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Research Report

Communicative effectiveness of pantomime gesture in people with aphasia

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Abstract

Background: Human communication occurs through both verbal and visual/motoric modalities. Simultaneous conversational speech and gesture occurs across all cultures and age groups. When verbal communication is compromised, more of the communicative load can be transferred to the gesture modality. Although people with aphasia produce meaning-laden gestures, the communicative value of these has not been adequately investigated.
Aims: To investigate the communicative effectiveness of pantomime gesture produced spontaneously by individuals with aphasia during conversational discourse.
Methods & Procedures: Sixty-seven undergraduate students wrote down the messages conveyed by 11 people with aphasia that produced pantomime while engaged in conversational discourse. Students were presented with a speech-only, a gesture-only and a combined speech and gesture condition and guessed messages in both a free description and a multiple-choice task.
Outcomes & Results: As hypothesized, listener comprehension was more accurate in the combined pantomime gesture and speech condition as compared with the gesture- or speech-only conditions. Participants achieved greater accuracy in the multiple-choice task as compared with the free-description task, but only in the gesture-only condition. The communicative effectiveness of the pantomime gestures increased as the fluency of the participants with aphasia decreased.
Conclusions & Implications: These results indicate that when pantomime gesture was presented with aphasic speech, the combination had strong communicative effectiveness. Future studies could investigate how pantomimes can be integrated into interventions for people with aphasia, particularly emphasizing elicitation of pantomimes in as natural a context as possible and highlighting the opportunity for efficient message repair.

Keywords: aphasia, gesture, pantomime, communicative effectiveness.

What this paper adds?

What is already known on this subject

Simultaneous conversational speech and gesture occurs across all cultures and age groups. When verbal communication is compromised, more of the communicative load can be transferred to the gesture modality. Although people with aphasia can produce meaning-laden gestures it is unclear if these are communicative.

What do we now know as a result of this study that we did not know before?

The pantomime gestures produced by people with aphasia in a conversational discourse significantly improved listener comprehension of the messages being conveyed. Future studies should investigate how pantomimes can be integrated into interventions for people with aphasia, using naturalistic methods of shaping and reinforcement.

Introduction

Human communication occurs through both verbal and visual/motoric modalities. Successful communication can be achieved through one modality in isolation, for instance, speaking on the telephone without gesturing or using sign languages and pantomime without speech. Most commonly, however, speech and gesture co-occur.

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Simultaneous conversational speech and gesture occurs across all cultures and age groups (Kita 2009). Gesticulation, or co-speech gesture, encompasses a variety of gesture types that serve to augment the verbal message in some way. Of particular interest in the study of language and gesture interaction are iconic gestures. Iconic gestures are movements that depict the action, size, motion, and shape of a referent described in the spoken utterance (e.g., inverted 'V'-shaped fingers stepping across gesture space to demonstrate walking, while saying 'he was walking') (McNeill 1992). Pantomimes constitute a class of gestures which are similar in function to iconic gestures, in that they depict physical objects and actions. Unlike iconic gestures however, pantomimes are generally performed in the absence of speech, and are typically more elaborate, consisting of a sequence of several phases (McNeill 1992), and as such can communicate a message that may involve several referents.

There is debate in the literature concerning the functions of iconic gestures with the two main propositions being that (1) gesture is produced to facilitate speech production or (2) gesture is produced to communicate a message (see de Ruiter and de Beer 2013 for a review of current models). When verbal communication is compromised, more of the communicative load can be transferred to the gesture modality. de Ruiter's Mutually Adaptive Modalities (MAM) or Trade-off hypothesis based on the Sketch Model of gesture production (de Ruiter 2000, 2006, de Ruiter *et al.* 2012) predicts that a speaker is more likely to gesture to communicate information in an environment where verbal communication is made difficult, for example, when there are high levels of background noise. Conversely, when gestural communication is not feasible, for instance, when speaking on the telephone, more information will be communicated in speech. Often, the more severely compromised the verbal communication, the more 'language-like' properties that begin to appear in gesture. For instance, Goldin-Meadow *et al.* (1996) found that when speakers were asked to communicate an event only through gesture, their hand gestures tended to assume the grammatical properties, segmentation and hierarchical combination associated with language. These properties are not generally seen when gestures are produced alongside speech. Thus, when the gesture modality carries the full burden of communication, in healthy speakers it takes on language-like properties.

Similarly, when spoken language is compromised in aphasia, other communicative modalities may be utilized to compensate for the linguistic deficit (Rose 2006). Gesture, in particular pantomime, may serve as a powerful communicative tool for many individuals with aphasia. Indeed, the MAM/Trade-off hypothesis predicts that individuals with aphasia should be able to compensate for their verbal deficits by transferring more of the communicative load to the gestural modality (de Ruiter and de Beer 2013). However, empirical evidence suggests that this is not the case for every individual with aphasia. Gestural ability is not always intact in people with stroke-induced aphasia due to aspects of the aphasic syndrome itself or to co-morbid neurological deficits. For example, Hogrefe *et al.* (2012) have shown that in people with severe aphasia, semantic impairments limit the amount of iconic gesture produced in video retell tasks. Further, in Hogrefe *et al.*'s study participants with severe aphasia and co-occurring limb apraxia produced iconic gestures whose comprehensibility was reduced. These additional semantic and praxis factors have typically been underspecified in cognitive neuropsychological models of gesture production.

Rose (2006) systematically reviewed the literature concerning gesture in aphasia and reported methodological limitations in previous work that made generalization to the aphasic population difficult. Of prime concern was the lack of attention to the heterogeneity of people with aphasia in terms of the specific linguistic impairments underpinning their communication disability. However, the literature suggested that the degree to which individuals' syntactic, semantic and phonological processing is impaired significantly impacts on the frequency, types and utility of gestures produced. Recently, researchers from our group investigated the gesture production patterns of people from a range of aphasia types and severities in a series of related studies. People with aphasia were found to produce more gestures per spoken word than typical speakers. Participants with Broca's aphasia produced the highest amount of gesture overall, and the highest number of meaning-laden gestures such as pantomimes, emblems, and iconics (Sekine *et al.* 2013, Sekine and Rose 2013). This finding was further refined to demonstrate that people with aphasia produce more iconic gesture during periods of word retrieval difficulty (WRD) than during fluent speech (Lanyon and Rose 2009, Sekine *et al.* 2013, Cocks *et al.* 2013). People with good semantic knowledge of actions and objects produced gestures rich in semantic information indicating, for example, both the path and manner of an object in movement (Cocks *et al.* 2013, Hogrefe *et al.* 2012), and this was particularly the case during verb retrieval (Cocks *et al.* 2013). However, whether the gestures produced by people with aphasia are actually communicative has received less attention in the literature.

Do the gestures produced by people with aphasia improve communication?

The spontaneous gestures of individuals with aphasia have the potential to convey highly specific information in an efficient manner that may otherwise be difficult to verbalize for a person with aphasia (Rose 2006). For example, a 'drinking' gesture may convey information about the type of beverage being consumed based on hand shape: a whole hand grasping an imaginary glass might indicate drinking beer (or milk or water), while use of the thumb and forefinger might convey that the drink consumed was tea (from a teacup) (Wilkinson 2013). In the example from Wilkinson (2013), a participant with severe non-fluent aphasia performed three such 'drinking' gestures in quick succession whilst smiling, relating to his communication partner in a humorous manner, that copious alcohol consumption occurs at his stroke support group. For this participant, communicating this information verbally would have proven extremely effortful (if not impossible). By using a pantomime gesture he was able to relate his message quickly and independently. This case suggests that spontaneously produced gestures can be an effective communication tool for people with aphasia.

A small number of studies have investigated the communicative effectiveness of gesture in aphasia. Carlomagno *et al.* (2005) compared the referential communication of 11 individuals with fluent (anomic) aphasia (FA) with that of 21 individuals with Alzheimer's-type dementia (DAT) and 18 healthy controls. In this study, participants were required to describe a given picture to the examiner through any modality available to them. The examiner then selected the item described from a set of four picture items (the target plus three distractors). The picture stimuli were in the form of black and white line drawings and consisted of simple objects or actions or a combinations of people, objects or animals. The examiner gave requests for repair when necessary. Verbal retrieval of target words and phrases was recorded, yielding a Crucial Information Score. Such scores (indicative of verbal performance) were comparable for the FA and DAT groups. Overall, communicative effectiveness (taking into account speech and gesture) was measured in terms of the numbers of misunderstandings on the part of the listener, and the number of turns required to complete the task. Overall, communicative effectiveness was poorer in the DAT participants than in individuals with aphasia. The authors then analysed the frequency of each type of gesture produced by each group. No significant between-group differences in overall gesture rate were found. As a group, however, the participants with aphasia produced substantially more meaning-laden gestures than control and DAT participants. This result is consistent with the idea that the DAT participants' cognitive impairments led to the production of both gesture and words as being equally compromised, whereas consistent with the MAM hypothesis, the FA participants can compensate for verbal communication failure with production of meaning-laden gestures. Whether or not the difference in gesture production patterns between the groups was the main determinant of communicative effectiveness remains unclear, as this was not directly investigated.

More recently, attempts to evaluate the communicative effectiveness of gesture in individuals with aphasia have instead focused on direct measures of listener comprehension. Two recent studies have yielded conflicting results regarding whether or not individuals with aphasia use gesture to compensate effectively for their verbal deficits. In the first of these studies by Hogrefe *et al.* (2013), 24 participants with aphasia were required to retell short film clips under two conditions. In the first, 'verbal' condition, participants were instructed to retell the story using speech. Gesture was allowed but there was no explicit instruction to produce gesture. In the 'silent' condition, participants were instructed to narrate the clip using gesture only. Intelligibility of both gestural and verbal output was inferred from ratings supplied by naïve, neurologically healthy judges. Judges viewed videos of gestural communication without sound, and listened to the auditory component of the narrations without video. Judges were required to indicate which cartoon was being narrated (forced choice of six), and to indicate on a six-point scale the certainty of their response. This yielded a weighted identification ratio (WIR) for each participant's narrations under each condition. Overall, there were significant differences in WIR across the verbal and silent conditions, with gesture comprehensibility higher in the silent condition than in the verbal condition. Additionally WIR of spoken expression was significantly correlated with WIR of gestural expression in the silent condition. These findings indicated that participants increased the content of their gestural communication to compensate for the absence of speech, thus supporting de Ruiter's Trade-off/MAM Hypothesis.

In another study by Mol *et al.* (2013), the informativeness of gesture production was investigated in 25 Dutch-speaking individuals with post-stroke aphasia and 17 healthy control participants during communication of two selected messages (woman buying a jumper, accident scene) from the Scenario test (van der Meulen *et al.* 2009). The Scenario test measures a person's ability to communicate messages to the examiner after viewing line drawings that depict an everyday scenario (e.g., woman shopping for a jumper) via speech, writing or gesture. Control participants were given instructions to speak and gesture on one task, and to only use gesture for a second task. People with aphasia were allowed to use both speech and gesture in each scenario. Independent raters judged three versions of the participants' responses in a forced choice test (was it the sweater or the accident scene being communicated): picture only, audio only, or combined picture and audio. The communicative attempts of speakers with severe or moderate aphasia were rated more accurately in the audiovisual conditions (containing gestures) than the audio only for one scenario each (accident for severe aphasia; sweater for moderate aphasia), but not for the second scenario, and not more accurately than the healthy controls. Mol *et al.* (2013) argued that given the gestures used by people with aphasia were less informative than the non-aphasic controls, the idea that speakers with aphasia compensate for their language impairment with gesture was not supported. While this study provided a large sample and used a range of statistical methods to search for factors contributing to relative success/failure in gestural communication, it is possible that the Scenario Test task used in this study lacked ecological validity. Only two scenarios were examined, and in fact yielded conflicting results in terms of gesture informativeness patterns.

The elicitation procedures (for both speakers and judges) in these studies may have limited the ecological validity of the results obtained. In both studies (Hogrefe *et al.* 2013, Mol *et al.* 2013), the metric used for scoring gesture informativeness was a forced choice: Was this the sweater scenario or the accident scenario, or which of the set of six videos was being narrated. Such binary scoring may have underestimated the communicative value of the gestures produced. Further, explicit instruction to gesture potentially reduces the naturalness or spontaneity of the gestures produced, compared with typical spontaneously produced conversational gestures (Rose 2006, Borod *et al.* 1989). As an alternative, conversational discourse offers an opportunity to view a range of communication acts in a more naturalistic setting, and thus may offer a more comprehensive and authentic perspective on the effectiveness of people with aphasia during everyday communication.

Aims

Therefore, the aim of this research was to investigate the communicative effectiveness of pantomime gesture produced spontaneously by individuals with aphasia during conversational discourse. We hypothesized that: (1) untrained listeners would comprehend significantly more message elements produced by people with aphasia when provided with a combined gesture plus speech message, as compared with a speech only or a gesture only message; (2) untrained listeners would comprehend messages more accurately in a multiple-choice task than in the free-description task; and (3) there would be a negative relationship between both participant aphasia severity (Western Aphasia Battery Aphasia Quotient—WAB-AQ) and aphasia fluency (Western Aphasia Battery Spontaneous Speech Fluency) with the communicative effectiveness scores.

Method

This research project was approved by the La Trobe University, Faculty Health Sciences, Human Ethics Committee (FHEC 12/181).

Participants

The study was piloted on nine volunteer undergraduate students from La Trobe University whose responses were used to refine the scoring protocol utilized during the free-description task and to refine the options provided for the multiple choice task. For the main study, 67 undergraduate students from La Trobe University were recruited and randomly allocated to one of three groups ($N = 22$–23). Each group was presented with one of three sets of clips counterbalanced for the three conditions for speech plus gesture, speech only, and gesture only (see the procedure section for further information).

Stimuli

The stimuli were drawn from 15 audiovisual recordings of 13 individuals with aphasia engaged in conversational discourse from the Aphasiabank database (http://www.talkbank.org/AphasiaBank). The 15 video clips were selected as the experimental stimuli based on the fact that the person with aphasia produced a clear-cut pantomime. These 13 individuals were selected from those utilized in a prior study (Sekine *et al.* 2013) whereby each participant had been shown to produce at least one gesture during discourse. The 13 participants selected for the current study also had to have produced at least one pantomime gesture during discourse. The video recordings of 2 participants were used in the piloting of this study (Clip ID Practice 1 and 2 in table 1), while the remaining 11 participants' recordings were used in the main study (Clip ID 1–13 in table 1). Note that some recordings are from the same participants; Clip ID 2 and 3 from 1 participant, and Clip ID 10 and 11 from 1 participant (table 1). The recordings used in this study were of free speech samples of individuals with aphasia conversing with a researcher about any chosen important event in their life. The individuals with aphasia in the recordings were all native English speakers or had English as their primary language, were at least 6 months post-onset of stroke, and their mean age was 67.6 years (SD = 9.86). Language profiles and aphasia severity ratings were completed according to the clinical criteria outlined by the WAB (Kertesz 2007). The demographic and relevant motoric and linguistic details of each individual with aphasia are summarized in table 1.

From each recording, 10–20 s was selected where the person with aphasia used pantomime without speech or during speech attempts to communicate a specific message. In line with Sekine and Rose (2013), a

Table 1. Details of persons with aphasia in the stimuli recordings

Clip ID	Age (years)	Gender	Handedness	Years post-onset	Aphasia type	Aphasia severity (WAB AQ)[a]	WAB spontaneous speech fluency	Apraxia of speech[b]	Dysarthria[b]	Hemiplegia[c]	Years of education
Practice 1	72.2	M	R	3;2	Conduction	49.9	6	U	U	NM	16
Practice 2	53.9	F	R	2;11	Broca	40.9	4	U	U	RH	12
1	69.8	M	Right	5;3	Conduction	74.9	8	Y	N	RP	20
2	80.9	M	Right	12;1	Broca	17	0	Y	N	RP	16
3	80.9	M	Right	12;1	Broca	17	0	Y	N	RP	16
4	71.4	M	Ambiguous	11;3	Conduction	83	9	N	Y	RP	13
5	78.3	M	Right	25;09	Broca	52.5	4	Y	N	RH	18
6	61.8	F	Right	11;07	Conduction	72.8	5	Y	Y	RP	12
7	70.2	M	Right	9;01	Conduction	70.1	6	Y	U	RP	16
8	58.3	M	Left	3;10	Conduction	68.3	6	N	N	RH	12
9	47.2	F	Right	1;7	Transmotor	86.5	9	Y	U	RH	16
10	68.2	M	Right	30;0	Broca	68.6	U	U	N	RP	13
11	68.2	M	Right	30;0	Broca	68.6	U	U	N	RP	13
12	63.2	F	Right	0;09	Anomic	89.5	9	N	N	RP	14
13	66.4	M	Right	6;07	Conduction	76.3	6	N	N	NM	18

Notes: [a]U, unavailable.
[b]Y, yes; N, no; U, unavailable.
[c]RP, right-sided hemiplegia; RH, right-sided hemiparesis; NM, no motor problems; U, unavailable; Transmotor, transcortical motor aphasia.

pantomime was defined as a gesture that consists of two or more iconic character viewpoint gestures, which occur continuously within the same gesture unit. An iconic character viewpoint gesture is one where the speaker uses their own body in depicting a concrete action, event or object event, as though they themselves are the character/object (McNeill 1992). No matter how many individual iconic character viewpoint gestures occurred continuously in a gesture unit, they together were counted as one pantomime. All gestures in a gesture unit were included in the experiment. A gesture unit is defined as the period of time between successive rests of the limbs (McNeill 1992). Each selection was then manipulated to create three different conditions of presentation: (1) speech plus gesture (SG) (the original video recording), (2) gesture only (G) (i.e., the video only component with the audio suppressed), and (3) speech only (S) (i.e., the audio only component with the video suppressed). This created a total of 45 different clips (15 original message selections × 3 different stimulus conditions). From the 45 clips, six clips (from two individuals with aphasia × 3 conditions) were used in practice trials, while the remainder of the clips (39 clips) were used in the experimental trials.

Procedure

Each student participant attended one of six possible group data collection sessions. Each group of student participants was presented with one of the three stimulus conditions from each of the 13 original message selections, that is, each student participant was presented with only one version (SG, G or S) of each message. Thus, each student participant viewed a total of 13 clips. Each participant was presented with one of the three (A, B or C) counterbalanced sets of clips for the experimental trials (set A = four trials in the G condition, four trials in the S condition, five trials in the SG condition; set B = four trials in the G condition, five trials in the S condition, four trials in the SG condition; set C = five trials in the G condition, four trials in the S condition, four trials in the SG condition). The 13 message selections were presented in a fixed order, albeit in different conditions, across the three sets. To control for order of condition order, each participant was presented with one of three sequences of intermingled conditions, depending on which set they viewed.

For each data collection session, participants were informed that they would watch a series of audio and/or visual recordings of individuals who have trouble communicating. For each clip presented, participants were asked to complete two tasks: a *free-description task* where the participants wrote their interpretation of the message conveyed by the clip; and a *multiple-choice task* where they chose the option that best reflected their interpretation of the message. The specific instructions given for the free-description task was to 'write down your best guess of the message. This can include anything you hear and/or see'. For each multiple choice task, the participants were presented with five response options in random order: (1) *Target message*; message actually conveyed by speech and gesture, (2) *Speech message*; message conveyed by speech without gesture, (3) *Speech distractor*; distractor to the speech message, (4) *Gesture message*: message conveyed by gesture without speech, and (5) *Gesture distractor*; distractor to the gesture message. The distractor messages were created by the first and second authors as possible but inaccurate interpretations of the messages conveyed by speech or gesture only. The multiple-choice options were refined following the pilot study to ensure options were more plausible and mutually exclusive. Refinements were guided by the semantic content provided by the participants' responses in the free description task in the pilot study.

The stimuli are presented in table 2. In order to minimize influence on the participants' responses in the free-description task, the participants were asked to complete the multiple-choice task after they completed the free-description task. Each clip was shown two times. Participants were allowed 1 min to complete each task.

To score the responses for the free description task, a list of the target semantic elements conveyed in each message by speech and/or gesture was created. Further to this, for each target semantic element, the authors created a list of closely related meanings, which are referred to as *semantic associates*. For each element in the participants' responses that matched a target semantic element, 2 points were awarded. For each element in the participants' responses that matched a related semantic element, 1 point was awarded. Unrelated elements in the participants' responses were awarded 0 points. The maximum possible score for each of the 13 open-ended tasks ranged from 8 to 24 (see table 2. showing the maximum score of each clip at the first row of each item). For the multiple-choice task, only the *target message* (message conveyed by speech and gesture) choice was awarded 1 point and all other options were awarded 0 points. Thus, the maximum possible score for each condition (S, G, SG) of the multiple-choice tasks was 5.

Reliability

The second author scored the results of the free-description task for all participants. To ensure the reliability of the speech and gesture coding, the results of 13 student raters (20% of participants) were independently re-scored by the third author. The participants for reliability scoring were selected using stratified random sampling across the three sets of clips (four participants

Table 2. Message that each video clip conveyed (*Target message* in the table) and multiple-choice options for each task

	Message for the multiple choice
Clip 1	
Target message	I've got two days of intensive weight training with a cross trainer. (Maximum score = 10)
Speech message	I've got two days of intensive use of the weights.
Speech distractor	I've two days of intense waiting.
Gesture message	I use an exercise machine.
Gesture distractor	I use a saw and build things.
Clip 2	
Target message	I heat the baby's bottle, shake it, and tip the bottle upside down. (Maximum score = 10)
Speech message	A whistle ... One ... Yep, one.
Speech distractor	The wind ... One ... Yep, one.
Gesture message	I shake the baby's bottle up and down and feed the baby the bottle on my lap.
Gesture distractor	I pick up the sauce bottle and pour the sauce onto the pie.
Clip 3	
Target message	I was travelling in the train and then I got off. And then I got on a horse. (Maximum score = 10)
Speech message	Yeah ... No. Yeah ... And ahhh.
Speech distractor	Yes, that's right.
Gesture message	I was riding in a train and then I got off. And then I continued in the train.
Gesture distractor	I whipped some eggs to make a meringue but it fell flat.
Clip 4	
Target message	'I asked her .... She has a cigarette in her hand; I said 'You don't listen to me, so'. (Maximum score = 12)
Speech message	I asked her if she had a cigarette in her hand and she said 'you don't listen to me'.
Speech distractor	I'm often asked, is that a cigarette in your hand?
Gesture message	I was smoking, and it was OK.
Gesture distractor	I was smoking and I was asked to leave the room.
Clip 5	
Target message	I was running and while I was mowing the grass, 'boop', I suddenly fell backwards. (Maximum score = 10)
Speech message	I was running and I was mowing the grass and then 'boop' the mower stopped.
Speech distractor	I was running and I was mowing the grass and then 'boop' a rock hit my head.
Gesture message	I was walking and then I mowed the grass and I collapsed backwards.
Gesture distractor	I was sanding and planting a piece of wood in the garage and I fell backwards.
Clip 6	
Target message	I gave the TV remote to someone who kept changing channels. It was annoying. (Maximum score = 12)

Continued

Table 2. Continued

	Message for the multiple choice
Speech message	I asked them if they wanted to watch TV.
Speech distractor	TB is a bad disease.
Gesture message	I offered the TV remote control to my friends.
Gesture distractor	I handed out some money to everyone. My husband found it annoying.
Clip 7	
Target message	I answered the phone while we were talking, I collapsed and my arm went weak. (Maximum score = 14)
Speech message	I answered the phone but it was very difficult.
Speech distractor	I answered the phone but I dropped the receiver.
Gesture message	I talked on the telephone but I got sleepy and went to bed.
Gesture distractor	I called them up but I couldn't understand. I was confused so I went to bed.
Clip 8	
Target message	I like the big, old cameras from the past I can take all kinds of photos with them. (Maximum score = 10)
Speech message	I especially like a big camera but I like all kinds of cameras too.
Speech distractor	I like big photos. I like all kinds of photos.
Gesture message	I am a photographer and I take photos all over the world.
Gesture distractor	I looked through the binoculars and got a great view behind my house. I could see all the places everywhere.
Clip 9	
Target message	I went to sleep. Then, I tried to eat an ice cream but I couldn't because my arm was tingling and weak. Then I had to go to the bathroom. (Maximum score = 20)
Speech message	I was asleep and then I had an ice cream. It was tingling and then I had to go to the bathroom.
Speech distractor	I was asleep and then I woke up. Then I had an ice cream and it made my face and teeth tingle. Then I had to go to the bathroom.
Gesture message	There was one item I was trying to grasp but it was difficult and I had to put it over there.
Gesture distractor	There was one I was trying to squeeze but I couldn't get it out.
Clip 10	
Target message	I tried to ring Hawaii but no one answered. (Maximum score = 8)
Speech message	Someone's calling from Hawaii. Oh boy.
Speech distractor	The door bell kept ringing while I was in Hawaii.

Continued

Table 2. Continued

	Message for the multiple choice
Gesture message	The telephone was ringing over there and people were knocking on the door.
Gesture distractor	I phoned a friend over there and I went and knocked on the door.
Clip 11	
Target message	Actually, I tried to get help but I dived in the pool and that's it for a month. (Maximum score = 12)
Speech message	Actually, I dived in the pool and that was it for a month.
Speech distractor	Actually, I was poor for a month and that was it.
Gesture message	Actually, I tried to get their attention but I just fell right down in the pool.
Gesture distractor	Actually, I waved at the friends but they just kept going down the slope.
Clip 12	
Target message	They gave me a lot of written homework to do. (Maximum score = 10)
Speech message	They gave me homework to do that was a lot of words on the page.
Speech distractor	They gave me homework to do that was a lot of drawing.
Gesture message	I was doing a lot of writing. And it took me a very long time.
Gesture distractor	I was doing a lot of drawing. And it took me a very long time.
Clip 13	
Target message	I am driving with the left hand because now it is a habit after 6 years, but I still grab a hold with my right hand every now and then and its fine, but most of the time I drive with my left hand. (Maximum score = 24)
Speech message	I still drive with the left hand because it's a habit now after 6 years, but every now and then I grab a hold and its fine but most of the time I drive with the left hand.
Speech distractor	I am driving on the left hand side of the road because it's a habit now and every now and then I grab a hold, but most of the time I drive on the left hand side of the road.
Gesture message	I can drive with only one hand, but that's my left hand only. I'm not so good at driving single handed with my right hand. I can't steer very well with my right hand only. My left hand is better at steering.
Gesture distractor	I can do handiwork with my left hand but sometimes I can use my right hand for all sorts of handiwork tasks. But it's much easier with my left hand, especially with sanding.

Note: *Target message* = message conveyed by speech and gesture; *Speech message* = message conveyed by speech; *Speech distractor* = distractor to the speech message; *Gesture message* = message conveyed by gesture; *Gesture distractor* = distractor to the gesture message.

from set A, five participants from set B, four participants from set C) using a random number generator. All participants were allocated number IDs. The Cohen's kappa statistic was used to assess inter-rater reliability for gesture type. Agreement between the two independent coders (kappa = .93) was high. Any disagreements were resolved through discussion and subsequent consensus.

Data analysis

In order to explore possible differences in the number of correct choices among the three conditions in each task, we used a series of repeated measures analyses of variance (ANOVAs). Paired *t*-tests were used to investigate whether the two tasks differed in difficulty. Spearman's rank correlation analyses were used to examine the relationships between two language indices (aphasia severity: WAB AQ; fluency: WAB Spontaneous Speech Fluency) and the scores achieved in each condition.

Results

Mean number of correct choices in the free-description and the multiple choice tasks

Repeated-measures one-way ANOVAs were conducted. The dependent variable was either the total scores of the free-description task or the total number of correct choices on the multiple-choice task. The independent variable was condition (S, G, SG). A main effect of condition was found for the free-description task, $F(2, 132) = 91.84$, $p < 0.001$, $r = 0.64$, and for the multiple-choice task, $F(2, 132) = 12.60$, $p < .001$, $r = 0.40$. Least significant difference post-hoc comparisons indicated that for the free-description task, the total score in the SG condition (mean = 29.0, SD = 7.7) was significantly higher than that in both the G condition (mean = 13.9, SD = 4.4) and the S condition (mean = 20.5, SD = 7.29). The score in the S condition was also significantly higher than that in the G condition (figure 1). For the multiple-choice task, the total number of correct choices in the SG condition (mean = 2.2, SD = 1.0) was significantly higher than that in both the G condition (mean = 1.4, SD = 1.0) and the S condition (mean = 1.5, SD = 1.0) (figure 2). There was no significant difference between the G and S conditions. These results indicate that when pantomime gesture was presented with speech, the combination conveyed greater or more precise information than either speech or gesture alone.

An error analysis of the specific choices made by the participants in the multiple-choice task indicated that in the Gesture condition, the gesture-related options, that is, the gesture message and the gesture distractor, were the dominant error type (82.1% of the 196 erroneous choices). Likewise, the speech-related options were the dominant error types in the Speech condition (84.2% of the 190 erroneous choices). In the SG condition, the error choices were split fairly equally between the speech related options (48.5% of 136 erroneous choices) and the gesture related options (51.5%).

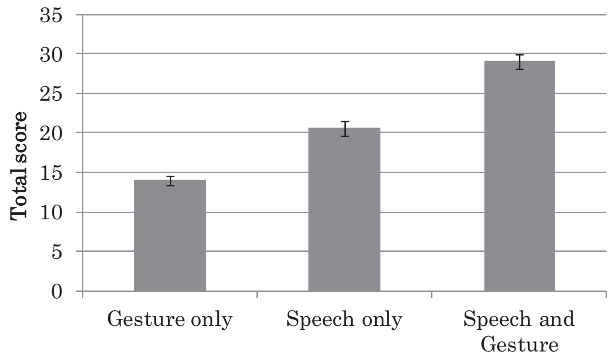

Figure 1. Mean total score of the free-description task for each condition.

Comparison between the free-description and multiple-choice tasks for each condition

To investigate whether the two tasks differed in difficulty, we converted the raw scores to proportion scores by dividing the total score achieved by each participant by the total possible correct score. Results are presented in table 3. We conducted paired *t*-tests to examine possible differences between the proportion of scores in the free-description task and the multiple-choice task for each condition. For the G condition, the proportion of correct choices in the multiple choice task was significantly higher than that in the free-description task, $t(66) = 2.13$, $p < 0.05$, $r = 0.25$. There were no other significant differences in the other two conditions.

Relationship of aphasia severity/fluency to message comprehensibility across conditions

Finally, we examined the relationship between two language indices (1) aphasia severity: WAB AQ; (2) fluency: WAB Spontaneous Speech Fluency) of the participants in the clips and the scores achieved in each condition. We used the raw scores, not the proportional scores, for this analysis. Results are presented in table 4. A series of Spearman's rank correlation coefficients revealed that for the free description task, WAB AQ showed a significant positive correlation with raters' message comprehension in the S condition, r_s (13) = 0.62, $p = 0.02$, and in the SG condition, r_s (13) = 0.58, $p = 0.04$, while WAB Spontaneous Speech Fluency (SSF) showed a significant positive correlation with message comprehension in the S condition r_s (11) = 0.64, $p = 0.04$. For the

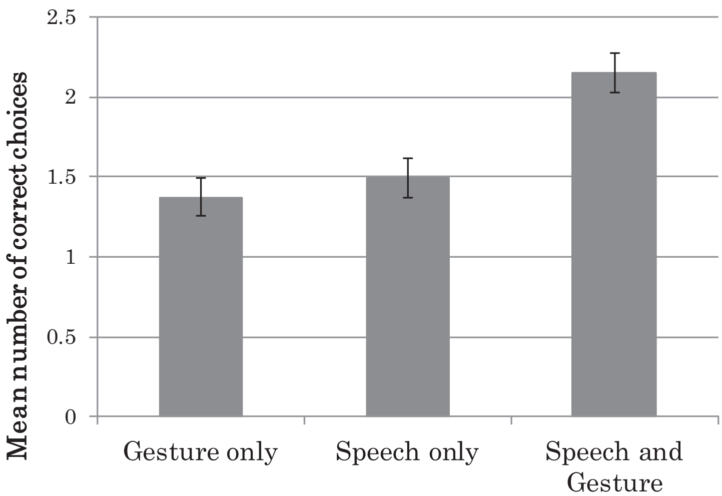

Figure 2. Mean number of correct choices of the multiple-choice task for each condition.

Table 3. Proportion (SD) of correct choices in the free-description and multiple-choice tasks for each condition

Condition/task	Free description	Multiple choice
Gesture only	0.27 (0.10)	0.33* (0.24)
Speech only	0.37 (0.09)	0.34 (0.22)
Speech and Gesture	0.54 (0.10)	0.50 (0.25)

Note: $^{*}p < 0.05$.

multiple choice-task, WAB AQ showed a significant positive correlation with message comprehension in the S condition, r_s (11) = 0.64, p = 0.02, and WAB SSF showed a positive correlation with message comprehension in the S condition, r_s (11) = 0.62, p = 0.04. There was a significant negative correlation between WAB SSF and message comprehension in the G condition, r_s (11) = –0.66, p = 0.03.

Thus, this correlational analysis provided three main findings: (1) regardless of the task, the milder the aphasia and the greater the fluency of the participants with aphasia the better the message comprehension by the student raters in the S condition; (2) in the SG condition, the milder the aphasia the better the message comprehension in the free description task; and (3) the less fluent the participant, the greater the message accuracy in the G condition, supporting the notion that gestures have the potential to compensate for communication difficulty associated with reduced speech fluency.

Discussion

We investigated the communicative effectiveness of pantomime gesture produced spontaneously by individuals with aphasia during conversational discourse through two tasks: a free-description task and a multiple-choice task. There were four main findings. First, as hypothesized, listener comprehension was more accurate in the combined pantomime gesture and speech condition as compared with the gesture- or speech-only conditions. Second, the participants achieved greater accuracy in the multiple-choice task as compared with the free-description task but only in the gesture-only condition. Third, raters comprehended more information from participants with milder aphasia. Fourth, in the multiple-choice task, the less fluent the person with aphasia was the greater the communicative effectiveness of their gestures. These results indicate that when pantomime gesture was presented with speech, the combination had strong communicative effectiveness, such that the combination conveyed greater or more precise information than either speech or gesture alone. Thus, the pantomimes produced by these individuals with aphasia were strongly communicative and effective and offered important augmentative information to the spoken message to the listeners.

In previous related studies (Hogrefe *et al.* 2013, Mol *et al.* 2013), a forced choice task was used to score gesture informativeness. In the current study, we utilized both a multiple-choice and a free-description task. In the free-description task points were awarded for selecting partial semantic attributes of the message. This was based on the idea that any fragment of information that can be communicated by the person with aphasia to the listener during everyday discourse potentially helps the listener to guess the intended message, and thereby reduces the number of repair turns required to achieve message transfer. In both tasks, scores were significantly higher in the combined gesture and speech conditions. Given these findings, the binary scoring systems used in the previous studies may have underestimated the communicative potential of gestures produced by people with aphasia. Further, previous research has focused on

Table 4. Spearman's rank correlations between gesture effectiveness and aphasia severity and speech fluency

	Free description			Multiple choice		
	G only	S only	SG	G only	S only	SG
WAB-AQ ($N = 13$)	−0.04	0.62*	0.57*	−0.41	0.64*	0.04
WAB spontaneous speech fluency ($N = 11$)	−0.16	0.64*	0.54	−0.66*	0.62*	0.10

Note: $^{*}p < 0.05$.

examining gesture production in decontextualized and less natural tasks. For example, Hogrefe *et al.* (2013) asked people with aphasia to retell short film clips. Mol *et al.* (2013) used two items from the Scenario test that required people with aphasia to communicate one of two possible messages after viewing line drawings depicting an everyday scenario. These elicitation procedures may have limited the ecological validity of the results obtained. The current study used samples of spontaneously produced interaction, and this may have contributed to the stronger gesture informativeness results. It appears that conversational discourse in natural settings can provide an enhanced opportunity to view the gesture effectiveness of people with aphasia during everyday communication.

One might have expected that scores in the multiple-choice tasks would be superior to the free description task for all three conditions based on chance alone. However, in the current study, the raters' scores in the multiple-choice task were only found to be significantly superior in the gesture-only condition. One interpretation of this result is that the raters were not simply relying on guessing and their multiple-choice results therefore do not reflect chance alone, but rather their abilities to detect meaningful elements in the speech and gesture signals. Scores in the gesture-only condition were the poorest overall, probably reflecting the degree of difficulty of the task, so it is not surprising that the multiple-choice options seemed to have assisted raters in the gesture-only condition.

The results of the error analysis of the choices made by participants in the multiple-choice task validates the chosen distractors in that speech-related options were the dominant error type in the Speech condition, gesture-related options were the dominant error type in the Gesture condition, while in the SG condition the error choices were evenly split between the speech- and gesture-related options. This finding also adds support to the notion that participants were not simply guessing during the task, as errors were not simply evenly distributed across conditions. One might generally expect participants to be more influenced by speech options in the SG condition. However, the fact that the errors in the SG condition were evenly spread across speech and gesture- related options may provide further evidence for gesture being a powerful communication modality in this population. We believe this is a more plausible interpretation than the possibilities that participants were somehow primed about gesture from the consent process or from being in a University that has produced prior research concerning gesture production in aphasia.

In the current study we found that the less fluent the person with aphasia, the greater the communicative effectiveness of their gestures in the multiple-choice-task. This is consistent with our previous findings (Sekine and Rose 2013, Sekine *et al.* 2013) where we examined the relationship between the number of gestures produced by people with aphasia and aphasia severity and fluency. We found that the WAB Spontaneous Speech Fluency scores were significantly negatively correlated with gesture production, especially for deictic and pantomime gestures. Thus, the results in the current study support these findings suggesting that aphasic speech fluency is a sensitive index to meaning-laden gesture production in people with aphasia.

The findings also suggest the opportunity for pantomime gestures as targets of aphasia therapy. In experimental work, Sekine *et al.* (2013) found that in a story retell task people with Broca's aphasia produced pantomime gestures more frequently than people with other types of aphasia (Wernicke, Anomic, Transcortical motor), and healthy control speakers. Taken together, this suggests that pantomime gestures can potentially be a strong communicative tool for people with specific types of aphasia. However, not all people with aphasia who can produce pantomimes do so spontaneously. Some people with aphasia need to explicitly learn to shift from verbal communication to gesture communication during communication breakdown (Purdy and Koch 2006). A recent systematic review of the efficacy of gesture-based aphasia therapy (Rose *et al.* 2013) revealed that individuals with non-fluent or global aphasia can be taught a repertoire of communicative gestures. Many techniques for teaching pantomime use have focused on copying a pantomime produced by the therapist or producing a pantomime in response to a picture (Marshall *et al.* 2012) but this can be difficult for individuals with co-morbid limb apraxia. Few studies have attempted to shape naturally produced pantomime or gestures within a conversational context. Caute *et al.* (2013) did attempt to shape naturally occurring gesture production in their strategy use therapy and although the study was limited by a small n, results supported the idea that training positively impacted communication success. The current study adds weight to the idea that pantomimes can be an important communication tool for people with aphasia. Therefore, future studies could investigate how pantomimes can be integrated into interventions for people with aphasia, particularly emphasizing elicitation of pantomimes in as natural a context as possible and highlighting the opportunity for efficient message repair.

One of the limitations of the current study was the small number of samples used. In order to generalize our findings, the result requires replication with a larger sample. A second potential limitation concerns the possible priming that the student raters may have received about the potential for gestures to aid in message comprehension through the wording of the participant information sheet they received during study consent procedures. However, we believe the possibility of such priming having impacted the students' message comprehension to be very small. A final limitation concerns the lack of available detailed information about the participants' semantic and phonological processing. Unfortunately, the Aphasiabank database does not provide detailed semantic and phonologic processing data. Given that previous studies have suggested that semantic and phonological impairment impacts on the frequency, types and utility of gestures produced (e.g., Cocks *et al.* 2013, Hogrefe *et al.* 2012), future studies should examine the relationship between the communicative effectiveness of pantomime gestures in aphasia and participants' semantic and phonological processing abilities.

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