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Research Report

Integration of speech and gesture in aphasia

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Abstract

Background: Information from speech and gesture is often integrated to comprehend a message. This integration process requires the appropriate allocation of cognitive resources to both the gesture and speech modalities. People with aphasia are likely to find integration of gesture and speech difficult. This is due to a reduction in cognitive resources, a difficulty with resource allocation or a combination of the two. Despite it being likely that people who have aphasia will have difficulty with integration, empirical evidence describing this difficulty is limited. Such a difficulty was found in a single case study by Cocks *et al.* in 2009, and is replicated here with a greater number of participants.
Aims: To determine whether individuals with aphasia have difficulties understanding messages in which they have to integrate speech and gesture.
Methods & Procedures: Thirty-one participants with aphasia (PWA) and 30 control participants watched videos of an actor communicating a message in three different conditions: verbal only, gesture only, and verbal and gesture message combined. The message related to an action in which the name of the action (e.g., ‘eat’) was provided verbally and the manner of the action (e.g., hands in a position as though eating a burger) was provided gesturally. Participants then selected a picture that ‘best matched’ the message conveyed from a choice of four pictures which represented a gesture match only (G match), a verbal match only (V match), an integrated verbal–gesture match (Target) and an unrelated foil (UR). To determine the gain that participants obtained from integrating gesture and speech, a measure of multimodal gain (MMG) was calculated.
Outcomes & Results: The PWA were less able to integrate gesture and speech than the control participants and had significantly lower MMG scores. When the PWA had difficulty integrating, they more frequently selected the verbal match.
Conclusions & Implications: The findings suggest that people with aphasia can have difficulty integrating speech and gesture in order to obtain meaning. Therefore, when encouraging communication partners to use gesture alongside language when communicating with people with aphasia, education regarding the types of gestures that would facilitate understanding is recommended.

Keywords: gesture, integration, aphasia, comprehension.

What this paper adds

What is already known on the subject

A previously published study by Cocks *et al.* in 2009 explored a single participant with aphasia’s ability to integrate gesture and speech. This participant had difficulty integrating speech and gesture. When the participant had difficulty integrating, he more frequently relied on the gesture channel.

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What this paper adds to existing knowledge
The current study replicates and extends the study of gesture and speech integration by Cocks *et al.* by including 31 PWA and 30 control participants. PWA were significantly worse at integrating gesture and speech than the control participants. When the participants had difficulty integrating, they relied more frequently on the verbal channel

What are the potential or actual clinical implications of this work?
Some therapy approaches encourage communication partners to use gesture alongside language in order to facilitate comprehension for the person with aphasia. The findings of this study suggest that when the person with aphasia is required to integrate speech and gesture in order to obtain meaning, then using gesture alongside speech will not facilitate comprehension.

Introduction

We often produce gesture alongside speech, and these gestures are referred to as co-speech gestures. Some co-speech gesture is iconic, meaning that the hand movements visually 像，类似于 resemble the entity or action they depict and also 'bear a close formal relationship to the semantic content of speech' (McNeill 1992: 12). For example, moving arms back and forth in a running motion to communicate that the person being discussed was running. Co-speech iconic gestures increase the listener's understanding of the speaker's intention (Hostetter 2011), aid in the memory of the communicative message (Hostetter 2011) and increase the attention the listener pays to the speaker (Preisig *et al.* 2015).

Speakers can present information in speech and in gesture in various ways. The information in co-speech iconic gesture can be redundant (also referred to as congruent), incongruent or additive. In experimental studies of gesture comprehension, redundant or congruent gesture tasks are those in which a listener is presented with the same meaning in both speech and gesture, e.g., 'brush your teeth' said verbally, and combined with a stereotypical tooth-brushing gesture. In incongruent gesture comprehension tasks, a listener is presented with opposing information provided in gesture and speech, and the listener is directed to follow the verbal message. For example, a listener might be presented with the verbal message 'read your book' and a stereotypical tooth-brushing gesture. Additive gesture tasks are those in which the gesture adds additional meaning to the verbal message, e.g., the verbal message 'I cleaned them', with a stereotypical tooth-brushing gesture adding the specific information about the nature of the cleaning.

Additive iconic gestures in particular benefit communication between a speaker and a listener (Hostetter 2011). In this scenario, the listener must integrate the information provided by the gesture and the co-occurring speech to obtain the full meaning of the speaker's intention (Cassell *et al.* 1999, Hostetter 2011). For example, when someone says 'birthday cake' and gestures a round shape, the listener needs to integrate the information from both speech and gesture to determine that the speaker is talking about 'a round birthday cake'. To do this, the listener needs to attend to both gesture and language, obtain meaning from both modalities, and then integrate this meaning. The process of integration results in a gain in understanding of the speaker's intention; this gain is referred to as 'multimodal gain' (MMG) (Cocks *et al.* 2009, 2011b). If the listener only understands one modality or does not integrate the two modalities, then they only understand part of the speaker's message.

The integration of speech and iconic gesture during language comprehension requires attention to be divided between two modalities (Hostetter 2011). Thus, the process of simultaneously processing and then integrating gesture and language is likely to result in competition for cognitive processes. A growing body of research suggests that individuals with aphasia have difficulty with tasks that require divided attention. It is likely that people with aphasia experience difficulties when performing dual tasks either due to difficulties with allocating attentional resources, due to a reduction in the resources available or a combination of both (see Murray 1999 for a review). In particular, task performance is negatively affected when there is competition for shared resources (McNeil *et al.* 1991, Erickson *et al.* 1996). But these studies have mainly used a dual-task paradigm in which two *different* tasks are performed simultaneously or in which two *different* messages need to be processed (see Murray 1999 for a review). A task in which speech and gesture needs to be integrated for language comprehension, on the other hand, requires attention to be divided between two modalities in the *same* task, and requires the simultaneous processing and then integration of gesture and language containing different aspects of the *same* message. While such a task will not distinguish between the different theories of attention difficulties, the findings have important clinical implications.

Previous research has found that some individuals with aphasia have difficulties comprehending iconic gesture in isolation (e.g., Lambier and Bradley 1991). However, as only one modality is processed in these tasks, such findings do not explore whether difficulties with attention extend to comprehending messages conveyed by both gesture and speech.

The understanding of redundant gesture and the effect of incongruent gestures has also been explored in two previous studies on aphasia (Yorkston *et al.* 1979, Eggenberger *et al.* 2016). These authors found that the addition of redundant gesture increased the accuracy of comprehension for people with aphasia (Yorkston *et al.* 1979, Eggenberger *et al.* 2016) and that comprehension accuracy decreased when an incongruent gesture was present for both people with aphasia and healthy controls (Eggenberger *et al.* 2016). However, neither of these tasks investigated the relative contribution made by speech and gesture in comprehension tasks, and so neither set of findings extend to comprehending messages in which different information is conveyed by both gesture and speech.

Only one single case study explores the ability of individuals with aphasia to integrate speech and iconic gesture (Cocks *et al.* 2009). Cocks *et al.* (2009) explored whether an individual with aphasia and a group of control participants could integrate iconic gesture and speech to comprehend a message. Participants were presented with a series of videos that included scenes in which an actor both spoke and produced iconic gesture; scenes where she only spoke; and scenes where she only gestured. In this study, the researchers used a measure of integration termed MMG. This measure was used because integration is more than the sum of the two parts. When integration occurs, the certainty in decoding the message from multimodal input is higher than the certainty derived from separate considerations of each modality. We refer to such an increase as MMG. Such a gain occurs when two modalities mutually enhance their informativeness, in other words, when there is a synergistic effect of considering two modalities together while decoding (Kelly *et al.* 1999). To determine the gain in comprehension of the message in the scenes in which both speech and gestures were used (the multimodal condition), MMG was calculated. For a more detailed explanation of the calculation of MMG, see the data analysis section below.

The findings from the single case indicated that the participant with aphasia had a significantly lower MMG score than the control participants. When he was unable to integrate, he frequently chose the gesture match rather than the target, suggesting that he was allocating his attention to the gesture modality. In the current study we aimed to extend these findings with more participants with a range of aphasia profiles.

While we hypothesized that the findings of the current study would be useful theoretically in further understanding the attention difficulties people with aphasia have, there are also clinical implications. There are some therapy approaches for people with aphasia where conversation partners are encouraged to use gesture alongside verbal language. For example, in 'supported conversation for aphasia', the conversation partners of people with aphasia are trained to reveal competence in the speaker with aphasia by 'ensuring comprehension, e.g., using gesture, written key words, drawing, or resource material to make the topic of conversation clear' (Kagan 1998: 820). The details of what types of gestures to use are not clearly specified and the contribution these gestures make to the person with aphasia's understanding in these therapy approaches has not been formally investigated. It is likely, however, that the listener would need to integrate gesture and speech to obtain meaning in some scenarios. It is therefore essential to know whether people with aphasia can integrate gesture and language to aid in the design of similar therapy approaches.

The current study, therefore, aimed to determine whether a group of participants with aphasia (PWA) had more difficulty with an iconic gesture and speech-integration task than a group of control participants. It used the same methodology as Cocks *et al.* (2009) with a larger group of PWA. It was hypothesized that the PWA would have greater difficulty with the integration task than a group of healthy controls.

Materials and methods

Participants

Thirty-one PWA aged 36–93 years (mean = 60, SD = 14.63 years) were compared with 30 control participants aged 39–89 years (mean = 60.8, SD = 12.88 years). Control participants self-reported that they had no difficulty with hearing or vision that was not able to be corrected with a hearing aid or glasses. PWA were only included if they had no other neurological diagnoses other than a history of stroke. PWA had a range of aphasia types: anomic (15); conduction (8); Broca's (4); Wernicke's (4); and severities (mean aphasia quotient = 72.56, range 40.1–89.7) as indicated by the Western Aphasia Battery—Revised (WAB-R; Kertesz 2006). One of the PWA had previously taken part in a study on gesture production, and their integration results were published as background assessment information in Cocks *et al.* (2011a). Table 1 summarizes the participant data.

Materials and procedure

The participants were shown 21 video vignettes of an actor producing iconic gestures depicting common everyday actions (G), 21 video vignettes of an actor producing an iconic gesture that depicted common everyday actions accompanied by a verbal phrase (VG), and 21 still images of an actor accompanied by a verbal phrase (V).

Table 1. Participants with aphasia background information

Participant	Gender	Age (years)	Aphasia type according to the WAB-R	WAB-R Aphasia Quotient score	Auditory verbal comprehension score	Error preference
1	Male	65	Wernicke's	55.7	4.75	Gesture
2	Male	64	Wernicke's	62.8	5.60	Gesture and unrelated with equal frequency
3	Female	50	Wernicke's	72.5	5.85	Both verbal and gesture with equal frequency
4	Male	54	Brocas	58.4	5.90	Verbal
5	Male	46	Brocas	69.6	6.10	Gesture
6	Male	63	Wernicke's	74.2	6.10	Verbal
7	Male	73	Brocas	40.1	6.45	Verbal
8	Female	39	Anomic	71.2	6.90	Verbal
9	Male	65	Anomic	80.0	7.00	Verbal
10	Male	62	Brocas	62.5	7.15	Gesture
11	Male	93	Anomic	84.5	7.35	Verbal
12	Female	75	Conduction	46.1	7.35	Verbal
13	Male	78	Anomic	72.3	7.55	Verbal
14	Male	36	Anomic	82.3	7.55	Gesture
15	Female	73	Conduction	58.0	7.60	Unrelated
16	Female	58	Anomic	85.2	7.80	Verbal
17	Female	82	Conduction	54.0	7.90	Verbal
18	Male	46	Anomic	86.8	8.00	Verbal
19	Male	83	Conduction	80.0	8.00	Verbal
20	Male	48	Anomic	86.8	8.10	Verbal
21	Female	61	Conduction	78.8	8.30	Verbal
22	Female	49	Anomic	89.5	8.65	Verbal
23	Male	80	Conduction	70.1	8.65	Verbal
24	Male	73	Anomic	88.5	8.75	Verbal
25	Female	48	Anomic	83.2	8.90	Verbal
26	Female	47	Conduction	55.6	9.00	Verbal
27	Female	42	Anomic	81.4	9.00	Verbal
28	Female	44	Conduction	56.0	9.00	Verbal
29	Male	57	Anomic	85.2	9.50	Verbal
30	Male	67	Anomic	88.4	9.50	Verbal
31	Female	52	Anomic	89.7	9.95	Verbal

Note: WAB-R, Western Aphasia Battery—Revised.

The same procedure and resources were used as in Cocks *et al.* (2009). The still image was an image of the actor standing still with their hands by their side. The actor's face was covered in each condition to reduce the effect of facial expression on comprehension. The verbal phrases consisted of simple subject–verb or subject–verb–object sentences of high frequency, semantically simple verbs, e.g., 'I paid'; 'I cut it'. To reflect gesture produced in spontaneous speech, the gestures produced by the actor were vague and less detailed than pantomime gestures or simple signing systems. For example, the gesture for 'I cut it' involved a vague 'cutting with a knife'-like gesture. Participants were shown the 63 test items in a randomized order which was the same as Cocks *et al.* (2009). After each item, they were asked to select an image that 'best matched' the item from a selection of four photographs. Of the photographs, one represented a gesture match only (G match), one a verbal match only (V match), one an integrated verbal–gesture match (Target) and one unrelated foil (UR). The UR was semantically related to the gesture match and therefore unlikely to be selected in any of the conditions. Each test phrase was presented in each of the three conditions: V, G and VG. When presented in the VG condition, the target item was selected if the participant integrated the speech and gesture information. The target item could also be selected if the participant focused on just one modality (i.e., speech or gesture) and did not integrate the speech and gesture information. To determine any gain the participants obtained from integrating gesture and speech, as opposed to unimodal processing, MMG was calculated.

As in Cocks *et al.* (2009), the probability of the participants choosing the target item in the VG condition without integrating two modes of information was calculated (i.e., the probability that only one modality was used). This was referred to as P(Unimodal). This probability is estimated as a weighted mean of the proportion of trials in which the target item was selected in the V condition (WV) and the proportion of trials

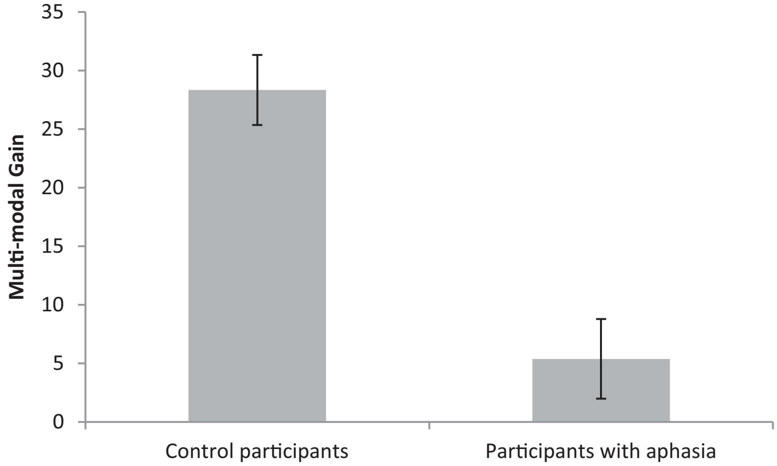

Figure 1. Mean multimodal gain (MMG) percentages for the control participants and participants with aphasia (PWA). Errors bars represent the standard error. The higher the percentage, the greater the gain obtained from integration.

in which the target item was selected in the G condition (WG). It was assumed that the modality, which the participants were more likely to use, was stronger and provided more accurate information, therefore WV and WG were estimated as normalized. Normalization ensures that the sum of the weights equals to one. MMG was used as an index to ascertain the extent that the two modalities were integrated in the VG condition. Therefore, MMG represents the likelihood that the VG condition was chosen by means of both modalities being integrated.

The G and V conditions were examined in more detail to determine whether the participants who had difficulty integrating were those who also had difficulty with these tasks in isolation.

Outliers in the data were identified by examining how often control participants chose the integrated target in the VG condition. For most items, the target was chosen by nearly all the control participants in the VG condition; however, 'I walked' fell more than 2 standard deviations below the mean and was therefore removed from the analysis. Similarly to Cocks *et al.* (2009), one control participant was also removed from the analysis as they only selected the target on six occasions in the VG condition. It is unclear why this participant had difficulties with integration.

Statistics

MMG and VG scores were compared between PWA and control participant groups using two *t*-tests, with a threshold of $p < 0.05$. The relationship between the number of participants from each group who selected the target in VG compared with either the V or the G condition, or both V and G conditions, was explored using a Fisher's exact test, with a threshold of $p < 0.05$.

Results

Multimodal gain

The MMG percentages were compared between the control participants and the PWA. The PWA had a significantly lower MMG score than the control participants, $t(58) = 5.06$, $p < 0.05$ (figure 1).

Multimodal condition

The number of times the target was selected in the VG condition was compared between the two groups of participants. Levene's test for equality of variance was significant ($p = 0.03$), so equal variance was not assumed and the degrees of freedom were adjusted from 58.00 to 53.44. The PWA selected the target in the VG condition significantly less than the control participants $t(53.44) = 2.46$, $p < 0.05$. Error pattern analysis revealed that both groups frequently selected the verbal match when they did not select the target in the VG condition (figure 2). Four PWA selected the gesture match more frequently than the verbal match or unrelated foil.

How often the target was chosen in the VG condition compared with the other modalities was then compared between the two groups. Fourteen of the 31 PWA selected the target in the VG condition less often than in either the V or the G condition, or in both V and G conditions. Comparatively only two of the 29 control participants selected the target in VG less often than either the V or the G condition, or both V and G conditions (table 2). An inspection of the demographic information about these two control participants did not indicate that there was anything unique about them. A Fisher's exact test indicated that there was a significant relationship for the number of participants from each group who selected the target in VG less often than

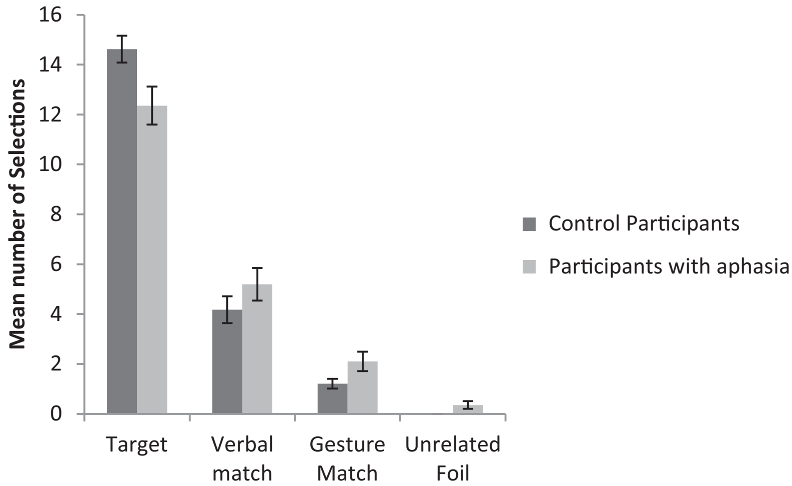

Figure 2. Mean number of selections by control participants and participants with aphasia (PWA) of the target (the correct response), the verbal match, gesture match and unrelated foil in the VG condition (21 items). Error bars represent the standard error.

Table 2. Selection of the target in VG compared with V and G conditions by group

	Selected the target more often in the VG condition than in the V or G conditions	Selected the target more often in the V or G, or both V and G conditions than in VG
Participants with aphasia	17	14
Control participants	27	2

either the V or the G condition, or both the V and G conditions ($p < 0.05$). Inspection of the profiles of the 15 PWA who selected the target in the VG condition less often than either the V or the G condition, or both the V and G conditions, revealed that this subgroup included participants with a range of aphasia types (Anomic = 6; Conduction = 5; Wernicke's = 3; Broca's = 1).

Verbal and gesture-only tasks

To determine whether participants were comprehending the verbal message in the verbal only task, the verbal match and target scores were combined. The control participants all obtained near ceiling scores of 90–100% accuracy (mean = 98.79%; SD = 2.55%). There was a greater range of scores from the PWA with scores ranging from 75% to 100%; however, the majority obtained near ceiling scores (mean = 95%; SD = 6.83%). The two participants who obtained scores of 75% were visually examined more closely to determine whether they also obtained the lowest MMG scores. They did not obtain lowest MMG scores.

To determine whether the participants were comprehending the gesture message in the gesture-only task, the gesture match and target scores were combined. The control participants again obtained near ceiling scores ranging from 85% to 100% (mean = 96.2%; SD = 4.93%). The PWA obtained scores ranging from 75% to 100% (mean = 92.74%; SD = 8.14%). Again, the two participants who obtained scores of 75% were visually examined more closely to determine whether they also obtained lowest MMG scores. They did not obtain the lowest MMG scores.

Discussion

This study is the first to look at how a large group of speakers with aphasia integrate gesture and speech, and it has findings of theoretical and clinical interest. The PWA were less able to integrate iconic gesture with speech than the control participants, suggesting reduced overall comprehension of the speaker's messages. Furthermore, almost half the participants selected the target less often in the integration condition than in the single modality conditions, indicating that understanding the message was worse in the integration task than in the single-modality conditions. That is, when the PWA were presented with visual *and* auditory information, they were less likely to understand the message accurately than they did when presented with either visual or auditory information. This suggests there is not an MMG associated with integration but instead a 'multimodal loss'. This seemingly counterintuitive finding supports the suggestion that people with aphasia have either reduced attentional resources, difficulties with allocating attention or a combination of these two difficulties (Murray 1999) because it suggests they are not processing all the available information.

The findings of the current study extend that of the single-case study (Cocks *et al.* 2009) in which the participant who had comprehension difficulties most frequently chose the gesture match when he was unable to integrate. Specifically, the data from the current study suggest there is not one error pattern of all people with aphasia.

Determining whether the difficulty lay with attention allocation, reduced resources or a combination is extremely difficult and indeed drawing a stark contrast between the different theories of attention difficulties was not the main aim of our research. We do suggest, however, that an attentional difficulty most likely lies at the core of the gesture–speech integration difficulty. The process of integrating speech and gesture requires an individual to attend to two modalities, obtain meaning from them and then integrate the information received from both modalities (Cocks *et al.* 2009, 2011b). Difficulties with attention allocation, reduced resources or a combination would result in the listener either attending to one modality more than another, not having sufficient attention to attend to either of the modalities, or not allocating or not having sufficient resources in order to integrate and obtain meaning. Current models of gesture and speech for the most part deal with the production of language rather than comprehension and thus can provide little insight into the interpretation of our findings.

Where our research has more to offer is that the study's findings have important clinical implications. There is evidence that encouraging conversation partners to use gesture alongside verbal language is a component of some therapy approaches (Kagan 1998). The findings from the current study suggest that if the person with aphasia is required to integrate gesture and speech to obtain meaning, then using gesture alongside language may not aid comprehension. These findings contradict the guidance around using iconic gesture alongside language to support clients' comprehension if the gesture is not redundant. As there is evidence to suggest that redundant gestures can aid comprehension (Yorkston *et al.* 1979, Eggenberger *et al.* 2016), this suggests that communication partners should have training about what appropriate and inappropriate gestures could be used alongside verbal language in order to facilitate comprehension. Appropriate gestures would be redundant gestures and inappropriate gestures would be additive gestures.

While the current study makes an important contribution to the field of research, it had some limitations. The stimuli were artificial in that an actor produced selected gestures alongside a chosen verbal message. This was required for the experimental design. Although this decision meant participants used identical resources, and that additional contextual information could not be used to aid interpretation, it might be argued that this means the results cannot be generalized to naturally produced gestures. However, comparing how a listener understands information in speech, gesture, and integrating speech and gesture naturalistically is likely to be challenging. This is because any more naturalistic study regarding speech and gesture is likely to introduce additional variables that may act as confounds (e.g., facial expression, tone of voice, contextual cues).

It is interesting that in both this study and that of Cocks *et al.* (2009), one control participant was removed as an outlier. It was unclear why these participants had difficulty with integrating speech and gesture. For example, these participants may have made a swift initial decision that the information in the gesture was redundant, and thus stopped attending to the gesture modality; they may have had difficulties with the task; or they may have presented with cognitive difficulties of which they were unaware. However, the presence of such participants in both studies suggests that this task may be difficult even for healthy controls.

The current study was the first to investigate how a group of PWA integrate speech and gesture. The findings suggest that future research in this area should focus attention on difficulties with resource allocation, resource capacity or a combination of both impacts on the ability of the people with aphasia to integrate gesture and speech. Clinical implications of the research suggest that caution should, therefore, be applied when recommending that communication partners use gesture alongside language in order to facilitate a person with aphasia's comprehension.

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References

Cassell, J., McNeill, D. and McCullough, K. E., 1999, Speech–gesture mismatches: evidence for one underlying representation of linguistic and non-linguistic information. *Pragmatics and Cognition*, **7**, 1–33.

Cocks, N., Dipper, L., Middleton, R. and Morgan, G., 2011a, What can iconic gestures tell us about the language system? A case of conduction aphasia. *International Journal of Language and Communication Disorders*, **46**, 423–436.

Cocks, N., Morgan, G. and Kita, S., 2011b, Iconic gesture and speech integration in younger and older adults. *Gesture*, **11**, 24–39.

Cocks, N., Sautin, L., Kita, S., Morgan, G. and Zlotowitz, S., 2009, Gesture and speech integration: An exploratory study of a case of a man with aphasia. *International Journal of Language and Communication Disorders*, **44**, 795–804.

Eggenberger, N., Preisig, B. C., Schumacher, R., Perkins, L., Hopfner, S., Vanbellingen, T., Nyffeler, T., Gutbrod, K., Annoni, J.-M., Bohlhalter, S., Cazzoli, D. and Müri, R. M., 2016, Comprehension of co-speech gestures in aphasic patients: an eye movement study. *PLOS One*, 11.

Erickson, R. J., Goldinger, S. D. and Lapointe, L. L., 1996, Auditory vigilance in aphasic individuals: detecting nonlinguistic stimuli with full or divided attention. *Brain and Cognition*, **30**, 244–253.

Hostetter, A. B., 2011, When do gestures communicate? A meta-analysis. *Psychological Bulletin*, **137**, 297–315.

Kagan, A., 1998, Supported conversation for adults with aphasia: methods and resources for training conversation partners. *Aphasiology*, **12**, 816–838.

Kelly, S. D., Barr, D. J., Church, R. B. and Lynch, K., 1999, Offering a hand to pragmatic understanding: the role of speech and gesture in comprehension and memory. *Journal of Memory and Language*, **40**, 577–592.

Kertesz, A., 2006, *Western Aphasia Battery—Revised* (San Antonio, TX: Harcourt Assessment).

Lambier, J. D. and Bradley, D., 1991, The effect of physical similarity on pantomime recognition in aphasia. *Aphasiology*, **5**, 23–37.

Mcneil, M., Odell, K. and Tseng, C. H., 1991, Toward the integration of resource allocation into a general theory of aphasia. *Clinical Aphasiology*, **20**, 21–39.

Mcneill, D., 1992, *Hand and Mind: What Gestures Reveal about Thought* (Chicago, IL: Chicago University Press).

Murray, L. L., 1999, Attention and aphasia: theory, research, and clinical implications. *Aphasiology*, **13**, 91–111.

Preisig, B. C., Eggenberger, N., Zito, G., Vanbellingen, T., Schumacher, R., Hopfner, S., Nyffeler, T., Gutbrod, K., Annoni, J. M., Bohlhalter, S. and Muri, R. M., 2015, Perception of co-speech gestures in aphasic patients: a visual exploration study during the observation of dyadic conversations. *Cortex*, **64**, 157–168.

Yorkston, K. M., Beukelman, D. R. and Waugh, P. F., 1979, A comparison of verbal, pantomime and combined instruction modes with severely aphasic individuals. Paper presented at the Clinical Aphasiology Conference, Phoenix, AZ, USA, 28–31 May, pp. 187–195.