AJSLP

Research Article

How Much Information Do People With Aphasia Convey via Gesture?

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Purpose: People with aphasia (PWA) face significant challenges in verbally expressing their communicative intentions. Different types of gestures are produced spontaneously by PWA, and a potentially compensatory function of these gestures has been discussed. The current study aimed to investigate how much information PWA communicate through 3 types of gesture and the communicative effectiveness of such gestures.
Method: Listeners without language impairment rated the information content of short video clips taken from PWA in conversation. Listeners were asked to rate communication within a speech-only condition and a gesture + speech condition.
Results: The results revealed that the participants' interpretations of the communicative intentions expressed in the clips of PWA were significantly more accurate in the gesture + speech condition for all tested gesture types.
Conclusion: It was concluded that all 3 gesture types under investigation contributed to the expression of semantic meaning communicated by PWA. Gestures are an important communicative means for PWA and should be regarded as such by their interlocutors. Gestures have been shown to enhance listeners' interpretation of PWA's overall communication.

Kendon (2004, p. 7) defines gestures as "visible action as it is used as an utterance or as part of an utterance." When expressed as part of an utterance, gesture can express semantic content related to the accompanying speech. Furthermore, gesture can be categorized into different subtypes (De Ruiter, 2000; Kendon, 2004; McNeill, 1992). According to Kendon, these subtypes can be conceptualized as existing on a continuum organized by three characteristics: (a) their relation to speech, (b) their degree of conventionalization, and (c) their linguistic properties. Kendon distinguishes the subtypes of sign languages, pantomimes, emblems, and gesticulations. McNeill (1992, 2005) formulated what he called *Kendon's continuum,* arranging these four subtypes according to their characteristics (these characteristics are specified in Table 1). On the basis of Kendon's approach, McNeill (1992) suggested a system of categorization that includes the following subtypes:

- *Iconic gestures* are idiosyncratic and depict certain characteristics of the referent by their shape (e.g., making a circle shape in the air to depict a round cake).
- *Deictic gestures* are pointing gestures that define a referent by being the object of the pointing action. Deictic gestures can refer to concrete or abstract entities and are often necessary to understand the accompanying speech (e.g., pointing to an object or pointing in a certain direction).
- *Metaphoric gestures* are similar to iconic gestures by being idiosyncratic in their production, but they differ from iconic gestures by referring to abstract concepts (e.g., referring to the concept of knowledge by forming a "container" with the hands).
- *Beats* are defined as rhythmic movements that do not express semantic meaning.

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Editor: Krista Wilkinson
Associate Editor: Daniel Kempler

Received March 27, 2015
Revision received September 14, 2015
Accepted March 15, 2016
https://doi.org/10.1044/2016_AJSLP-15-0027

Disclosure: The authors have declared that no competing interests existed at the time of publication.

Table 1. Overview of the classifications of gesture types.

Gesture types			Characteristics in relation to Kendon's Continuum (Kendon, 2004; McNeill, 1992, 2005)
Current study	**McNeill (1992)**	**Kendon (2004)**	
Referential gestures (Gullberg, 2006) Not investigated	Iconic gestures Deictic gestures Metaphoric gestures Beats	Gesticulations	• Only occur with spoken expression (speech accompanying) • Meaning is interpretable in close relation to speech • No linguistic properties • No conventions for their realization (idiosyncratic)
Pantomimes	Pantomimes	Pantomimes	• Occur mostly without speech • Can express interpretable meaning without speech (potentially speech replacing) • No linguistic properties • Not fully conventionalized (only some aspects of their execution follow conventions)
Emblems	Emblems	Emblems	• Occur with or without speech • Can express interpretable meaning without speech (potentially speech replacing) • Some linguistic properties (form–meaning–relation, rules of well formedness) • Culturally dependent conventions

Note. Descriptions of the characteristics are given according to Kendon's (2004) Continuum.

- *Pantomimes* refer to actions by demonstrations of complex motor movements or sequences of movements and depict potentially related objects (e.g., the imitation of opening a door with a key).
- *Emblems* are culturally dependent conventionalized hand movements that can be interpreted without the accompanying speech due to their conventionalized accordance of form and meaning (e.g., "thumbs up").

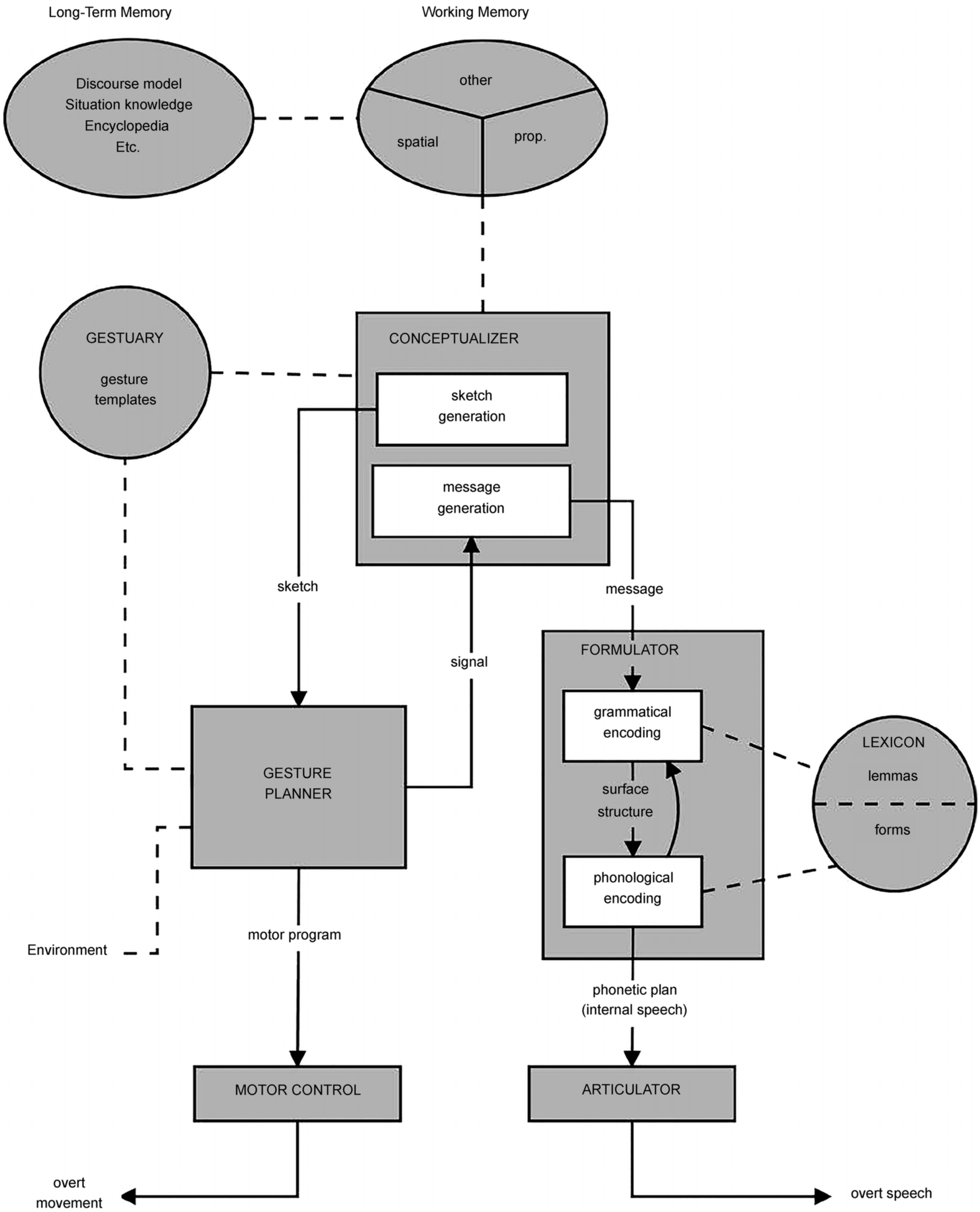
Building on this system of categorization, Gullberg (2006) suggests an additional category of *referential gestures* to describe gestures referring to the entity of referents (objects, places, and characters). See Table 1 for an overview of the systems of categorization of gesture types.

The role of gesture for the expression of semantic content has been the subject of a long-standing debate within gesture research. In particular, there has been debate concerning whether gesture augments and complements verbal output or whether the information expressed via gesture is redundant to speech. In an investigation of the semantic content of iconic gestures produced in conversation, Krauss, Dushay, Chen, and Rauscher (1995) found no evidence for a beneficial effect of visual information on the accuracy of listeners' interpretations. The authors concluded that iconic gestures do not add crucial information. Rather, it has been argued that iconic gestures convey information that is mostly redundant to speech—that is, iconic gestures are not highly informative for the listener (Krauss et al., 1995; Krauss, Morrel-Samuels, & Colasante, 1991).

In contrast, Bangerter (2004) found that in target identification tasks, participants often omitted spatial information about positions from their verbal descriptions. Instead, reference to such spatial information was communicated to the communication partners exclusively by the use of pointing gestures. In a similar manner, Melinger and Levelt (2004) found that speakers used iconic gestures to convey spatial information that was not conveyed within their verbal message. Moreover, in narrative tasks, Beattie and Shovelton (2011) found that part of the information expressed via gesture could not otherwise be inferred from the content of the verbal narrations or the context information in the stories. Taken together, these findings support the argument that gestures can add crucial semantic content and complement the spoken utterance.

The question of the function of gesture within communication has led to the investigation of the underlying processes of gesture production. Various theoretical models of production suggest that speech and gesture arise from a shared origin and evolve from the same communicative intention (De Ruiter, 2000; Kita & Özyürek, 2003; McNeill, 1992). In the Sketch Model (De Ruiter, 2000, see Figure 1), built upon Levelt's (1989) model of speech production, both speech and gesture are assumed to evolve from a shared communicative intention and both have a communicative function. Gesture and speech are therefore initiated by the same module, the conceptualizer, which has access to working memory. For the production of speech, the conceptualizer retrieves propositional information from working memory to generate a preverbal message. For the production of gesture, spatiotemporal information is accessed, and a sketch is generated. The sketch represents the information that is to be expressed in the gesture. The Sketch Model of gesture and speech production does not explicitly include speech perception within the model, although according to Levelt's model, the conceptualizer receives and processes verbal input. Speech and gesture are generated by the conceptualizer but then proceed to production via separate channels. These assumptions give rise

Figure 1. The Sketch Model of gesture and speech production (De Ruiter, 2000, p. 298), based on Levelt's (1989) blueprint for the speaker. Reprinted from "The Production of Gesture and Speech" (p. 298), by J. de Ruiter, 2000, in Language and Gesture (pp. 284–311), D. McNeill (Ed.). Cambridge, United Kingdom: Cambridge University Press. Copyright © 2000 Cambridge University Press. Reprinted with permission.



to a flexible and potentially compensatory trade-off relationship between gesture and speech (De Ruiter, 2006; but see De Ruiter, Bangerter, & Dings, 2012, for evidence against the trade-off hypothesis in nonimpaired speakers). Hence, information that cannot be expressed in the one modality can be transferred to the other modality. In summary, gestures evolve from the same communicative intention as speech and hold the potential to compensate if the informational content cannot readily be expressed verbally.

The Relationship Between Gesture and Speech in People With Aphasia

In the case of an impaired language system, as is the case for an individual with aphasia, some authors have suggested a parallel breakdown of both the gesture and verbal communication channels (e.g., Cicone, Wapner, Foldi, Zurif, & Gardner, 1979; Duffy & Duffy, 1981). According to this view, it is assumed that people with aphasia (PWA) make no effective use of gestures to compensate for their verbal disturbances and are therefore not able to effectively improve their communication by the use of gestures (Cicone et al., 1979).

However, in line with the core assumptions of the Sketch Model it is assumed that the communicative intention (and the processes involved in forming this communicative intention) remains intact (De Ruiter & De Beer, 2013) in individuals with aphasia. The two separate production processes assumed in the Sketch Model can account for differing performance capabilities in the two communication channels—that is, for a shift of information toward the gesture output modality. In this sense, a compensatory role of gesture for PWA would be expected (De Ruiter, 2006; De Ruiter & De Beer, 2013).

A number of studies have presented evidence to support the compensatory role of gesture for individuals with aphasia. Two longitudinal single-case studies showed that gesture use decreased with increasing language capacities and vice versa (Ahlsén, 1991; Béland & Ska, 1992). It has also been shown that some speakers with severe aphasia convey more information in gesture than in speech when retelling a story (Hogrefe, Ziegler, Wiesmayer, Weidinger, & Goldenberg, 2013; for an overview of further evidence, see Rose, 2006). In addition, evidence suggests that PWA make use of a broad range of different gesture types: Sekine and colleagues (Sekine & Rose, 2013; Sekine, Rose, Foster, Attard, & Lanyon, 2013) identified 12 different gesture categories (including the gesture categories defined by McNeill, 1992, and Gullberg, 2006, introduced above) that were spontaneously used by PWA. The frequency of the overall use of gestures as well as the use of specific gesture types varied in relation to aphasia type and severity (Carlomagno & Cristilli, 2006; Sekine & Rose, 2013; Sekine et al., 2013). Sekine et al. (2013) suggest the Dual-Factor Hypothesis to explain the different patterns of gesture use in PWA; they argue that the two determining factors are (a) the need of a PWA to use gesture in the transfer of meaning and (b) the capacity of a PWA to present and transmit the intended meaning to the gesture modality. The Dual-Factor Hypothesis therefore incorporates the core assumptions of the Sketch Model: first, that gesture and speech originate from the same communicative intention and, second, that the relationship between gesture and speech is adaptive and flexible. Therefore, compensatory use of the two communicative channels can be explained by (a) defining the underlying production processes with respect to the Sketch Model and (b) defining the underlying factors for a compensatory use of gestures in PWA with respect to the Dual-Factor Hypothesis.

Investigating the relationship of gesture and speech in PWA, Hogrefe, Ziegler, Weidinger, and Goldenberg (2012) identified neuropsychological disorders, namely nonverbal semantic processing and limb apraxia, as influencing factors on the production of gesture in persons with severe aphasia. They were able to demonstrate that a deficit in nonverbal semantic processing significantly correlated with poor performance on a measure of the diversity of produced gestures, whereas measures of language processing did not. In addition, the presence of limb apraxia in PWA had a negative influence on the comprehensibility of gestures. However, measures of language processing did not significantly correlate with the comprehensibility of gestures (Hogrefe et al., 2012).

Taken together, this evidence suggests that gesture production by PWA is related to impairment in the production of speech as well as to semantic processing and the presence of limb apraxia. There is controversy in the literature concerning the relationship between gesture and speech in PWA: Whereas some studies lend empirical support for a parallel breakdown of both modalities, other studies support a trade-off relationship, with gesture compensating for reduced verbal abilities.

The Communicative Role of Gestures in PWA

Some studies supporting a trade-off relationship of gesture and speech illustrate the communicative role of gestures in PWA, and this is probably most clearly seen in the communication of people with severe aphasia. In a series of single-case studies, Goodwin (2000, 2006) investigated the compensatory role of gesture production for an individual who presented with severely impaired spoken output (restricted to *yes, no,* and *and*), whereas comprehension was relatively intact in familiar contexts and situations. Goodwin demonstrated that this PWA, who integrated gesture and speech into the interaction with his interlocutors, was able to express complex ideas and ultimately achieve communicative success. The communicative use of gestures in the presence of a severe language impairment has also been examined in group studies. For example, Herrmann, Reichle, Lucius-Hoene, Wallesch, and Johannsen-Horbach (1988) found that people with severe aphasia produced more gestures that could be interpreted without the accompanying speech compared with control participants. Furthermore, the work of Hogrefe et al. (2012) showed that PWA with very severe production deficits used comprehensible gestures. The findings suggest that the comprehensibility of gestures produced by PWA is not affected by aphasia severity. In fact, neither comprehensibility nor diversity of gestures was related to aphasia severity. The compensatory role of gestures within aphasia is further supported by a single-case study that found that specific gesture types (speech-accompanying vs. speech-replacing gestures) influence the expression of meaning. The effects differed depending on the communicative situation—that is, the gesture types were used with varying frequencies in a story narration versus an object description task (van Nispen, van de Sandt-Koendermann, Mol, & Krahmer, 2014).

Aiming to overcome the lack of clarity regarding researchers' opinions about the communicative role of gesture and the relationship between gesture and speech in PWA, investigation of listener interpretations has been a commonly applied paradigm. For example, Hogrefe et al. (2013) set up two experimental conditions to compare the comprehensibility of gestures and verbal messages. The participants were diagnosed with different types of aphasia, with aphasia severity ranging from severe to mild. The participants with aphasia were asked to convey a cartoon story first in a verbal condition (in which gesture production was neither encouraged nor discouraged) and second in a nonverbal condition using gesture only. Data were extracted from the two conditions to form three different presentation modes: audio from the verbal condition, gesture from the verbal condition, and gesture from the nonverbal condition (a combined condition of gesture + speech was not investigated). The comprehensibility of the narratives in the three presentation modes was rated by independent judges. In the verbal condition, a comparison of audio versus video presentation indicated that listeners were more accurate in message interpretation in the audio presentation for eight of 16 PWA. For two of 16 PWA, gesture was found to be more informative. In comparing the gestures from the nonverbal and the verbal conditions, the judges' interpretations were significantly more accurate in the nonverbal condition for half of the PWA in the study. These findings suggest first that speech was generally more informative than gesture in the verbal condition and second that PWA were able to significantly augment the comprehensibility of their gestural production if they were explicitly asked to rely only on gestures. The authors argue that most PWA did not spontaneously make use of their full gestural potential to enrich communication, but they could when explicitly asked to solely express the content via gestures (Hogrefe et al., 2013).

Using a similar paradigm, Rose, Mok, and Sekine (2017) investigated the effectiveness and comprehensibility of pantomime gestures produced by PWA in samples of conversational discourse. Eleven PWA were included in the study with varying degrees of aphasia severity (Western Aphasia Battery–Revised Aphasia Quotient [WAB-R AQ] range from 17 to 89.5; Kertesz, 2007). The 11 PWA presented with different types of aphasia (Broca's $n = 3$, conduction $n = 6$, transcortical motor $n = 1$, anomic $n = 1$). Three versions of each videotaped spontaneous speech sample were created: video + audio (gesture + speech, the original video), audio (speech only, only the audio file of the original video), and video (gesture only, only the video version of the original video without sound). As all three versions of the video clips were extracted from spontaneous speech samples, this study did not utilize a condition in which gesture was used in a speech-replacing manner, as was the case in the study by Hogrefe et al. (2013). Sixty-seven listeners rated the information they could detect from the presented clips by first answering open-ended questions and then multiple-choice questions in written form. Listeners were most accurate in recognizing information in the gesture + speech condition. A significant negative correlation was detected between the accuracy of judges' reactions in the gesture-only condition and the WAB-R score for fluency of spontaneous speech. This indicates that the PWA with more severe impairment of their spoken output produced more gestures that enabled the participants to interpret the meaning of the gestures even when speech was missing.

In summary, evidence suggests that the production processes of gesture and speech enable speakers to express semantic content via gesture and therefore to compensate for verbal disturbances by the use of gestures (De Ruiter, 2000, 2006). Gestures can provide additional information beyond that expressed in the accompanying speech (e.g., Beattie & Shovelton, 2011). PWA have been observed to use gestures to compensate for their verbal impairment (Herrmann et al., 1988) and to spontaneously use a wide range of various gesture types (Sekine & Rose, 2013). PWA can use gestures to convey comprehensible semantic content (Hogrefe et al., 2013), and the production of pantomime gestures can increase comprehensibility of the speech produced by PWA (Rose et al., 2017). It remains unclear if other gesture types also complement the accompanying speech by adding crucial information in a group of PWA with a predominant production deficit of varying severity.

Study Aim and Hypotheses

We focused on the role of gestures for individuals with aphasia who present with a primary production deficit (i.e., relatively preserved comprehension and semantic processing). We hypothesized that the nature of a production deficit creates opportunities and a communicative need for the individual to produce gesture within spontaneous speech.

Given the continuum of the relationship between specific gesture types and accompanying speech, conventionalization, and linguistic properties, the current study aimed to investigate the differential effect of various gesture types on the comprehensibility of utterances by PWA by using a listener experiment. We aimed to confirm prior findings supporting the communicative role of gesture for PWA in spontaneous conversation. We focused on gestures produced within spontaneous conversation in order to ensure validity of the findings. It is crucial to account for the natural communicative behavior of PWA by examining the impact on communicative effectiveness of a variety of gesture types that PWA use spontaneously.

We selected referential gestures, emblems, and pantomimes in order to capture varying potential for the expression of semantic content in the spontaneous speech of participants with aphasia. This potential was assumed to be lower for referential gestures compared with the potentially speech-replacing categories of pantomimes and emblems because referential gestures are by definition only interpretable in tight coordination with the accompanying speech. For these three gesture types, the study aimed to answer the following 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?

We hypothesized that (1) listeners with access to both gesture and speech would be more accurate in judging messages communicated by PWA compared with listeners who only have access to speech, and (2) the expected improvement of accuracy will be true for emblems and pantomimes but not referential gestures.

Method

Participants

Participants With Aphasia

Ten participants with aphasia were chosen from the AphasiaBank database, an online database with a collection of data contributed by participants with aphasia and available for research purposes by researchers who are registered with the database (http://www.talkbank.org/AphasiaBank). The AphasiaBank includes a comprehensive data set for each participant, including demographic information; relevant medical details; video data; and assessment results, such as from the WAB-R AQ (Kertesz, 2007), the short form version of the Boston Naming Test–Second Edition (Kaplan, Goodglass, & Weintraub, 2001), the Verb Naming Test (Cho-Reyes & Thompson, 2012), and the AphasiaBank Repetition Test (TalkBank, http://talkbank.org/).

Inclusion criteria for the current study consisted of a history of a left hemisphere stroke with a presentation of a primary production deficit (and relatively preserved receptive processing) as evidenced by performance on the WAB-R (Kertesz, 2007)—that is, at least a score of 6 (maximum 10) on the Auditory Verbal Comprehension task (this score is a transformed score, which is based on the scores for three different comprehension tasks: yes/no questions, auditory word recognition, and sequential commands). In addition, we defined a minimum score of at least 40 (maximum 60) on the Auditory Word Recognition task (accounting for relatively well-preserved semantic processing). Participants with aphasia were deemed not to be eligible for inclusion if they presented with (a) a severe receptive or semantic processing deficit because the compensatory role of gesture production was assumed to be less clear for those individuals with moderate-to-severe semantic impairment or severe deficits of speech perception or (b) a history of depression because depression has been shown to influence functional communication in PWA (Fucetola et al., 2006).

We included 10 PWA who met the eligibility criteria. Interparticipant variability existed for aphasia severity and type (Broca's aphasia $n = 5$, conduction aphasia $n = 3$, Wernicke's aphasia $n = 2$). For the group, performance on the WAB-R ranged from 49 to 88 (maximum 100). This range of linguistic ability and impairment enabled investigation of gesture production and its effect on communication across individuals with various aphasic types and severities. Demographic and medical data, WAB-R scores, and types of aphasia for the participants with aphasia are presented in Table 2.

Student Participants

Sixty university students were recruited to participate in the study as naive judges, all of whom had English as their first language. All participants were enrolled for an undergraduate degree in health sciences (speech pathology or occupational therapy) at La Trobe University in Melbourne, Australia. Participants' ages ranged from 19 to 42 years ($M = 22.72$, $SD = 4.01$), and 56 female and four male students participated in the study. The student participants were blinded to the hypotheses of the study. The student participants were familiar with theoretical knowledge about aphasia, but experience of communicating with PWA was not required for participation. All participants received a $25 voucher for their participation. The project was approved by the University Human Ethics Committee of La Trobe University.

Stimuli

Operational Definitions of Referential Gestures, Emblems, and Pantomimes

The specific gestures (referential gestures, pantomimes, and emblems) were selected on the basis of their communicative potential. As discussed earlier in this article, emblems and pantomimes can replace speech; therefore, it was assumed that these gesture types might hold a higher potential to complement verbal speech. The third category of referential gestures might be more difficult to interpret for listeners and therefore less likely to add crucial information to the verbal message. Although comparable to Kendon's (2004) gesticulations category, we chose to specifically focus on referential gestures in order to eliminate from the analysis those gestures unlikely to hold semantic content (such as beat gestures within the gesticulation category). The operational definition of referential gestures used within the current study included McNeill's (1992) definitions of iconic gestures and deictic gestures as well as metaphoric gestures.

Selection of Stimuli Clips

For each participant with aphasia, video clips were sourced from AphasiaBank. We used the spontaneous speech samples of the AphasiaBank protocol in which PWA were asked to (a) tell their stroke story and about coping with their stroke and (b) explain an important event in their life. Gestures in the clips were coded and classified as either referential, emblem, or pantomime by the first author using the EUDICO Linguistic Annotator (ELAN version 4.3.1, https://tla.mpi.nl/tools/tla-tools/elan/). For each of the PWA, one clip was chosen per gesture type (i.e.,

Table 2. Demographic and clinical data of participants with aphasia.

Subject	Gender	Age	Aphasia duration (years)	Etiology	Aphasia type (WAB-R)	WAB-R AQ score	WAB-R AVC score	WAB-R AWR score
1	F	56.2	7.90	stroke	Conduction	80.1	9.35	60
2	M	57.4	3.50	stroke	Wernicke's	74.4	6.30	58
3	F	76.3	4.70	stroke	Wernicke's	65.7	6.05	53
4	M	50.4	1.30	stroke	Conduction	49.0	8.30	55
5	M	70.3	9.10	stroke	Conduction	70.1	9.05	57
6	M	41.9	6.25	stroke	Broca's	70.1	8.65	57
7	M	57.2	7.90	stroke	Broca's	63.9	7.95	49
8	M	37.8	1.00	stroke	Broca's	54.7	6.65	43
9	M	54.9	9.10	stroke	Broca's	72.2	9.00	59
10	F	52.7	4.75	stroke	Broca's	69.4	9.10	58

Note. WAB-R = Western Aphasia Battery–Revised; AQ = aphasia quotient; AVC = auditory verbal comprehension; AWR = auditory word recognition.

referential gesture, pantomime, and emblem), resulting in a total of 30 clips (for examples, see the transcripts of one clip per gesture type below). The criteria for the selection of the clips were as follows: (1) The message in the clip had to be interpretable without knowing the context of the whole interview; (2) the gesture in the clip had to be classifiable as one of the gesture categories under investigation; and (3) if there were several options meeting Criteria 1 and 2, the first gesture produced within the sample was selected for inclusion as stimuli within the current study. It should be noted that in most cases, there was only one stimulus clip per gesture type that met Criteria 1 and 2. These criteria for selection of stimuli ensured that both speech-replacing gestures and non-speech-replacing gestures were included in the study, thus reflecting the range from redundant to speech-complementary gestures. It is worth noting that none of the target gestures in the category of referential gestures was classified as a metaphoric gesture. Metaphoric gestures by definition refer to abstract concepts, whereas we aimed to incorporate clearly interpretable and concrete content in the stimuli.

One anomaly was noted: Subject 2, one of the PWA, did not produce any pantomime gestures. To ensure an equal number of each of the three gesture types, two different clips with pantomime gestures were chosen from Subject 4.

The duration of each clip varied between 2 and 10 s, depending on the complexity and length of the message being communicated. In order to investigate how speech-accompanying gestures complement the expression of meaning in speech, the study was designed to include a combined (gesture + speech) condition to enable comparison with an audio (speech-only) condition. Therefore, from each video clip, a corresponding audio clip was edited by using the software XMedia Recode (Dörfler, 2016).

Examples of Stimuli

Transcript of Clip 1 (Referential Gesture; see Figure 2)

Spoken output: *and I uh* / (1.4)

Gesture: Arm is raised in front of the chest.

Spoken output: [*lay*] *down*

Gesture: Arm is lowered into horizontal position, and hand is flattened.

Spoken output: *an* [*back*]

Gesture: Arm is turned up into vertical position, and hand stays flattened.

Transcript of Clip 20 (Pantomime; see Figure 3)

Spoken output: *and one le uh left*

Gesture: Left hand is in front of the body, palm turned upward (preparation).

[/1.5/]

Gesture: Left hand and arm at chest height, hand is oriented downward, circular movement above the table, imitates sprinkling something on top of a round object (target gesture).

Spoken output: [*and decorate*] *cakes an*

Transcript of Clip 2 (Emblem; see Figure 4)

Spoken output: *talking* [*zip*]

Gesture: Right hand is placed next to the participant's right mouth corner, pincer grip, hand surrounds the mouth counterclockwise.

Key for Symbols Used in the Examples Above

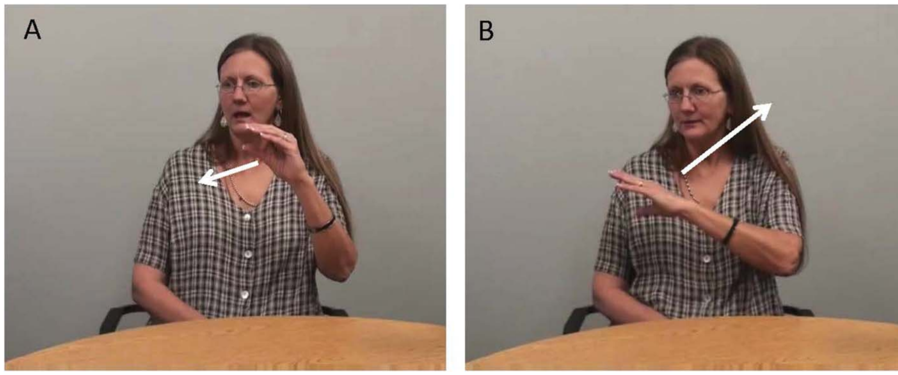
/ silent pause (duration in seconds reported in brackets)

[ ] stroke of gestures (indicates when the execution of the core part of the gesture occurred in relation to spoken output)

Gesture Coding and Reliability

The gestures in the clips had already been coded by the first author of the article prior to the selection of stimuli clips (see above). The third author of the article, who was familiar with coding and classification of gestures, also coded and classified all gestures in the 30 clips independently and blind to the first author's classification to ensure the reliability of the gesture categorization. Point-to-point inter-rater agreement regarding gesture classification was 83.3%. Cohen's kappa was used to test the inter-rater

Figure 2. Illustration of the referential gesture (Clip 1). (A) Starting point of the gesture (the arrow represents the trajectory of the movement. (B) Position of the arm and hand after succession of the movement (the arrow represents the trajectory of the movement).



reliability (κ = .75). Any disagreements were resolved through discussion and a consensus reached.

Response Booklets

Response booklets were used to record the student participants' interpretation of each video and audio clip. The student participants were presented with the response booklets, which included one open question (OQ) and one multiple-choice question (MCQ) per clip. For each video clip (gesture + speech information), a target message was defined by the first and last author and agreed upon. The target message was designed to depict the combined information of gesture and speech and was used for both the MCQ and the OQ. An alternative message was designed that was solely based on the information conveyed via speech in the clips (the speech-only message) on the basis of the formulation by one researcher being exposed to the audio content only for the relevant clip. Thus, each clip was paired with a possible communicative message that was based on gesture + speech (audio + video) and a possible message that was based on speech only (audio only). For each clip, another two distractor messages were designed in order to distinguish between the information uptake of the participants that was based on either the speech-only or gesture + speech information. The two messages and the two distractors resulted in the four options for the MCQ:

1. The target message or gesture + speech message (G + S message)
2. A distractor that was semantically related to the gesture and speech information (G + S distractor)
3. The message that was solely based on the information contained in the speech (SO message)
4. A distractor that was semantically and phonologically related to the SO message—that is, to the speech (SO distractor)

The four different response options were defined for all clips; even when gesture and speech were nearly redundant, there was always at least one distinctive feature inferable from the clips and referred to in the messages and distractors. All messages and distractors were reviewed

Figure 3. Illustration of the pantomime performed in Clip 20 (the arrow represents the trajectory of the movement).

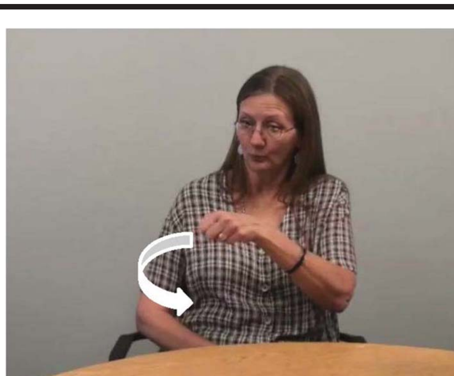


Figure 4. Illustration of the emblem performed in Clip 2 (the arrows represent the trajectory of the movement).

by two other authors and modified until consensus was reached.

The response booklets contained the same OQ for all clips: "Please write down the message you think the person is trying to communicate." The OQ was presented before the MCQ to avoid influencing the participants' answers to the OQ. For the MCQ, the participants were presented with the four prepared options and asked to select the response they thought best matched the message in the presented clip. The order of the four choices was randomized.

Procedure

Student participants viewed the video clips within a group data session. Ten data collection sessions were held to maximize student participation in the study. Attendance at a session was restricted to once only, and each session lasted for 45 min. Student participants were informed that each person in the clips was diagnosed with aphasia. They were informed that the aim of the study was to find out about the communicative effectiveness of PWA. Gesture was not mentioned in any of the instructions or the written forms.

The student participants were asked to listen to 15 audio clips and watch 15 video clips. Each clip was presented twice before the student participants replied to the questions in the response booklet. After viewing a clip, the student participants were asked to first answer the OQ; they were then prompted by the researcher to proceed to the MCQ. The response time was 25 s per question, and all answers were recorded in written form. For the OQ, participants were asked to write down the intended message they thought the PWA attempted to communicate; they were explicitly instructed not to write down verbatim what the PWA had said. They were instructed only to proceed to the MCQ after completing their answer to the OQ and not to adjust their responses after checking the MCQ options. Adherence to these instructions was monitored throughout each session by the attending researcher (the first author). The semantic content of each clip was considered in the order of presentation of the clips; for example, two clips related to the topic *hospital* were not played in a row. To avoid familiarity with the speaker with aphasia, the order of presentation was such that the same PWA did not appear in two clips in a row. The order of the clips was fixed across sessions to control for these potential confounding variables.

The student participants were randomly assigned to Group 1 or Group 2. Group 1 was exposed to the speech-only versions of Clips 1–15 and the gesture + speech versions of Clips 16–30. Group 2 first listened to the speech-only files of Clips 16–30 and watched the gesture + speech versions of Clips 1–15. Both groups started in the SO condition and proceeded to the G + S condition to avoid different effects of order of condition between the two groups. In each condition, the student participants were initially presented with a sample item to familiarize them with the material and the task. Participants were encouraged to ask questions about the task in case of uncertainty on completion of the sample items. These samples items were not subsequently used in the experiment.

Data Analysis

Scoring of Participants' Responses

Responses to the MCQs were scored as follows:

- Three points awarded for selection of the G + S message (target response)
- Two points awarded for the G + S distractor
- One point for the SO message
- Zero points for the SO distractor

Hence, scoring was weighted to award more points for the options related to the combined G + S information and fewer points for the options related to the SO information. Because the G + S message was the target message, the G + S distractor was the closest to the target message (i.e., to the full semantic content conveyed by the PWA) and therefore scored higher than the SO message. The messages (G + S message and SO message) were scored higher than their respective distractors.

For the OQ, semantic components were defined for each target message. The first, second, and last authors subsequently rated the semantic components of the 30 target messages prior to the administration of the task to the student participants. Features that were identified by at least two of the three raters were defined as the target features for each message. See Table 3 for examples of the MCQ options and the semantic features of the target message defined for Clip 1 (see the transcript for Clip 1 above).

Because the complexity of the target message differed between the clips, with the number of semantic components ranging from two to six, the scoring procedures for the student participants' responses to the OQ were as follows:

- Two points were awarded for each correctly detected semantic target feature.
- One point was awarded for each detected feature that was semantically related to the target feature.

Table 3. Overview of the target message, multiple-choice question options, and semantic features for Clip 1.

Message, distractors, and semantic features	Example
Target message	*I lay down and got up again.*
G + S distractor	*I went to sleep and got up again.*
SO message	*I lay down on my back.*
SO distractor	*I lay down after I came back.*
Semantic features	(a) Lying down (b) Getting up

Note. G + S = gesture + speech; SO = speech only.

This resulted in a raw score per OQ. This scoring scheme was adapted from one utilized by Rose et al. (2017) and is fully explained in this section of the current article. The raw scores from the OQ and MCQ resulted in a total score per question. All raw scores were converted to a percentage score to allow comparison of the scores across target messages and type of question. One item (Clip 4) had to be removed from the analysis for both conditions because the student participants' performance was influenced by the poor sound quality of the clip. The gesture in this clip had been coded as an emblem. Most participants did not react to the questions of Clip 4 when they were presented with this clip in the SO condition, which was not the case for any other clip. The majority of no responses to this item suggested poor sound quality and justified removing this item from analysis. Statistical analyses were performed on the remaining 29 clips (referential gestures $n = 10$, pantomimes $n = 10$, emblems $n = 9$).

Statistical Analysis

A Shapiro–Wilk test indicated that the data were not normally distributed. Therefore, the nonparametric Wilcoxon signed-ranks test (two-tailed) for related samples was used to investigate (a) possible differences between conditions regarding the accuracy of participants' message comprehension (percentage scores) and (b) the frequency of participants' MCQ choices to test the sensitivity of the constructed messages and distractors and the reliability of the research method. Spearman's rho was used to examine the relationships between the accuracy of the participants' message comprehension and the severity of aphasia as well as the fluency of PWA.

Results

G + S Condition Versus SO Condition

Descriptive data are given in Table 4. For all gesture types across both tasks, the mean percentage of the total scores was higher in the G + S condition compared with the SO condition; this difference was statistically significant ($Z = -6.729$, $p = .00$). With regard to the two types of questions, there were differences between the two conditions in the mean percentages correct for the OQ scores and the MCQ. The differences reached statistical significance for both the OQ scores ($Z = -6.714$, $p = .00$) and for the MCQ scores ($Z = -6.579$, $p = .00$; see Figure 5). We subsequently analyzed each of the three different gesture types.

Pantomimes

In the OQ task, student participants scored higher in the G + S condition compared with the SO condition. Similarly, for the MCQ task, the scores in the G + S condition were higher than the scores in the SO condition. The total scores (OQ + MCQ) were higher in the G + S condition compared with the SO condition. The differences between conditions reached statistical significance for the OQ ($Z = -5.620$, $p = .00$), the MCQ ($Z = -5.888$, $p = .00$), and the total scores ($Z = -6.294$, $p = .00$; see Figure 5).

Emblems

For the category of emblems, participants' scores were higher in the G + S condition for the OQ compared with the SO condition. For the MCQ, participants scored higher in the G + S condition compared with the SO condition. The percentages of the total scores were higher in the G + S condition than in the SO condition. These differences were statistically significant for the OQ ($Z = -6.041$, $p = .00$), the MCQ ($Z = -4.620$, $p = .00$), and the total scores ($Z = -6.059$, $p = .00$; see Figure 5).

Referential Gestures

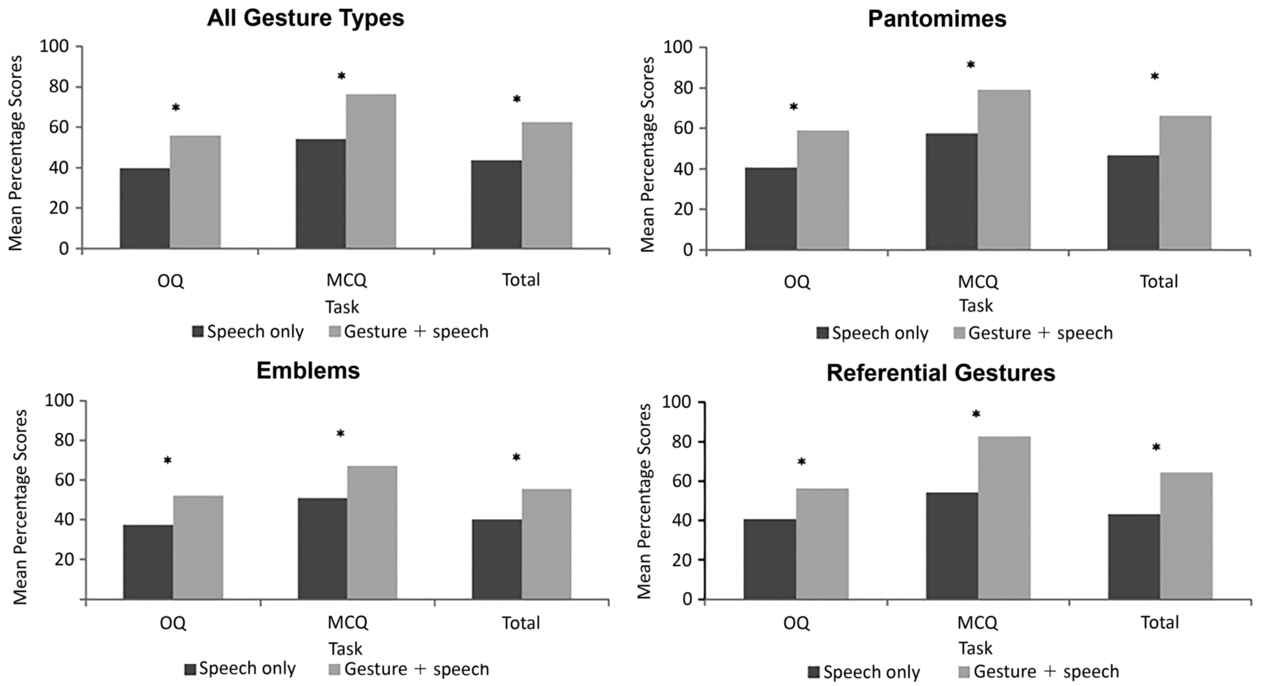
For the OQ, the scores that participants were awarded for their responses in the G + S condition were higher than the scores in the SO condition. Similarly, scores of the MCQ were higher in the G + S condition compared with

Table 4. Descriptive data for the percentage scores for the three different tasks and the different gesture types.

Gesture and condition	Total score			OQ score			MCQ score		
	M	*SD*	Median	*M*	*SD*	Median	*M*	*SD*	Median
All gesture types									
SO	43.55	5.24	42.25	39.48	6.47	38.46	54.04	8.94	53.33
G + S	62.51	6.02	63.12	55.76	6.30	55.89	76.28	7.99	76.67
Pantomimes									
SO	46.47	8.88	46.34	40.45	9.94	38.46	57.22	14.33	53.33
G + S	65.96	9.58	66.04	58.88	12.60	59.21	79.00	14.15	76.67
Emblems									
SO	40.22	9.01	40.70	37.19	10.32	36.38	50.67	15.43	50.00
G + S	55.41	9.65	57.14	52.01	8.83	53.57	67.06	16.16	66.67
Referential gestures									
SO	43.26	9.11	40.43	40.81	11.48	37.80	54.22	17.85	53.33
G + S	64.25	10.56	65.43	56.40	12.44	59.36	82.78	13.24	86.67

Note. OQ = open question; MCQ = multiple-choice question; SO = speech-only condition; G + S = gesture + speech condition.

Figure 5. Mean percentages of scores in the three different measures across conditions for (a) all gesture types (top left), (b) pantomimes (top right), (c) emblems (bottom left), (d) referential gestures (bottom right). Significant difference is indicated by asterisks (*$p < .05$). OQ = open question; MCQ = multiple-choice question.



the SO condition. The total scores in the G + S condition were higher than in the SO condition. These differences were statistically significant for OQ ($Z = -5.257$, $p = .00$), MCQ ($Z = -6.061$, $p = .00$), and the total scores ($Z = -6.316$, $p = .00$; see Figure 5).

In summary, the student participants' responses to the messages being communicated by the PWA were significantly more accurate in the G + S condition compared with the SO condition. These effects were true for all gesture types, for both question types, and for the total scores across both tasks.

Choices of Messages and Distractors

For the MCQ, the frequency of participants' responses across the four response options were compared between conditions; see Table 5 for descriptive statistics. The G + S message—that is, the target response—was correctly selected more often in the G + S condition compared with the SO condition. This difference reached statistical significance ($Z = -4.425$, $p = .00$). No difference was found for the choice of the G + S distractor between conditions. The SO message was chosen significantly more often ($Z = -3.773$, $p = .00$) in the SO condition compared with the G + S condition. The student participants were significantly more likely ($Z = -4.129$, $p = .00$) to choose the SO distractor in the SO condition compared with the G + S condition.

Correlations of Total Scores With Measures of Aphasia Testing

The mean total scores for each gesture type were calculated for each PWA and correlated with the measures of aphasia fluency and severity. For Subjects 2 (no pantomime produced) and 6 (emblem excluded), the mean was calculated between the remaining scores. For Subject 4 (two clips with pantomimes), the mean was calculated between the four scores.

As a measure of aphasia severity, the WAB-R AQ did not correlate significantly with the total scores of the SO condition ($r_s = .146$, $p = .688$) or the G + S condition ($r_s = -.055$, $p = .881$). The WAB-R fluency score did not correlate significantly with the total scores of the SO condition ($r_s = -.488$, $p = .153$). A moderate-to-good negative significant correlation was found between the total scores of the G + S condition and the WAB-R fluency score ($r_s = -.629$, $p = .027$).

In-Depth Analysis of Outliers

In some of the tested items, the student participants were not able to infer any of the target meanings in the SO condition. A score of 0 for the OQ in the SO condition was found for three of the 29 clips (Clips 7, 19, and 22). In the G + S condition, the OQ responses indicate that the student participants struggled to interpret these clips. For Clip 7, the mean percentage score in the G + S condition

Table 5. Descriptive data for choices of the four response options in the multiple-choice question compared between conditions.

Condition	G + S message			G + S distractor			SO message			SO distractor		
	M	*SD*	Median	*M*	*SD*	Median	*M*	*SD*	Median	*M*	*SD*	Median
SO	10.52	8.21	11.00	3.28	5.14	1.00	10.21	7.29	9.00	6.0	6.39	4.00
G + S	19.48	8.46	24.00	3.00	4.50	1.00	4.97	6.16	3.00	2.55	4.61	1.00

Note. G + S = gesture + speech; SO = speech only.

was 34.17 for the OQ. For Clips 19 and 22, the percentages in the G + S condition for the OQ were even lower (7.5 for Clip 19 and 18.33 for Clip 22).

Post Hoc Analysis of Order Effects

All of the student participants started with the SO condition. To verify effects of condition, we conducted a post hoc regression analysis to test a possible order effect in our experiment. We divided the mean percentage total scores that were achieved as reactions to the first half of items of each condition and group with the scores achieved in the respective second halves of trials to test if participants were generally more successful in the later trials of each condition. The post hoc variance analysis of repeated measures did not reveal a significant order effect between those scores ($F = 1.696$, $p = .204$). In addition, we used the mean percentages of the total scores to test the interaction between effects of condition and order with Pearson's chi-square test. Pearson's chi-square test did not reveal a significant interaction between condition and order ($\chi^2 = 0.37663$, $p = .54$).

Discussion

The main findings from the current study indicated more accurate listener comprehension within the G + S condition for all three gesture types and for all scores (OQ, MCQ, and total scores). The target message and the SO message as well as the respective distractors were shown to be sensitive to the different conditions. While the target message was chosen significantly more often in the G + S condition, the two SO options were chosen significantly more often in the SO condition.

In summary, these results indicate that the student participants' interpretation of the PWA's communication was more accurate in the G + S condition compared with the SO condition. Thus, production of gestures by PWA in the conversation data presented had a crucial impact on the comprehensibility of the PWA's communication. These findings add weight to the communicative value of gesture for PWA, even for listeners who are unfamiliar with the individuals with aphasia. The observed differences between the G + S and SO conditions suggest that gestures produced by PWA provide additional informational content beyond the information conveyed by speech alone. This is further underlined by student participants' choices of messages and distractors in the MCQs: Responses in both conditions (G + S and SO) indicated that the informational content communicated by gesture and speech was superior to that derived from the content of the verbal message alone. The outcomes of the current study support the argument of a single underlying origin of gesture and speech—that is, aspects of the meaning that PWA try to communicate but cannot utter verbally are shifted to a relatively more intact output channel—that is, the gesture modality. This was shown in a sample of PWA with a predominant production deficit who were assumed to have the need to partly rely on gesture to express informative content. In this way, gesture production is used (consciously or unconsciously) to compensate for reduced linguistic resources; this compensation is possible because of the closely coordinated but separate production processes of gesture and speech as hypothesized in the Sketch Model (De Ruiter, 2000).

The gestures of interest within the current study (referential gestures, pantomimes, and emblems) were selected on the basis of the assumption that they differ in terms of potential to augment verbal communication. We hypothesized that any enhancing effects of combined speech and gesture would be greater for emblems and pantomimes because of their potential to convey meaning independent of the accompanying speech. Our findings indicate listeners' interpretation improved for all three gesture types in the combined condition (the G + S condition). A defining feature of emblems and pantomimes is that they can express interpretable content without accompanying speech and thereby even completely replace speech. Interpretation of referential gestures (reflecting Kendon's (McNeill, 1992) gesticulations) was assumed to be more dependent on the accompanying speech. In contrast to our hypothesis, we found that the effects of condition were equally remarkable for the categories of referential gestures, pantomimes, and emblems. Hence, the category of referential gestures was more influential on the expression of information content than was initially expected.

These surprising findings might relate to the operational definitions used in the current study, in which deictic gestures and iconic gestures were collapsed into one category. Deictic gestures hold the potential of functioning in a speech-replacing way and are often needed to understand the full meaning of an accompanying utterance. The decision to include deictic and iconic gestures within a single category was based on the observation that deictic and iconic gestures are often used in tight coordination to refer to referents and their respective characteristics. This was found to be the case in the spontaneous speech samples used in this study. Separating the categories would not have reflected the natural communicative behavior of the PWA in the sample and would have resulted in less comprehensible data. Hence, the decision to combine deictic and iconic gestures within the category of referential gestures was essential to capture the spontaneous communicative gesture use of these PWA.

Although emblems hold the potential to express meaning in a speech-replacing manner, this does not mean that PWA actually do use emblems to replace speech. Rather, PWA might also use emblems to express meaning that is redundantly expressed in speech. In the data used for this study, emblems often accompanied particular key words, referring to the same semantic concept (such as the word *good* accompanying the thumbs up gesture). In the context of emblems that did not fully convey the speaker's intended meaning, these key words might have enabled the participants to make accurate guesses about the intended meaning. It is proposed that the redundant use of the two modalities leads to more clarity and avoidance of misunderstandings. Emblems are easy to interpret for listeners and can therefore be used in a highly communicatively effective way. However, their potential to express semantic content might be limited in the sense that there is not one emblem for every semantic concept that a PWA wishes to express. Iconic gestures, by contrast, are produced idiosyncratically and can be used to express a range of features of various referents, but their interpretation is more closely related to the accompanying speech. Deictic gestures can be used to indicate present or absent referents given that indication is useful for the expression of the communicative intention of a PWA. Pantomimes can express complex actions through their motor enactment in a speech-replacing or speech-accompanying manner. PWA can use pantomimes to express information that would be complicated and complex to describe verbally. However, the use of pantomimes is limited to the expression of motor actions. Therefore, all gesture types under investigation have the potential to augment communicative effectiveness in PWA and compensate for problems in speech. According to their different properties, the most appropriate and efficient gesture type must be chosen for the expression of the respective content in early stages of the production process. This decision would, in the framework of the Sketch Model be finalized by the conceptualizer according to the communicative intention—that is, the semantic content that needs to be communicated via gesture given relatively intact semantic processing (De Ruiter, 2000; De Ruiter & De Beer, 2013).

The current study aimed to investigate the function of speech-accompanying gestures in spontaneous discourse. Responses from naive listeners indicated that when it was not possible to infer meaning from the verbal message, listeners also struggled to interpret the gestures even if the responses were more accurate when gestures were visible. It is important to note that gestures can convey crucial informational content but that the interpretation of these gestures seems to be highly dependent on speech. When replying to the MCQ, it is interesting to note that the SO options were also chosen in the combined G + S condition, indicating that listeners place greater inferential significance on the verbal message even when this is not completely congruent with the semantic content of the accompanying gesture. This highlights the importance and attention that interlocutors generally pay to the speech output.

No remarkable correlations were found between aphasia severity (as measured using the WAB-R) and the scores of the participants' reactions to the clips. This is in line with the findings by Hogrefe et al. (2012) that comprehensibility of gesture does not correlate with results from aphasia testing. Sekine et al. (2013) found that aphasia severity affects the frequency of production of gestures, whereas the comprehensibility of gestures was not tested in their study. A significant negative correlation was found between the fluency of spontaneous speech and the total scores in the G + S condition in the current study—that is, the less fluent PWA are, the more listeners seem to rely on gestures to infer meaning from their utterances. This is in line with the results of former studies (Rose et al., 2017; Sekine & Rose, 2013). Taken together, the evidence suggests that aphasia severity has an impact on the frequency of gestures used in spontaneous communication, but the comprehensibility of gestures seems to neither remarkably increase nor decrease as a function of aphasia severity. The effects of gesture on the comprehensibility of communicated content were shown to increase when verbal fluency decreased.

This is promising and important evidence for the compensatory role that gesture plays for communication in PWA. Hence, gesture as a communicative means is more important for PWA if speech production is severely impaired—that is, if their speech is less fluent. PWA in the current sample were shown to have the capacity to use gesture for the successful expression of informative content. Building upon the results of the current study in line with former evidence, assumptions about the relationship of gesture use, aphasia severity, and verbal fluency can be formulated. Aphasia severity does not seem to have a negative impact on the comprehensibility of gestures, but a decline in verbal fluency leads to a more significant role of gestures for the expression of semantic content.

The current results reveal important clinical implications. Gestures have been shown to be a communicative means of high importance for many PWA and furthermore a relevant source for the interpretation of meaning for their listeners. This potential should be addressed in aphasia therapy, enabling PWA to achieve communicative competence in everyday life. For many PWA who, according to the Dual-Factor Hypothesis (Sekine et al., 2013), (a) have the need to use gesture for compensation because of impaired speech production and (b) are capable of doing so, the optimal use of gesture can be the key to communicative participation. It is crucial to consider different gesture types to hold the potential of improving communicative effectiveness, and therefore, PWA should not be limited to the use of only one gesture type or the other. More research is needed to identify factors determining the capability for using gestures effectively. Limb apraxia and nonverbal semantic processing deficits have been identified as negatively affecting the production and comprehensibility of gestures (Hogrefe et al., 2012), and the relationship between certain verbal symptoms and the use of gestures has been examined (e.g., Sekine & Rose, 2013). To date, the relationship of speech comprehension, and gesture production has not attracted much interest. There are only a few studies that took into account the relationship of gesture production and speech comprehension, and these have produced inconsistent findings (e.g., Goldenberg & Randerath, 2015; Hogrefe et al., 2013). There is still a need to shed more light on the identifying factors of PWA with good potential for the effective use of gestures in communication.

Future research into the communicative function of gesture might include a larger number of PWA across a broader range of aphasia severity and fluency of spontaneous speech. The above-made assumptions should be further challenged in PWA with different disturbances of (a) speech production and also (b) perception of speech. Theoretical frameworks, such as the Sketch Model, could be extended to include assumptions about PWA with impaired semantic processing. Furthermore, as the conversation partner plays a key role in shaping and progressing the interaction (Goodwin, 2000; Heeschen & Schegloff, 1999), future research could investigate gesture production in naturally occurring conversation between the PWA and an interlocutor. Connected to the role of the listener, factors guiding listeners' attention to gestures in a conversation with PWA should be identified. It could be hypothesized that interlocutors of PWA are a priori more attentive to gestures as a compensatory communicative means driven by their awareness of the impaired language processing. As an alternative, there might be specific signals or factors influencing the interlocutors' attention to the gestures used by PWA.

We acknowledge that the study would have benefited from some methodological improvements. The construction of the messages and the distractors on the basis of independent judges' ratings of the stimuli would have led to improved validity, especially when administered by judges who are less familiar with the interpretation of gestures. This would better reflect the knowledge base of the judges participating in the experiment.

The degree of exposure to aphasia of the undergraduate students who participated in this study was not specifically controlled for. It is therefore possible that there may have been an interaction between students' prior exposure to people with aphasia and their accuracy in message identification. However, it seems unlikely that such lack of control would have seriously affected the results in this study.

Furthermore, the order of the experimental conditions should have been randomized to control for order effects. However, our post hoc analysis of variance did not reveal a significant order effect; neither did Pearson's chi-square test reveal a significant interaction between order and condition. A future study with a larger group of participants might control for an order effect by randomization.

It is possible that other factors might have contributed to the differences between the G + S and SO conditions, such as the judges' access to facial expression and seeing the lips of the PWA. However, we decided to use the two conditions as we have described above to account for the use of natural data. The scoring of the MCQ can be challenged because we awarded the G + S distractor higher scores than the SO message. This decision was made because the G + S distractor was by definition closer to the target message. Only in the G + S message and the G + S distractor were the actual full extent of the semantic meaning (expressed by speech and gesture) considered. It is unfortunate that we are not able to report the potential impact of limb apraxia or cognitive deficits on the use of gestures by PWA in the current study because no results about those capabilities are accessible from AphasiaBank.

Conclusion

Overall, results of the current study indicate that referential gestures, pantomimes, and emblems have the potential to add crucial information to the expression of semantic content. Hence, these three gesture types that PWA use spontaneously play an important role in augmenting communicative effectiveness. This has been shown for PWA with a predominant production deficit of varying severity—that is, PWA who need to rely on gesture to express semantic content. The manner of the expression of meaning differs between the tested gesture types due to their respective characteristics. The results do not suggest that some gesture types hold a higher potential in adding crucial information than others but rather that depending on the communicative intention, the most effective gesture type has to be chosen for the expression of that meaning. To actually infer what PWA are trying to express, both modalities must be taken into account by the interlocutor to understand the full extent of the underlying communicative intention and to avoid misunderstandings. The results suggest that interlocutors actually are attentive to both communicative modalities and most often use the collaboratively expressed content to infer communicated messages. Taken together, the use of the full orchestra of expressive means, including speech, the different gesture types, and additional communicative behavior will enable PWA to make use of their full communicative potential. In PWA, gestures have therefore been shown to be a highly important communicative and compensatory means that crucially contribute to the expression of meaning in tight collaboration with speech.

Acknowledgments

Carola de Beer was funded by a short-term PhD scholarship of the DAAD (German Academic Exchange Service). Katharina Hogrefe was funded by the German Research Foundation (DFG

GO 968/3-3). Karin van Nispen was funded by the Jo Kolk Study Fund. Further acknowledgments go to Dr. Kazuki Sekine and Dr. Annett Jorschick for supporting the statistical analysis, to Dr. Abby Foster and Dr. Lucy Knox for their support in the preparatory phase of the experiment, and to the lecturers of the School of Allied Health at La Trobe University who helped with participant recruitment.

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