sekine, Rose, Foster, Attard, and Lanyon, (2013) included participants who were native speakers of English and produced at least one gesture during a story retell task. For a detailed description of inclusion and exclusion criteria, see Sekine and Rose (2013) and Sekine, Rose, Foster, Attard, and Lanyon, (2013).¹ One individual,

Table 1. Participant details of PWA and their use of Essential gestures in number (*N*) and percentage of total number of gestures (%)^a.

Participant	Age	Gender ^b	Handedness ^c	Paresis ^d	Aphasia duration	AoS ^e	Dys ^f	Aphasia type	AQ	Info in spont. speech	Essential gestures	
											<i>N</i>	%
Adler02a	70	M	R	RW	5.25	Y	N	Conduction	75	9	12	36
Adler04a	75	F	R	LW	6.00	N	Y	TransMotor	73	8	7	7
Adler06a	71	M	R	NM	4.90	N	N	Wernicke	28	2	12	22
Adler09a	42	F	A	RW	4.30	Y	N	Anomic	93	10	6	6
Adler13a	52	M	L	RW	5.00	Y	Y	Broca	56	8	19	33
Adler14a	71	M	A	RW	11.25	N	Y	Conduction	83	10	14	5
Adler18a	72	M	R	RP	5.75	Y	Y	TransMotor	60	8	5	25
Adler21a	36	M	R	LW	2.60	Y	N	Anomic	88	9	6	9
Adler23a	81	M	R	NM	7.00	N	N	Wernicke	47	5	8	16
Adler25a	66	M	R	RP	6.30	Y	Y	Broca	78	9	5	19
Cmu02a	36	M	R	RP	4.75	N	Y	Broca	U	U	9	47
Elman2a	82	F	R	NM	1.20	Y	N	Conduction	62	6	8	19
Elman03a	55	M	R	RP	11.00	Y	N	Broca	66	8	20	24
Elman07a	65	M	R	RP	4.90	N	N	Anomic	63	5	13	12
Elman12a	57	M	R	NM	3.50	N	N	Wernicke	74	9	6	5
Elman14a	76	F	R	NM	4.70	N	N	Wernicke	66	9	18	8
Kansas5a	70	F	R	NM	2.50	N	N	Wernicke	33	4	1	2
Kansas12a	U	M	U	RP	U	N	N	Wernicke	46	5	9	41
Kansas14a	77	F	R	RW	0.70	N	N	Wernicke	67	8	0	0
Kempler04a	60	F	R	RP	3.30	N	N	Broca	55	6	12	26
Scale01a	78	M	R	RP	25.75	Y	N	Broca	53	8	67	35
Scale02a	58	M	A	RP	8.25	Y	N	Anomic	71	8	0	0
Scale04a	62	F	R	RW	11.60	Y	Y	Conduction	73	8	32	37
Scale05a	64	M	R	RP	5.70	Y	Y	TransMotor	73	8	12	92
Scale08a	73	M	R	NM	5.00	N	N	Anomic	88	10	3	21
Scale13a	70	M	R	RW	9.10	Y	U	Conduction	70	7	58	54
Scale14a	64	M	R	RP	2.40	N	U	Anomic	68	8	3	11
Scale15a	58	M	L	RP	3.80	N	N	Conduction	68	8	48	51
Scale17a	54	F	A	RP	12.00	N	N	Anomic	92	9	7	6
Scale19a	84	M	R	RP	11.20	N	N	TransMotor	68	7	15	22
Scale24a	62	M	R	RW	0.25	N	N	Wernicke	40	5	9	20
Tap08a	55	F	R	NM	1.80	N	N	Anomic	69	8	0	0
Thompson01a	45	M	R	NM	3.00	N	N	Conduction	93	9	6	8
Thompson02a	47	F	R	RP	1.60	Y	U	TransMotor	87	9	6	21
Thompson04a	80	F	R	NM	3.00	U	U	Anomic	74	8	9	32
Thompson09a	74	F	R	NM	4.00	U	N	TransMotor	79	9	1	4
Tucson03a	47	F	R	NM	11.30	N	N	Wernicke	35	2	10	14
Tucson08a	57	F	R	RW	11.10	Y	N	Conduction	73	8	16	27
Tucson12a	73	M	R	NM	13.20	U	U	Conduction	50	6	12	29
Tucson13a	68	M	R	RW	30.00	U	U	Broca	69	U	42	27
Tucson14a	54	F	R	RW	12.90	U	U	Broca	41	3	8	42
Tucson15a	74	M	R	U	11.25	N	N	Wernicke	43	5	15	33
Wright201a	55	M	R	RW	13.00	Y	N	Broca	58	8	2	18
Wright202a	63	F	R	RW	10.75	N	N	Anomic	90	9	5	11
Wright203a	66	M	R	NM	16.60	N	N	Conduction	76	9	7	6
Wright206a	39	F	R	RW	11.90	N	N	Broca	54	7	7	20

^aU: unavailable.^bF: female; M: male.^cR: right handed; L: left handed; A: ambidexterity.^dRP: right-sided hemiplegia; LP: left-sided hemiplegia; RW: right-sided hemiparesis; LW: left-sided hemiparesis; NM: no motor problems.^eAoS: Apraxia of Speech; Y: yes; N: no.^fDys: Dysarthria.

Adler11 was not included in the present study, since his main method of communication was drawing. We replaced him with Scale01a, who also had Broca's aphasia. Table 1 provides an overview of participant details of the PWA in our study. In addition to

aphasia severity, as indicated by the WAB Aphasia Quotient, (AQ) (range = 28–93, $M = 65$, $SD = 17$) we examined the ability to convey information in speech as indicated by the WAB Spontaneous speech information content (range: 2–10, $M = 7$, $SD = 2$) (Kertesz, 1982).

Gesture analysis

We analysed all gestures produced by the PWA during the interview. These could be co-speech gestures, including gestures accompanying fluent as well as effortful speech, and pantomimes. For the analyses, we used three types of coding: (1) gesture type, (2) iconic representation technique, and (3) communicativeness of these gestures. All coding was performed using the software ELAN (Wittenburg, Brugman, Russel, Klassmann, & Sloetjes, 2006).

Gesture type

We used the codings for gesture type as reported by Sekine & Rose (2013); Sekine et al. (2013). We focused on: Concrete deictics, Iconic Character Viewpoint (ICV) Gestures, Iconic Observer Viewpoint (IOV) gestures, Emblems, Metaphoric gestures, Numbers, Pointing to self, Referential and Time gestures. See appendix Table A1 (Sekine & Rose, 2013; Sekine et al. (2013)) for a detailed description of these codes. Beats and Letter gestures were not further analysed for their communicativeness, the former because Beats do not convey concrete information and the latter because Letters were often not clearly visible on the videos and their communicativeness could not be determined.

Iconic gesture types

For all iconic gestures (ICV and IOV), we specified what kind of representation technique was used: Handling, Enact, Object, Shape (based on van Nispen et al., 2016) or Path (based on Cocks et al., 2013). See Table 2 for definitions and examples of these codes.

Communicativeness

To determine the communicativeness of a gesture, we used a coding scheme based on Colletta et al. (2009). This scheme determines the relation of information contained in a gesture to the information in the corresponding speech. See Table 3 for short definitions of the labels used. For the present study, we were mostly interested in finding out how gesture conveys information essential for understanding PWA's communication. Therefore, we collapsed these six gesture labels into three categories: (1) Similar: gestures that conveyed information similar to information conveyed in speech. For this, we collated the Reinforce and Integrate codes. (2) Additional: gestures that conveyed information additional to speech, but were not essential for understanding communication. This equated to the Supplement code in Colletta et al.'s scheme. Finally, (3) Essential: all gestures that conveyed information absent in speech and were essential for understanding a message. For this, we collated the Complement, Contradict, and Substitute codes. We determined the communicativeness of a gesture within its spoken context. As context, we took into account all gestures and speech on the same topic. This included not only fluent, hesitant, effortful, revised, and errorful speech but also moments of silence. A topic ended when there was a speaker shift, the

Table 2. Coding scheme for representation techniques used (Cocks et al., 2011; van Nispen et al., 2016).

Representation technique	Definition	Example
Handling	Pretending to use an object	<i>Pretending to write with a pencil</i>
Enact	One pretends to be in a different situation, without using an object	<i>Pretending to be cold by rubbing one's hands to opposite shoulders</i>
Object	Using one's hands to represent (part of) an object	<i>Holding a hand in front of one's face for representing a mask</i>
Shape	Outlining or moulding the shape of an object	<i>Drawing the outline of a house with one's index finger</i>
Path	The hands show the direction or path of a referent. If a gesture also depict manner of the movement, it is coded as Object	<i>Moving a pointed index finger diagonally in front of the body</i>

Table 3. Labels and definitions with examples for the communicativeness of gestures: How information in gesture relates to information in speech, based on Colletta et al. (2009) and Kong et al. (2015).

Labels	Definitions	Example		Similar to the codes used by	
		"speech"	gesture	Colletta et al. (2009)	Kong et al. (2015)
Similar	Information in gesture is Similar to information conveyed in speech	"Me" "Drinking"	<i>point to self</i> <i>pretend to drink</i>	Reinforce Integrate	Enhancing
Additional	Information in gestures adds to information conveyed in speech, but is not Essential for understanding the message.	"Cake"	<i>draw round shape</i>	Supplement	Additional
Essential	Information in gesture is absent in information in speech and Essential for understanding the message.	"I have pain here" "Five" "..." "Slowly"	<i>point to leg</i> <i>show four fingers</i> <i>thumbs up gesture</i> <i>move hands upwards</i>	Complement Contradict Substitute	Alternative means

interviewer asked the next question, or there was an introduction of a new topic by the speaker (for instance, explaining a second hobby). For example, a person could say "I like to *p*, eh you know₁, pay, no₂... paint" and accompany this with two gestures: ₁move hand as if holding something upwards, and ₂make a hand movement as if painting a wall (fictional example). These gestures would both be coded as Similar, as, in this context these gestures are similar to the information conveyed in speech. If the word "painting" would have been unintelligible, or not produced, both gestures would be coded as Essential.

All first codings were performed by the first author of this article. Coding of the communicativeness labels was sometimes difficult, as there is no defined meaning of gesture and it was therefore difficult to purely objectively determine whether the gestures conveyed information absent in speech. To check whether the coding was a reliable representation

of the informativeness of the gestures, we performed a precise second coding procedure. Sixty-four per cent of all gestures (excluding Beats and Letter gestures) for PWA were second coded by three other coders. The procedure was as follows: All videos were coded independently by two coders. All mismatches between these two coders were discussed and resolved which resulted in the first codings for this study. Next, a third coder performed second coding for these data. Agreement between first and second coding, according to Landis and Koch (1977), was substantial for the iconic labels ($\kappa = .75$) and communicativeness labels ($\kappa = .67$). For NBDP, 10% of the gestures (excluding Beats and Letter gestures) were second coded by an expert gesture coder. Agreement between coders for the iconic labels was almost perfect ($\kappa = .88$) and was moderate for the communicativeness labels ($\kappa = .78$). Analyses were performed over first codings.

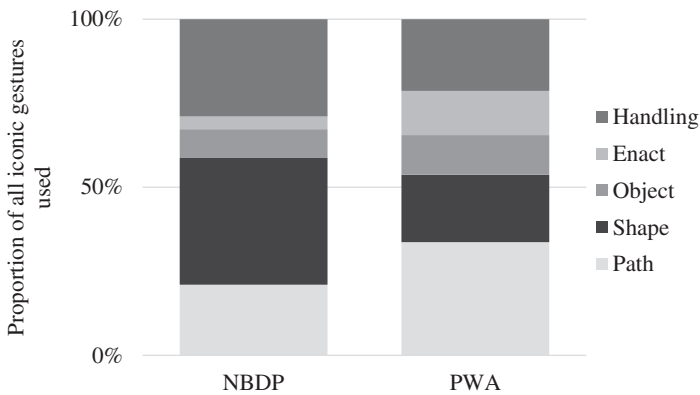
Analyses

Since the length of the interviews and number of gestures differed between individuals, we performed analyses over both number and proportions of gestures. The analyses contained four components. First, we examined which iconic representation techniques individuals produced. We described the use of different representation techniques for NBDP and PWA. We correlated the WAB AQ and the WAB score for Information in Speech with the different techniques used with Pearson's Correlation test. Second, we focused on how informative the gestures produced by PWA and NBDP were by looking at the number and proportions of their gestures that conveyed information that was Similar, Additional, or Essential. Using a MANOVA, we determined differences between these two groups for the Essential gestures produced. We calculated the correlation of WAB AQ and the Information in speech scores to the communicativeness of these gestures, again, using Pearson's Correlation test. Furthermore, we tried to determine patho-linguistic profiles of PWA who produced relatively many Essential gestures. For this analysis, we determined for which individuals their use of Essential gestures was more than two standard deviations above the use of Essential gestures by NBDP in number and proportion. Third, for the gestures produced by PWA we did a combined analysis of gesture type and communicativeness in which we determined how often each gesture type conveyed information that was Essential. We did this (1) for all gesture types and (2) specifically for the iconic representation techniques. For this analysis, we calculated the proportion of Similar, Additional, or Essential gestures for each gesture type. Finally, we focused specifically on the Essential gestures produced and we described the roles of the Essential gestures in the communication of PWA, illustrating these with examples.

Results

Iconic representation techniques

Except for one PWA, all individuals produced iconic gestures. There was great individual variation in the number of iconic gestures produced by PWA (range = 0–53, $M = 15$ $SD = 14$) and NBDP (range = 1–21, $M = 10$ $SD = 7$). In proportions, Iconic gestures



	NBDP				PWA			
	Number		Proportion ¹		Number		Proportion ¹	
	R	M(SD)	R	M(SD)	R	M(SD)	R	M(SD)
Handling	0-5	2(2)	0.00-1.00	0.29(0.35)	0-21	3(5)	0.00-1.00	0.21(0.26)
Enact	0-2	0(1)	0.00-0.20	0.04(0.07)	0-33	3(6)	0.00-0.69	0.13(0.20)
Object	0-5	1(2)	0.00-0.31	0.09(0.12)	0-09	2(2)	0.00-0.50	0.12(0.15)
Shape	0-8	4(3)	0.00-0.89	0.38(0.30)	0-13	2(3)	0.00-1.00	0.20(0.25)
Path	0-9	3(3)	0.00-0.43	0.21(0.15)	0-21	5(6)	0.00-1.00	0.33(0.32)

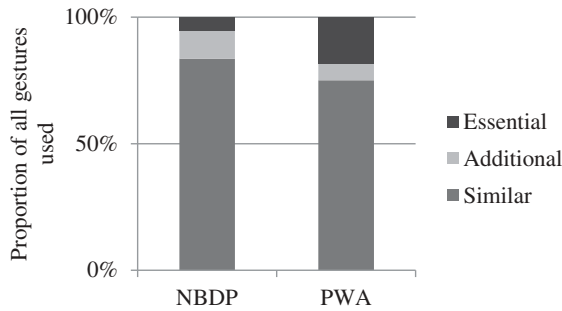
Figure 1. The different representation techniques used by PWA and NBDP in average proportions¹ of all iconic gestures used. Table shows range, *M* and *SD* for number and proportion¹ per representation technique.

¹Proportion = number of times this representation technique is produced per individual/total number of iconic gestures produced per individual.

accounted for approximately a fifth of all gestures produced by PWA (range = 0.00–0.58, *M* = 0.21, *SD* = 0.13) and NBDP (range = 0.07–0.59, *M* = 0.22, *SD* = 0.17). For PWA, out of all the iconic gestures produced, the Path technique was produced most often (Figure 1). The other techniques were distributed quite evenly. For NBDP, Handling and Shape, and to a lesser degree, the Path techniques were produced most often. We found no significant correlations for WAB-AQ or Information in Speech and the iconic representation techniques that PWA produced.

Communicativeness

In total, the number of gestures produced by PWA ranged from 11 to 128 (*M* = 51, *SD* = 37) and for NBDP from 11 to 285 (*M* = 68, *SD* = 58). More than 70% of the gestures produced by PWA carried meaning that was coded as Similar to the information conveyed in speech (Figure 2). Of particular interest, 22% of PWA’s gestures were coded as Essential for understanding their communication. By contrast, NBDP produced hardly any Essential gestures, Figure 2. This difference was significant in that PWA produced more Essential gestures than NBDP, in both number of gestures: *F*(1,53) = 5.40, *p* = .02, and in proportion of gestures: *F*(1,53) = 9.68, *p* < .01. We found no significant correlations between the proportion or number of Essential gestures



	NBDP				PWA			
	Number		Proportion ¹		Number		Proportion ¹	
	Range	<i>M</i> (<i>SD</i>)	Range	<i>M</i> (<i>SD</i>)	Range	<i>M</i> (<i>SD</i>)	Range	<i>M</i> (<i>SD</i>)
Essential	0-6	2(2)	0.00-0.14	0.03(0.05)	0-67	13(14)	0.00-0.92	0.22(0.18)
Additional	0-13	5(4)	0.00-0.29	0.11(0.09)	0-21	4(4)	0.00-0.26	0.06(0.06)
Similar	11-114	44(34)	0.68-1.00	0.85(0.10)	1-264	51(50)	0.08-1.00	0.72(0.20)

Figure 2. Average communicativeness of gestures in proportions¹: Similar, Additional, and Essential for NBDP and PWA. Table shows range, *M* and *SD* for number and proportion¹ per communicativeness label. ¹Proportion = number of Similar, Additional or Essential gestures produced per individual/total number of gestures produced per individual.

produced and WAB-AQ or Information in Speech. This indicated that PWA with little information in speech did not necessarily produce more information in gesture.

There was great individual variability in the total number of gestures produced (excluding Beats and Letters) by PWA and NBDP and the communicativeness of these gestures, **Figure 3**. For the following analysis we determined for which PWA their use of Essential gestures was more than two standard deviations above the mean use of Essential gestures produced by NBDP, for number of Essential gestures produced (NBDP *M* = 2, *SD* = 2) and proportions (NBDP *M* = 0.03, *SD* = 0.05). For a majority of PWA, 28 individuals (58%), more than 14% of their gestures were Essential for understanding their communicative message. Furthermore, 30

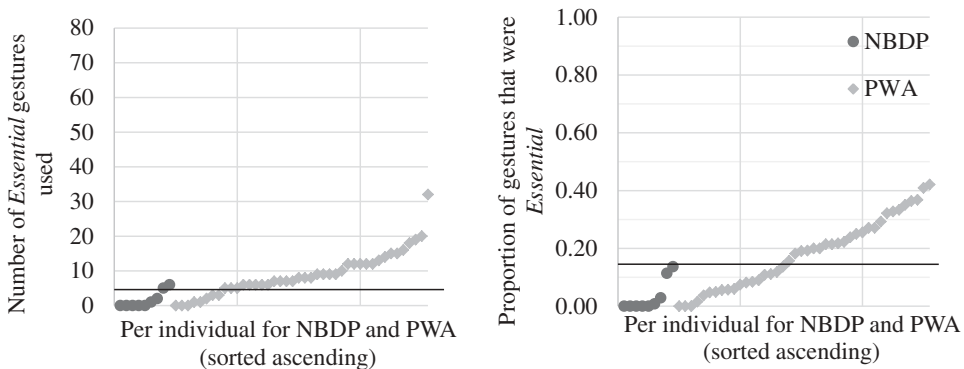


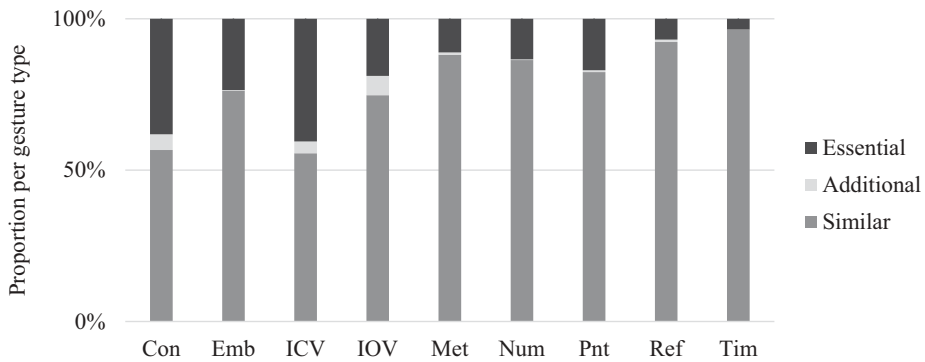
Figure 3. Individual variation in use of Essential gestures: a) total number of Essential gesture and b) proportion¹ of Essential gestures used per individual clustered per group: PWA and NBDP, and sorted ascending (black horizontal line indicates two *SD* above NBDP *M*).

¹Proportion = number of Essential gestures produced per individual/total number of gestures produced per individual.

individuals produced more than six Essential gestures. There were 23 individuals for whom these criteria overlapped, consequently 35 out of 46 PWA conveyed substantial amounts of information in gesture Essential for understanding their message, and only a few did not. We found no clear characteristics that set these individuals apart. Interestingly, out of these 23 there were only two individuals with a WAB Information in Speech score below 4 (out of 10). Eight had a score of 5 or 6, and 11 had a score of 7 or higher (the scores of the remaining two individuals were unknown).

Communicativeness per gesture type

For PWA, we determined for each gesture type how often these were Similar, Additional, or Essential. Figure 4 shows that all gesture types mostly conveyed information that was Similar to the information conveyed in speech. Although not often produced, Additional gestures were almost exclusively Concrete deictics, ICV’s, and IOV’s. More than 25% of Concrete deictics and ICV were Essential, but Emblems were also relatively often

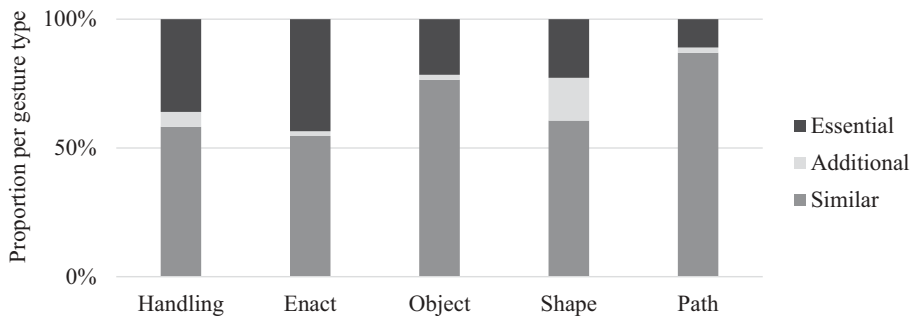


	Essential gestures			
	Number		Proportion ¹	
	Range	M(SD)	Range	M(SD)
Con	0-15	2(3)	0.00-1.00	0.32(0.32)
Emb	0-10	2(3)	0.00-1.00	0.18(0.21)
ICV	0-22	3(5)	0.00-1.00	0.33(0.32)
IOV	0-13	1(2)	0.00-1.00	0.15(0.25)
Met	0-05	1(1)	0.00-0.80	0.06(0.17)
Num	0-06	1(1)	0.00-0.60	0.10(0.20)
Pnt	0-04	1(1)	0.00-1.00	0.14(0.26)
Ref	0-13	1(1)	0.00-1.00	0.06(0.17)
Tim	0-02	0(0)	0.00-0.67	0.03(0.14)

Figure 4. Communicativeness (in proportions)¹ for the different gesture types used by PWA. Table shows range, M and SD for number and proportion¹ of Essential gestures produced per gesture type.

Con = Concrete deictic, Emb = Emblem, ICV = Iconic Character Viewpoint, IOV = Iconic Observer Viewpoint, Met = Metaphor, Num = Number, Pnt = Pointing to self, Ref = Referential, Tim = Time (See Table A1 for descriptions of each gesture type).

¹Proportion = number of times this gesture type is Essential per individual/total number of gestures in this gesture type produced per individual.



	Essential gestures			
	Number		Proportion ¹	
	Range	<i>M(SD)</i>	Range	<i>M(SD)</i>
Handling	0-19	2(4)	0.00-1.00	0.34(0.29)
Enact	0-15	3(5)	0.00-1.00	0.42(0.39)
Object	0-06	1(1)	0.00-1.00	0.21(0.34)
Shape	0-07	1(2)	0.00-1.00	0.21(0.29)
Path	0-02	0(1)	0.00-0.67	0.10(0.22)

Figure 5. Communicativeness (in proportions¹) for the different iconic representation techniques used by PWA. Table shows range, *M* and *SD* for number and proportion¹ of Essential gestures produced per representation technique.

¹Proportion = number of times this representation technique is Essential per individual/total number of times this individual produced this representation technique.

Essential. None of the gesture types were never Essential, but Metaphoric gestures, Referential and Time gestures were only rarely Essential.

ICV and IOV gestures represent various iconic representation techniques. Each of these techniques depicts information that was mostly Similar to information in speech (Figure 5). More than 25% of the Handling and Enact gestures were Essential. For both Object and Shape, this was 21% and Path gestures were the least often Essential.

Communicative role of essential gestures

The Essential gestures observed in PWA are a phenomenon not typically seen in NBDP. While coding the data, we noticed that these Essential gestures fulfilled different roles in the communication of PWA, which we describe here (Figure 6):

- (1) *Provide information in the absence of speech.* In example 6a, Kansas12a seems unable to produce the word 'fishing', which results in a moment of silence. In this moment, he produces a gesture (*Swinging the hand as if casting a fishing rod*) that conveys essentially this information. This illustrates that gesture can convey information in instances of silence which PWA were not able to produce in speech. Interestingly, Scale 01 in example 6e of a Similar gesture, after he performed a gesture in silence depicting that he cannot speak (*Move lips without producing sound + Moving hand back and forth in front of mouth*), conveyed the same information in speech "I can't talk". Considering this context, Scale 01's

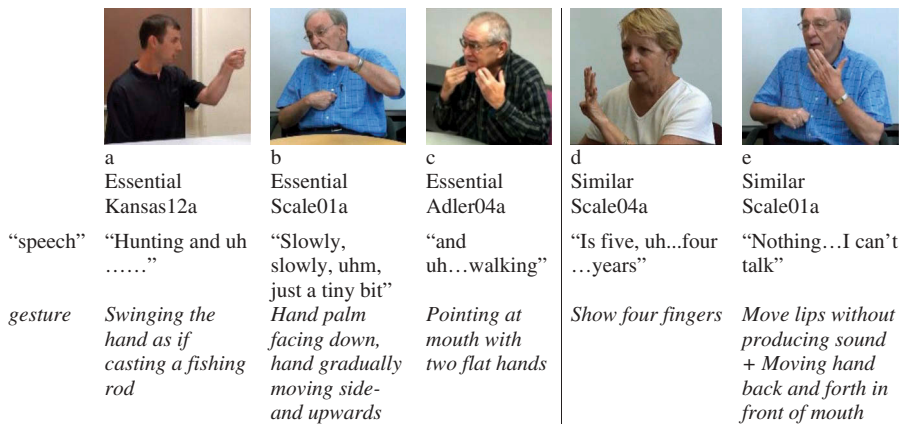


Figure 6. Examples of the different roles of Essential gestures, as compared with Similar gestures: a) Essential gesture provides information in absence of speech, b) Essential gesture that provides information missing in speech, c) Essential gesture clarifying speech, and two Similar gestures, d) Similar gesture, contradicting the first utterance in speech and reinforcing the second utterance (in this context, the gesture is Similar), e) Similar gesture provides information originally absent in speech.

gesture is no longer Essential, and was therefore coded as Similar (although arguably you could also say the speech was not essential). It illustrates that individuals often felt the need to convey information explicitly in speech, even though the information had already been conveyed in gesture.

- (2) *Provide information missing in speech.* Most Essential gestures seemed to be produced co-occurring with speech, not in moments of silence, and example 6b shows that these also replaced information missing in speech. Scale 01 produced the words: “Slowly, slowly, slowly, uhm ... just a tiny bit”, but seemed unable to produce the word “improvement”. His gesture (*Hand palm facing down, hand gradually moving side and upwards*) conveyed essentially this “gradual improvement” information.
- (3) *Help clarify or contradict speech.* Figure 6(c) illustrates that gestures helped clarify the meaning of speech when words were unintelligible. In this example, Adler04 produced the word “walking”, but his gesture (*pointing at his mouth*) clarified his speech in that he meant to say: “talking”. Similarly, gestures disambiguated the meaning of other semantic and phonological paraphasias or neologisms. Sometimes information in gesture clearly contradicted information in speech. This was almost exclusively seen for Number gestures as individuals sometimes produced numbers in gesture different from the numbers produced in speech. The correct interpretation of the gesture or speech in these cases could usually be determined based on PWA’s non-verbal communication. Similar to the idea we discussed that for gestures conveying information in the absence of speech, we often saw that individuals tried to produce the correct number in speech, even though the number was clearly conveyed by the gesture (Figure 6(d)). The example of Scale04 illustrates that while she produced the correct number in gesture (*show four fingers*), she also struggled to produce the correct number in speech (“Is five, uh ... four ... years”).

These analyses were discussed from the gesture's perspective. However, taking the other viewpoint, one could summarise that gesture can compensate for information unclear or missing in speech resulting from several language production difficulties: for example, word finding difficulties, semantic and phonological lexical selection mistakes, paraphasias, neologisms, and phonological and articulatory production errors.

Discussion

This study is one of the first to identify the amount of information conveyed in gesture in the communication of PWA and how different gesture types convey information absent in PWA's speech. Our major finding is that on average 22%, and for some up to 92% of the gestures produced by PWA, is Essential for understanding their message. This is more (in number and proportion) than for NBDP, for whom this Essential category of gesture occurred only rarely (5%). Concrete deictics, Emblems, and ICV gestures were often coded as Essential. Within the category of iconic gestures, a fifth of each representation technique, except for Path, conveyed Essential information. Handling and Enact gestures were most often coded as Essential. We were not able to identify specific patho-linguistic profiles of PWA who produced gestures communicatively. Nor did we find correlations between the number or proportion of Essential gestures produced and WAB-AQ or Information in speech scores. Despite the individual variability in aphasia, for the majority of PWA a substantial part of their gestures conveyed Essential information, more than observed for NBDP (in number and/or proportion). This reveals the importance of gesture in PWA's communication and stresses the need to pay attention to these gestures in order to understand fully what PWA want to convey in their communication. Finally, we observed that Essential gestures produced by PWA: (1) conveyed information in the absence of speech, (2) conveyed information missing in speech, or (3) helped clarify and at times contradicted errorful speech. Below we discuss the implications of these findings and the utility of the coding schemes used for analysing gestures produced by PWA.

Do gestures produced by PWA enhance their communication?

Our observation that gestures produced by PWA were more often Essential than gestures produced by NBDP is in line with the notion that gesture can compensate for information missing in speech (de Ruiter, 2000) and suggests that gesture can improve the communication of PWA (de Beer et al., *in press*; Herrmann et al., 1988; Hogrefe et al., 2013; Kong et al., 2015; Mol et al., 2013; Pritchard et al., 2015; Rose et al., 2017). It is interesting to note that our findings seem to be in contrast with earlier findings for NBDP. Gullberg (1998) reported that NBDP did not produce gesture compensatorily when facing language difficulties. We showed that for PWA gestures do convey information missing in speech (whether consciously or not). In PWA, the need to communicate and resolve communication difficulties may be greater than the urge or capacity to communicate verbally. Therefore, PWA, differently from, for instance, individuals who stutter or learn a second language (see Graziano & Gullberg, 2013; Mayberry & Jaques, 2000), use gesture communicatively. Interestingly, we also observed that PWA who already had conveyed information in gesture, sometimes tried to (and sometimes

successfully) produce the same information in speech as well. This illustrates that for PWA, speech remained the preferred method of communication. Only when speech was not possible, because individuals were unable to resolve their language difficulties, was gesture solely relied upon. It would be interesting to examine in more detail whether the communicative use of gestures is similar for PWA who had a recent stroke and individuals with chronic aphasia. It is possible that PWA with a recent stroke struggle to shift their communication style from communicating in speech to communicating in different modalities.

It should be pointed out that for determining whether gestures were essential, coders took both speech and gesture into account. Kong, Law, Kwan, Lai, and Lam (2015) have argued that the information in gesture and speech should be coded separately. In our study, we chose not to do this. Mol et al. (2013) have shown that the combination of speech and gesture is particularly informative. We also saw this in the present study as, for instance, gesture could disambiguate the meaning of incomprehensible speech. Also, speech could help interpret the meaning of a gesture (as in Figure 6c). By taking into account both speech and gesture, this study gives a complete view of the instances in which gestures are essential for interpreting PWA's communication.

Gesture type

Although gestures mainly conveyed information that was Similar to speech, we found that most meaning laden gestures including Concrete deictic, Emblem, and ICV gestures (Handling and Enact), but not IOV gestures, often conveyed information that was Essential for understanding PWA's message. Each of these gesture types conveys information that can be interpreted without accompanying speech. For Emblems, this is due to their conventionalisation, in that the meaning of Emblems is determined within specific communities (McNeill, 2000). For Concrete deictic and ICV gestures (Handling and Enact), this can be established via an iconic mapping between form and meaning (Müller, 1998; Perniss et al., 2010), which interlocutors can rely upon to identify meaning. For Concrete deictic gestures, this mapping is done for the location of the gesture and its meaning: *pointing at a leg* or *pointing at self*. For ICV gestures, the depicted action is similar to the real action one would perform: *pretending to dance* or *pretending to brush one's hair* (Hostetter & Alibali, 2008). It is important to note that IOV gestures (Object, Shape, and Path) are also meaning laden gestures and that one could also make iconic mappings between form and meaning (for instance, *drawing the shape of a house* or *showing a fist with stretched index and middle finger to represent scissors*). However, our findings showed that these were less often Essential for understanding PWA's communication. Possibly, this is because the meaning of these latter gestures was more difficult to interpret than for the ICV gestures, something we have observed in a different study for the use of pantomime, gestures produced in the absence of speech (van Nispen et al., 2016).

Individuals who produced many essential gestures

There was great individual variation in how often PWA's gestures were Essential, but for the majority this was well above the range observed for NBDP. Differently from Kong et al. (2015), we did not find correlations between WAB-AQ and the information conveyed in gesture. Furthermore, we did not find correlations between Information in

Speech and the use of Essential gestures. In our profiling of individuals for whom a substantial part of their gestures was Essential, we were not able to identify discriminant patho-linguistic profiles of PWA using gesture communicatively. However, we observed very few low scores for Information in Speech. Therefore, it was not the case that individuals with little verbal output relied more heavily on gesture. On the contrary, we saw that individuals with a relatively high information in speech score (seven or higher) produced many Essential gestures. This may indicate that gesture is most useful in combination with speech. Speech can help to disambiguate the meaning of a gesture and vice versa.

Counter-intuitively, we did not observe that individuals with low WAB scores for Information in Speech produced many Essential gestures. There could be several explanations for this finding, but we assume that this mainly lies in the study set-up. First, because these PWA were not able to communicate a lot of information via speech, they had short interviews and used relatively few gestures. Second, and most importantly, the interviews were conducted following a strict protocol and the interviewer was not allowed to ask questions to further clarify the meaning of PWA's communication. As described by Goodwin (1995) and Goodwin & McNeill (2000), the latter is very important for identifying the meaning of a gesture, particularly in the absence of further spoken context. An interlocutor needs to actively participate in communication to come to understand the meaning of a gesture. In a setting with more interaction between PWA and an interlocutor, PWA with little information in speech could possibly more successfully convey information in gesture. Third, it could also be that PWA with higher WAB scores for Information in Speech benefitted from the fact that they produced more speech. As gestures naturally co-occur with speech (McNeill, 2000) these individuals also produced more gestures. At times these gestures might have compensated for information missing in speech by default. Last, it should be noted that in our data set, there was a relatively large number of individuals with a WAB Information score of 7 or 8 out of 10 (25 out of 46) and few with a score of 4 or lower (4 out of 45). Possibly, this is a bias in our data set, and more research is needed to identify the communicative role of gesture in PWA who differ in their abilities to convey information in speech.

Finally, it should be pointed out that our attempts to determine patho-linguistic profiles of PWA using gestures communicatively were restricted by the information available on AphasiaBank. Therefore, several factors that might play a role in PWA's use of gestures could not be taken into account in the present study. For future research, it would be interesting to see how levels of apraxia relate to the communicative use of gestures by PWA, as there is discussion on whether or not apraxia affects the use of spontaneous gestures (Hogrefe et al., 2012; Rose & Douglas, 2003) and the informativeness of gestures (Hogrefe et al., 2013; Mol et al., 2013). Furthermore, future research could also look at how semantic processing relates to the communicativeness of PWA's gestures, as previous studies have shown that it impacts on the type of gestures produced by PWA (Cocks et al., 2013; Hogrefe et al., 2012, 2013; van Nispen et al., 2016).

Communicative role of essential gestures

Essential gestures were used by PWA, but hardly at all by NBDP. This prompted us to further analyse their role in communication. We observed that these gestures: (1) convey

information in the absence of speech, (2) convey information missing in speech, and (3) clarify or contradict information in speech. As such, gesture can compensate for all kinds of language production difficulties: word finding difficulties, semantic or phonological paraphasias or neologisms, etc. Importantly, Essential gestures did not necessarily occur in moments of silence, but often accompanied speech.

Our study gives rise to a more theoretical question on whether (1) the Essential gestures produced by PWA were intended as such and (2) perhaps clinically more relevant, to what degree PWA have the same abilities as NBDP to produce information in gesture if needed. Based on the method used in the present study, we cannot make any claims on the communicative intent of the gestures we observed. The Essential gestures could be the result of various but not mutually exclusive underlying processes: (a) These gestures were produced spontaneously alongside speech, similarly to gesture production in healthy speakers (Kita & Özyürek, 2003; McNeill, 2000). Because of the language impairment in PWA information in speech was missing and the information in gesture “became” Essential; (b) Gesture and speech are part of one communication process and information that could not be produced in speech was automatically and unconsciously produced in gesture instead (de Ruiter, 2000); (c) Gestures were produced in order to facilitate speech production and their communicativeness was a useful “side effect” (Krauss, Chen, & Gottesman, 2000); (d) PWA made an explicit attempt to convey information in gesture. This balance between speech and gesture production in PWA is further complicated by the notion that each of these processes can also be impaired in PWA, which may affect their ability to convey information in gesture (Cicone et al., 1979; Cocks et al., 2013; Hogrefe et al., 2013; Mol et al., 2013; Rose, Douglas, & Matyas, 2002; Rose et al., 2013; van Nispen et al., 2014). This argument is beyond the scope of the present study and we refer to de Ruiter and de Beer (2013) for a more elaborate description of the relation of gesture and speech in aphasia.

Coding schemes

Rather than developing new tools to analyse the gestures produced by PWA, we used coding schemes that were readily available and we explored whether these were useful for the assessment of gestures produced by PWA in spontaneous speech: (a) Iconic gestures and (b) communicativeness.

Iconic representation techniques

We found that Handling and Enact gestures (both ICV) were often Essential, but Object, Shape, and particularly Path (all IOV) were less so. We did not observe a difference in the use of iconic representation techniques between NBDP and PWA. This is partly in contrast with earlier literature suggesting that some PWA produce fewer gestures depicting actions but more often produce gestures depicting a shape (Mol et al., 2013, and co-speech gestures; Cocks et al., 2013; for gestures during word finding difficulties, van Nispen et al., 2016; for pantomime). These studies showed that limb apraxia and semantic processing can influence gesture use. A limitation of the present study is that we were not able to look into this, as AphasiaBank does not provide information on semantic processing and limb apraxia.

In this study, our differentiation of representation techniques showed limited benefits beyond the distinction between ICV and IOV gestures in PWA. Nevertheless, this differentiation into specific representation techniques can be insightful in different contexts, such as pantomime or gesture therapy.

Communicativeness

Our analysis of the information conveyed in gesture as compared to speech was based on the coding scheme developed by Colletta et al. (2009). Advantages of our coding scheme were that it enabled us to determine the communicativeness of a gesture in the absence of knowledge of the specific referent. Also, it proved useful for coding the impaired communication of PWA. The agreement between coders was substantial, but there was sometimes difficulty with overlap between codes. With clearer definitions of the various codes and a more detailed manual, it should be more easily and reliably applicable for coding gestures of PWA. We chose to collapse the six categories described by Colletta et al. (2009) into three categories: Similar, Additional, and Essential. For the present study, these collapsed categories gave clear insight in the communicative value of gestures for PWA. An advantage of the full Colletta et al. (2009) coding scheme is that it also differentiates into contradicting gestures, an interesting category as this type of gesture is a particular communicative role of gesture used by PWA, but rarely used by NBDP. For the present study, this category was collapsed, together with the complement and substitute categories, into the category Essential. For future research, it could be interesting to add this category to the coding scheme.

Clinical implications

Our finding that a fifth of gestures produced by PWA were Essential for understanding their communicative message in full has direct clinical implications. It stresses the need for communication partners to pay attention to the information conveyed in gesture. It is important that interlocutors, such as partners and family members and also speech language therapists do not ignore the gesture modality in communication assessments and interventions for aphasia. Successful communication is a responsibility shared between PWA and interlocutors (Simmons-Mackie, Raymer, Armstrong, Holland, & Cherney, 2010). Particularly when gestures are used, a great deal of responsibility lies with the interlocutor to identify the exact meaning of these gestures. Importantly, we observed that besides Handling and Enact gestures, the Object and Shape gestures that PWA may rely on in communication (Cocks et al., 2013; Mol et al., 2013) also convey Essential information. These Shape techniques in particular (*drawing the shape of a toothbrush*) might be more difficult to interpret than for instance Handling techniques (*pretending to use a toothbrush*). Consequently, interlocutors should be aware of this. They might need to put more effort into unravelling the meaning of these gestures. For instance, by asking questions ("Is it a square object?") and checking interpretations ("I think you are referring to a book, am I correct?") they could identify the meaning of these and other gestures. In this study, we evaluated spontaneous gesturing in an interview setting. Our results underline that it may be useful to encourage PWA to produce gestures. We observed that gestures can convey information in the absence of speech or missing in speech and they can clarify or contradict information in errorful

speech, and as such gestures can be a useful tool for PWA with impaired verbal communication.

Clinically, gesture is often seen as a last resort, a resource that needs to be used only in the rehabilitation of patients with very severe aphasia. In our study, the majority of PWA conveyed a great deal of Essential information in their gestures. Also, our profiling of individuals who produced many Essential gestures showed that these were, to a large extent, individuals who could convey reasonable amounts of information in speech. This suggests that gesture is not exclusively beneficial for PWA with limited verbal output, but could be useful for most PWA. Gesture might be particularly beneficial in an interplay between gesture and speech, in which the context of speech can help interpret gesture and vice versa. Importantly, an interlocutor has a great responsibility in identifying the meaning of gestures and co-constructing meaning. This is particularly important for communicating with individuals who convey little information in speech.

In the present study, Emblems, Concrete Deictic, and ICV gestures: Handling and Enact were often Essential. Therefore, in therapy, it may be most beneficial to specifically encourage the use of these techniques. Also, we saw an interesting category of Contradicting gestures that almost exclusively occurred for communicating about numbers. This indicated an interesting dissociation between conveying numbers in speech and gesture. For clinical practice, it could be useful to train PWA to depict numerical information in gesture. Although we know that gesture therapy can be beneficial (Caute et al., 2013; Daumüller & Goldenberg, 2010; Marshall et al., 2012; Rose et al., 2013), more research is needed to determine the effectiveness of encouraging the use gestures and whether it would be useful to encourage or train the use of these specific gesture types.

Finally, in our description of the different communicative roles of gestures, we observed that PWA often struggle to produce information in speech that they have already conveyed in gesture. Speech language therapists should make PWA aware of the information they convey in gesture. This could contribute to the flow of communication and it could reduce the struggles and frustrations in aphasic communication.

Conclusions

A great deal of the gestures produced by PWA is essential for understanding their communicative message. Despite large individual differences, this was true for the majority of our participants with aphasia. In this respect, they differ from NBDP who hardly ever produced Essential gestures. Concrete deictics, Emblems, and Iconic Viewpoint gestures were most often Essential. Within the group of iconic gesture, all except for Path gestures were frequently Essential. Essential gestures produced by PWA often occurred in an interplay with speech, in which they replaced missing information or disambiguated speech, and the remaining spoken context helped in interpreting the gesture.

Whereas in clinical practice gesture is often seen as a last resort for individuals with little verbal abilities, our findings suggest that it can be useful for most PWA, including PWA with substantial information in speech. For clinical practice, it is important that interlocutors pay attention to gestures produced by PWA and are informed about the

role of specific gesture types that are particularly informative and the type of information these can convey. This can improve the understanding of PWA's communication. Furthermore, PWA should be made aware of the information they convey in their gestures, as this may improve their communication flow. Future studies could look into whether enhancing the use of these gestures could further improve the communication abilities of PWA.

Note

1. Note that the aphasia types in the present study deviate slightly from the aphasia types as provided by AphasiaBank. For four individuals, Sekine, Rose, Foster, Attard, and Lanyon, (2013) recoded the aphasia type differently from the aphasia types provided in the database: For CMU02a, no aphasia type was available and instead the clinical impression provided by AphasiaBank, Broca, was used. For Thompson01a (originally Anomic), Thompson02a (originally Anomic), and Tucson13a (originally Wernicke), the impression from the video samples did not comply with the aphasia type reported in the database, usually because the WAB had been administered some time before the video recordings were made and participants aphasia type had changed over time. Instead, for Thompson01a (Conduction) and Thompson02a (Transcortical motor), they used the clinical impression provided in AphasiaBank and for Tucson13a (Broca), they used their clinical judgement established from viewing his entire video sample and after confirmation from his speech language pathologist about the suggested change. For the present study, we used the Sekine and Rose (2013) labelling of aphasia types.

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Appendix

Table A1 Gesture types (Sekine & Rose, 2013; Sekine et al., 2013).

Type	Description
Concrete deictic (CON)	Indicates a concrete referent in the physical environment, such as a picture book or an item of actual clothing.
Iconic character viewpoint (CVP)	Uses the speaker's own body in depicting a concrete action, event, or Object, as though he is the character/Object itself. For example, to depict someone running, he swings his arms back and forth, as if he is running.
Iconic observer viewpoint (IOV)	Depicts a concrete action, event, or Object as though the speaker is observing it from afar. For example, to depict someone running, the speaker traces her index finger in the frontal space from left to right as if she is seeing the scene as an observer.
Emblem (EMB)	Form and meaning are established by the conventions of specific communities and can usually be understood without speech, such as thumb and pointer finger making a circle Shape for OK.
Metaphoric (MET)	Presents an image of an abstract concept, such as knowledge or justice, language itself, the genre of the narrative, and so on. It often has a cup-Shaped hand Shape.
Number (NUM)	Uses the speaker's fingers to display numbers.
Pointing to self (POI)	The speaker points to his or her own body (mostly the chest) in order to refer to him- or herself.
Referential (REF)	Is used to assign the entity of referents, such as Objects, places, or characters in the story, into the space in front of a speaker where any concrete Object is absent. The hand Shape of the gesture usually takes the form of a pointing gesture or of holding some entity. Is used to assign the entity of referents, such as Objects, places, or characters in the story, into the space in front of a speaker where any concrete Object is absent. The hand Shape of the gesture usually takes the form of a pointing gesture or of holding some entity.
Time (TIM)	Indicates some space to denote a time, such as past (back of the body) or future (front of the body).
Beat ^a	Movements that do not present a discernible meaning and are recognised by their prototypical repetitive movement characteristics timed with speech production.
Letter ^a	Movements associated with writing letters in the air or on the desk or on one's thigh with an empty hand or fingers.
Pantomime ^a	Consists of two or more CVPT gestures, which occur continuously within the same gesture unit. No matter how many CVPT gestures occur continuously, they are counted as one pantomime.

^aThese gesture types were not further analysed in the present study.