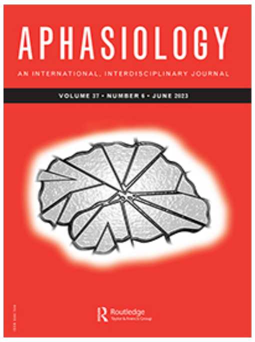

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Does Gesture Improve the Communication Success of People with Aphasia?: A Systematic Review

Naomi de Kleine[a], Miranda L. Rose[b,c], Michael Weinborn[a], Robert Knox[a] and Nicolas Fay[a]

[a]School of Psychological Science, University of Western Australia, Perth, Western Australia, Australia; [b]Centre of Research Excellence in Aphasia Rehabilitation Recovery, Melbourne, Victoria, Australia; [c]La Trobe University, Melbourne, Victoria, Australia

ABSTRACT

Background: Speakers with aphasia gesture, but the extent to which these gestures improve their communication success is unclear.
Aim: The primary aim is to assess if gesture improves the communication success of people with aphasia using a systematic review.
Methods & Procedures: Following the PRISMA protocol, we systematically reviewed the literature assessing the contribution of gesture to the communication success of people with aphasia. Multiple electronic databases were searched using specified keywords and MeSH explode. This identified 2177 articles, seven of which met our inclusion criteria.
Outcomes & Results: The included articles were reviewed in the context of three research questions, which concluded that: (1) the communication success of gesture is compromised in people with aphasia when compared to healthy language users, (2) gesture improves the communication success of people with aphasia beyond spoken language alone, and 3) apraxia severity impedes the communication success of gesture, whereas aphasia severity and semantic processing deficits do not.
Conclusions: This systematic review clarifies inconsistencies in the literature and confirms that gesture can improve the communication success of people with aphasia. This supports the continued use of gesture as a therapeutic intervention for people with aphasia.

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Aphasia is an acquired neurogenic language disability characterised by difficulties in speaking, listening, reading and/or writing (American Speech-Language-Hearing Association, 2017). The most common aetiology is stroke, with approximately 20-40 percent of stroke survivors acquiring aphasia (Dickey et al., 2010). Aphasia creates significant communication difficulties, affecting social, occupational, and recreational activities, and often leads to social isolation, loneliness, loss of autonomy and stigmatization (Simmons-

CONTACT Nicolas Fay nicolas.fay@gmail.com School of Psychological Science, University of Western Australia 35 Stirling Highway, Crawley, WA 6009 Australia

Mackie & Damico, 2009). It follows that improving the communication of people with aphasia can benefit their wellbeing, and the wellbeing of their family (Shadden, 2005).

Communication is multimodal (Clough & Duff, 2020). Words, grammar, tone, facial expressions, and gestures often combine to form a message. Therapeutic approaches for people with aphasia try to improve communication in these modalities (Pierce et al., 2019), with a specific focus on gesture as an alternative or as a complement to verbal expression (Hogrefe et al., 2013; Pierce et al., 2019; Rose, 2006). Among healthy language users, gestures are ubiquitous, occurring across all cultures and age groups (Kita, 2009). Gesture is innate; congenitally blind individuals who have never seen the gestures of others gesture when speaking, and even gesture while communicating with other blind individuals (Iverson & Goldin-Meadow, 1997, 1998). Babies gesture before they learn to speak, with a longitudinal study showing that gesture onset predicts language acquisition (Bates, 1976). Neuroimaging studies find shared neural substrates between gesture and speech (Gentilucci & Dalla Volta, 2008; Willems & Hagoort, 2007; Wolf et al., 2017), making gesture a natural and 'hardwired' component of communication. In addition to the ubiquity of gesture, gesture can facilitate speech (i.e., assists in word finding; Beattie & Shovelton, 2006) and complement speech by adding extra information (e.g., using the distance between the hands to indicate size; Alibali, 2005; Bates, 1976). Furthermore, gestures can be used as a stand-alone communication modality. For example, hearing adults and children can use gesture as their sole means of communication (Fay et al., 2013, 2014, 2022; Lister et al., 2021), and sophisticated manual languages, with the same expressive range as spoken language, rapidly emerge from the gestures used in interacting populations of deaf people (Sandler et al., 2005; Senghas et al., 2004).

Early research in aphasia argued that a breakdown in speech will be accompanied by a parallel breakdown in gesture (e.g., Buck & Duffy, 1980; Cicone et al., 1979). More recent research suggests that gestural abilities remain relatively intact in people with aphasia (de Beer et al., 2020; Akhavan et al., 2017; Cocks et al., 2013; Kong et al., 2015; Kong et al., 2019). A similar tension is seen in theoretical accounts of the cognitive processes involved in gesture and speech production (for a comprehensive synthesis of the literature, see Clough & Duff, 2020).

Growth Point Theory argues that speech and gesture are inseparable cognitive processes (McNeill, 1992, 2013; McNeill & Duncan, 2000). Other models contend that speech and gesture are integrated but separate systems (e.g., 'Levelt's Model', 'Sketch Model'; Gesture for Conceptualisation Hypothesis, and the 'Interface Model'; Levelt, 1989; de Ruiter, 2000; Zhang & Hinzen, 2022; Kita & Özyürek, 2003; respectively). For example, de Ruiter's (2000) Sketch Model argues that gesture and speech originate from a shared communicative intention but proceed to production via separate channels (de Ruiter, 2000; Hogrefe et al., 2017; Levelt, 1989). On this account gesture can assume a flexible and compensatory role when speech is restricted (trade-off hypothesis; de Ruiter, 2000). However, the successor to the Sketch Model, the AR-Sketch Model (de Ruiter, 2017) contends that the relationship between gesture and speech is no longer flexible and compensatory. On this revised account speech is the primary modality of communication and gesture can only express information that is redundant to speech.

Taken together, research in aphasia and theoretical models of gesture and speech production suggest varying degrees of cognitive differentiation between gesture and speech. The extent to which gesture is able to compensate for verbal-linguistic limitations in aphasia can provide insight into the independence of these cognitive processes. The primary aim of this systematic review is to assess if gesture can improve the communication success of people with aphasia.

Gesture Use, Form and Communication Success in Aphasia

Observational studies have shown that during conversation speakers with aphasia gesture (Goodwin & Goodwin, 2000). Indeed, several studies report higher gesture rates among people with aphasia compared to healthy controls (Butterworth & Hadar, 1989; Hadar, 1991; Sekine & Rose, 2013; Sekine et al., 2013). Furthermore, it has been shown that as language capacities improve post brain injury, gesture use decreases (Ahlsén, 1991; Beland & Ska, 1992). This suggests a compensatory role for gesture: as language ability decreased, gesture use increased; and as language ability improved, gesture use decreased.

In addition to an increase in gesture production rate, people with aphasia produce more iconic gestures than healthy controls (Carlomagno & Cristilli, 2006; Cicone et al., 1979; Cocks et al., 2013; Pritchard et al., 2015; Sekine et al., 2013). Iconic gestures can convey substantive information independently of speech (e.g., requesting a 'drink' by manually simulating a drinking action), making them a valuable resource for persons with a language impairment. Indeed, iconic gestures are found to improve the communication of people with aphasia by enhancing speech content, and by providing additional information to that carried by the speech channel (Kong, 2015, 2017; van Nispen et al., 2017). Note that these studies are primarily descriptive (of the different gestured forms used by people with aphasia), and the relationship between gesture frequency, gesture form and if gesture use improves listener comprehension (i.e., communication success) is not directly tested. Despite the finding that aphasia is associated with an increase in gesture frequency, and the production of iconic gestures, it is not clear if this improves "communication success" (Rose et al., 2017; de Beer et al., 2020). If gesture use improves communication success, this can inform theoretical models of gesture production (de Ruiter, 2000; Hogrefe et al., 2017; Levelt, 1989), and treatment methods. By contrast, if gesture use is unrelated to communication success (e.g., if gestural communication is also impaired), this raises important questions around the function of these gestures.

Typically, studies examining the extent to which gesture improves communication success among persons with aphasia make use of audio and visual recordings of their communication (i.e., gesture producers). These recordings are then presented to non-aphasic viewers (i.e., gesture interpreters) who try to identify (with some context) what the person with aphasia is communicating. To be clear, in these studies communication success is operationalised as whether or not the interpreter correctly understood the producer's intended message. This review focuses solely on studies that include an explicit and unambiguous quantitative measure of communication success (e.g., a 1 if correct and a 0 if incorrect). To determine the impact of aphasia on gesture, some studies compare the communication success of people with aphasia and non-aphasic control participants. To determine the contribution of gesture to communication success, other studies assess communication success when the person with aphasia does and does not use gesture. Interpreting the contribution of gesture to communication success is difficult because the studies often used different stimuli, task instructions and participant pools. Moreover, in some cases the results are conflicting (i.e., Mol et al., 2013; Rose et al., 2017). Therefore, we systematically reviewed the literature to better understand if gesture can improve the communication success of people with aphasia. If gesture improves communication success, then it reinforces its use as a therapeutic intervention for improving the communication of people with aphasia (Clough & Duff, 2020; Rose et al., 2013). For people with aphasia, being understood by those around them can have tremendous benefit to their wellbeing (Shadden, 2005).

Heterogeneity of Aphasia and its Impact on Gesture Use and Communication Success

"Aphasia" is a broad classification for a language disorder that is heterogeneous, with substantial individual differences in people's communication profile (Holland, 1982). The ability of people with aphasia to produce gestures shows significant heterogeneity (Rose et al., 2017). For example, some studies have reported that speakers with moderate aphasia produce less complex gestures than those with mild aphasia (Cicone et al., 1979; Glosser et al., 1986; Mol et al., 2013). Other studies show that gesture use increases with the severity of aphasia (Herrmann et al., 1989; Hogrefe et al., 2012), consistent with observations of higher gesture rates during periods of word finding difficulty (Cocks et al., 2013; Lanyon & Rose, 2009; Sekine & Rose, 2013). Furthermore, there is evidence of differences in how gesture is used across different types of aphasia (Kong et al., 2017). For example, Bates and Goodman (2013) found that people with non-fluent aphasia produced more whole-body gestures in the absence of speech and produced higher rates of gestures compared to those with other types of aphasia. This suggests that difficulties in language production lead to increased gesture use in communication, in line with the original Sketch Model's assumptions.

Comorbid neurological deficits have been found to impact the ability to produce gestures (Rose et al., 2017). Apraxia is an impairment in purposeful movements that frequently co-occurs with aphasia (Rothi & Heilman, 1997; van Nispen et al., 2018). Limb apraxia has been suggested to account for early research findings that show an impairment in the gestural capacities of people with aphasia (Mol et al., 2013; Nispen et al., 2016). In particular, studies have demonstrated that individual differences between people with aphasia and their ability to use pantomime gesture are predicted by the presence of ideomotor apraxia (Hogrefe et al., 2013; Mol et al., 2013; Nispen et al., 2016). However, other studies have found that apraxia did not predict the frequency of gesture (Feyereisen, 1988; Rose & Douglas, 2008). Therefore, the impact of limb apraxia on gesture use is unclear. Impaired semantic processing is another factor that might affect the gestural communication of people with aphasia. People with aphasia show considerable variability in the integrity of their semantic processing abilities (i.e., their capacity to understand semantic relationships between words and differentiate words on this basis: Nispen et al., 2016). Various studies have shown that semantic impairments limit the frequency, types and utility of the gestures produced (Cocks et al., 2013; Hogrefe et al., 2012, 2013; Kong et al., 2015).

To understand the extent to which aphasia impacts gesture and its capacity to improve the communication success of people with aphasia, the heterogeneity of aphasia presentation must be considered. More broadly, discerning the nuances of how these related factors impact on the success of gestural communication may inform our theoretical understanding of the cognitive processes required to gesture and assist in treatment planning for people with aphasia. For example, if problems with semantic processing impede the communication success of gesture, this could guide clinicians to choose other treatment approaches. Thus, measurements of aphasia severity, limb apraxia and semantic processing were reviewed in the context of the studies included in the systematic review.

Aim

To examine the communicative benefit of gestures for people with aphasia through a systematic review and synthesis of the relevant literature. Two primary questions were examined:

(1) Is the communication success of gesture compromised in people with aphasia compared to healthy language users?
(2) To what extent does gesture improve the communication success of people with aphasia?

Because of the lack of clarity around the impact of the heterogeneity of aphasia presentation and associated neurological impairments on gesture production, a third question was addressed in the review process. Specifically,

(3) To what extent does aphasia severity, apraxia, and semantic processing moderate the communication success of gesture?

Method

Literature Search

A systematic search of the literature was conducted in August 2022 and updated in March 2023, using electronic databases (Keyword and MeSH explode) for published articles (Embase, Google Scholar, PubMed, Medline, AMED, CINAHL plus, Scopus, PLOS one, PsychINFO, and ERIC), grey literature (OpenGrey), and conference proceedings (Conference Proceedings Citation Index: Science). The search terms included Aphasi* AND Gest* OR sign OR signal OR "body language" OR "hand movement*" OR "nonverbal communication" OR nonverbal AND Communica* OR message OR transmi* OR exchange OR interaction OR conversation OR "connected speech" OR discourse OR monologue.

Additional relevant articles were retrieved from the reference lists of studies included in the original search, conference proceedings and dissertations. The processing of the review was conducted with Covidence software (https://www.covidence.org/) and is outlined in the PRISMA flow diagram in Figure 1. No limits for date of publication were applied, and duplicates from the total search were removed.

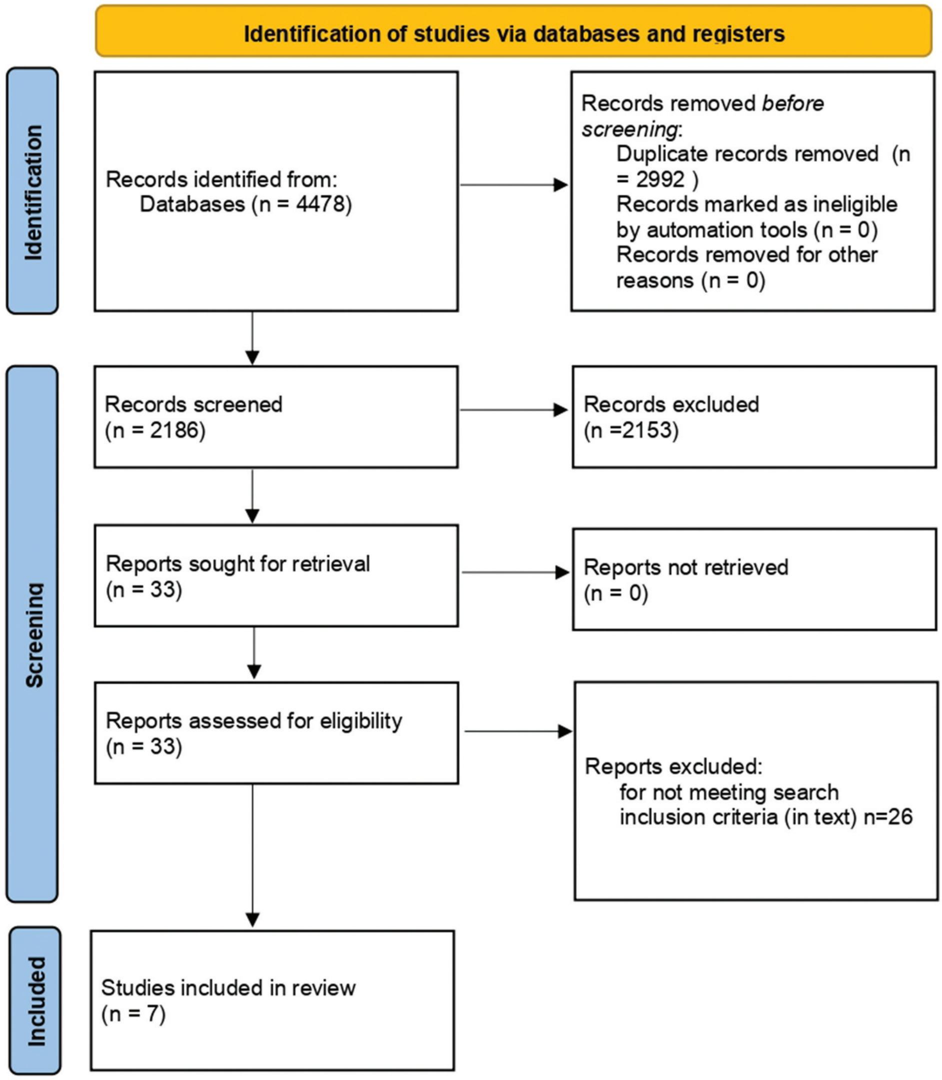

Figure 1. PRISMA flow diagram of search method. Template adapted from Page et al. (2021).

Study Selection

Resulting titles and abstracts were screened by two independent reviewers (NDK and RK), and evaluated for eligibility based on the presence of five criteria: (i) The study involved adults with aphasia (≥18 years), (ii) the study examined gesture use by people with aphasia, (iii) the study examined the impact of aphasia on gesture use in comparison to healthy language users (between-subject studies) OR the study examined whether gesture use improved communication success above that of verbal communication for people with aphasia (within-subject studies), (iv) the study measured the communication success of gesture, and (v) the study contained original data (including studies that used AphasiaBank, a shared database of multimedia interactions for the study of communication in aphasia). These criteria were initially evaluated on a subset of 100 titles and abstracts, with an inter-rater reliability of 85% 'agreeance' on inclusion for full text review.

Throughout the screening process, any discrepancies regarding the inclusion of a study were resolved by discussion between the two reviewers. All identified studies were then presented to all authors who agreed on their inclusion. This process resulted in a corpus of 7 articles included in the review, see Figure 1.

Data Extraction

The data for each of the included studies was extracted by the first author. An extraction template was created and included authors, year and publication source, data fields for sample size, demographics, aphasia-related measures (severity, time since brain injury, apraxia measure, hemiparesis, and other neuropsychological measures), and outcome measures. The final seven articles were grouped based on our two primary research questions (people with aphasia versus healthy controls, communication success with or without gesture) and the gesture elicitation task (conversation, story retell, naming, and scenario; see results).

Methodological quality

The studies varied in their methodological design, with one study being a single case observational study (Duffy et al., 1984) and the other six studies using post-observational experimental designs (see: results, *Study Design*). Methodological quality was not formally rated with a scale. Instead, a critical review is included in the results section below.

Results

Question 1: is the communication success of gesture compromised in people with aphasia compared to healthy language users?

Four studies compared the success of gestural communication in people with aphasia and healthy language users (control) (Duffy et al., 1984; Hogrefe et al., 2017; Mol et al., 2013; van Nispen et al., 2018).

Study Design

All four studies followed the same experimental format: 'producers' (adult participants with aphasia and healthy controls) communicated a series of referents to 'interpreters' (healthy adults). The referents and format for testing varied across studies.

Picture naming

In this design, producers communicated objects from a set of pictures using only gesture. Duffy et al. (1984) used a sample of 23 pictures selected by the experimenter, and in Nispen et al. (2018) a set of 30 pictures taken from the Boston Naming Test were sampled

(Kaplan et al., 1983). Producers in Duffy et al. (1984) communicated the referent in front of an interpreter who tried to pick out the picture being communicated from an array of four pictures (visible to the producer). In Nispen et al. (2018) producers communicated in front of a video camera, with recordings later shown to a sample of interpreters who either interpreted the recording in an unconstrained open-ended format or identified the correct picture from a constrained multiple choice sample of four pictures. That is, interpreters in Nispen et al. (2018) were split between the two different response formats.

Story retell

Hogrefe et al. (2017) conducted a story retell task. Here, producers communicated content from three Mr. Bean comedy clips and three Sylvester and Tweety cartoon videos in a "vivid and illustrative manner" in front of a camera. Gesture and speech were permitted, although no explicit instructions were given. Control participants performed the same task plus an additional task; they were instructed to communicate the clips silently via gesture only (control-silent), a condition the authors argued to be comparable to the constraints of aphasia. Silent video recordings of all producers (with aphasia and control participants) were then shown to groups of interpreters who tried to pick out from the list of six clips which clip was being communicated by the producer.

Scenario test

Mol et al. (2013) required participants with aphasia and control producers to communicate two pictorial scenarios (sampled from an experimental version of the Scenario Test; Meulen et al., 2010). Gesture and speech were permitted, although no explicit instructions were given. In addition, control producers communicated the scenarios in a second task; they were instructed to communicate the scenarios silently via gesture only (control-silent). Video recordings of producers were presented to interpreters with both video and audio, video only (no sound), or audio only (no video). Interpreters selected which scenario was being communicated from two alternatives. The communication of each producer from each participant group (with aphasia, control and control-silent) in each video presentation type (audio+video, audio-only, video-only) were interpreted by a different set of interpreters.

Participant characteristics

Characteristics of People with Aphasia

The average age of participants across the studies reviewed was 53.4 years (SD = 5.4). There were more participants with aphasia that were male than female (average 69% male), see Table 1. Participants in Nispen et al. (2018) had also been sampled in two previous studies (Nispen et al., 2016, 2017). The recruitment source of the two participants in Duffy et al. (1984) was not reported. Otherwise, the majority of participants were recruited from hospital and rehabilitation centers.

All four studies tested people from a heterogeneous sample of aphasia syndromes and severity (see Table 2 for an overview). Participant inclusion criteria varied, with Duffy et al. (1984) and Hogrefe et al. (2017) limited to severe aphasia. Standardised aphasia and apraxia assessments varied across studies. The average number of months' post stroke

Table 1. Characteristics of People with Aphasia.

		Total # participants	# male	Age: mean (SD); min, max	Years of education mean (SD)	Aphasia severity: mean (SD); min, max	Months post stroke: mean (SD); min, max	Limb apraxia: mean (SD); min, max	Hemiparesis/ Hemiplegia: # participants
Q1	Duffy et al. (1984)	2 (A & B)	2	n/a; A = 28 and B = 66		A = 1[a] B = 1[a]	A = 26 B = 1	Not reported	A = right hemiplegia B = none
	Nispen et al. (2018)	38	26	58.74 (9.56); min = 32 max = 74		33.13 (14.36) min = 2 max = 50[b]	13.3 (14.7) min = 3 max = 64	40.37 (13.44) min = 4 max = 53[c]	
	Hogrefe et al. (2017)	30	22	50.8 (9.5) min = 34 max = 68		≤ 2 (mode=1) min = 0 max = 2[d]	46.89 (42.72) min = 2 max = 191	40.33 (13.76) min = 6 max = 54[c]	Hemiparesis = 21 Residual = 3 None = 6
Q2	de Beer et al. (2017)	10	7	55.1 (11.5) min = 37.8 max = 76.3		66.9 (9.21); min = 49, max = 80.1[e]	66.6 (36.02) min = 12, max = 109.2		
	Rose et al. (2017)	13	9	67.6 (9.86) min = 47.2 max = 80.9	15.15 (2.54)	64.7 (21.1) min = 17 max = 89.5[e]	113.6 (107.1) min = 9, max = 360		Hemiplegia = 9 Hemiparesis = 3 No = 1
	Hogrefe et al. (2013)	16	9	48.44 (12.05) min = 29 max = 67		2.31 (1.14) min = 0 max = 4[d]	34 (20.89) min = 2, max = 124	45.43 (7.41) min = 24 max = 53[c]	Hemiparesis = 6 Residual = 4 No = 6
Q1 & Q2	Mol et al. (2013)	25	16	56.92 (10.86) min = 37 max = 71	10.56 (3.14)	22.56 (11.65) min = 10, max = 43[f]	25.6 (40.16) min = 1, max = 152	13.27 (5.12) min = 2 max = 18[g]	Severe hemiplegia = 9 Moderate hemiplegia = 7 None = 6 not reported = 3

Note. Blank cell indicates that it was not assessed/reported; A= participant nonfluent, B = participant fluent in Duffy & Duffy (1984); [a]= Boston Aphasia Severity Rating Scale (Goodglass et al., 1972); [b] = Akense Aphasia Test (Graetz et al., 1991); [c] = pantomime to command task (Goldenberg et al., 2003, 2007); [d] = Akense Aphasia Test verbal communication subtest (Graetz et al., 1991); [e] = WAB-R = Western Aphasia Battery – Revised (Kertesz, 2007); [f] = ANELT -Amsterdam-Nijmegen Everyday Language Test; [g] = "clinical assessment", assessment measure not reported.

was 60 (SD = 51). The primary language of participants with aphasia varied (Dutch: Mol et al., 2013; Nispen et al., 2018; German: Hogrefe et al., 2017; English: Duffy et al., 1984).

Healthy control participant characteristics

Healthy control participants ranged in age from 22 to 77. Control participants were age matched to the participants with aphasia in Mol et al. (2013). Half of the control participants in Duffy et al. (1984) and Nispen et al. (2018) were restricted to the left arm only during the communication tasks. This was done to match the hemiplegia present in some of the participants with aphasia. Additional demographic information is reported in Table 3.

Interpreter participant characteristics

Demographic information was not consistently reported. Of note, in Duffy et al. (1984) the interpreters for each producer with aphasia were acquaintances or family members, whereas all four interpreters of the control producers were unfamiliar with the producer. In the other three studies, interpreters were unfamiliar to the producers (with aphasia and healthy controls). The number of interpreters in Hogrefe et al. (2017) was not reported. Additional demographic information is reported in Table 4.

Outcomes

Communication success was operationalised differently across studies, see Table 5. Statistical analysis approaches also varied across studies: ANOVA (Mol et al., 2013; Nispen et al., 2018), Mann-Whitney U (Hogrefe et al., 2017), and in Duffy et al. (1984), no inferential statistics were performed.

In the two picture naming tasks (Duffy et al., 1984; Nispen et al., 2018), producers (with aphasia and control) were restricted to the gesture modality. Communication success was higher for control participants than participants with aphasia. In the other two studies (story retell, Hogrefe et al., 2017; and scenario test, Mol et al., 2013), participants with aphasia communicated clips in any modality available to them. In these studies, healthy controls communicated the same stimuli in two conditions: in any modality (matching the task instructions for participants with aphasia) or using gesture only (to simulate the pragmatic limitations of aphasia). Note that for all producers (with aphasia and control), only silent video recordings of their communications were shown to the interpreters. When the control participants' communication was unrestricted, the results were mixed. Hogrefe et al. (2017) found communication success to be higher among participants with aphasia compared to control participants, whereas Mol et al. (2013) found the opposite pattern (i.e., communication success was higher among control participants). When healthy controls were restricted to gesture, the control participants' gestures were identified with more success than participants with aphasia.

Across all four studies, when control participants' communication was restricted to the gesture modality, control participants' gestures were more successfully interpreted than participants with aphasia's gestures. By contrast, when control participants' communication was unrestricted, one study found that participants with aphasia's gestures were more successfully interpreted than control participants (Hogrefe et al., 2017). We believe this unexpected finding should be discounted for methodological reasons. In this study control

Table 2. Distribution of Aphasia Syndromes.

		Broca	Wernicke	Conduction	Global	Anomic	Trans cortical	Residual	Non classifiable	Unknown	Total sample
Q1	Duffy & Duffy (1984)	1	1								2
	Nispen et al. (2018)	16	4		7	5			6		38
	Hogrefe et al. (2017)	4	7		16		3				30
Q2	de Beer et al. (2017)	5	2	3							10
	Rose et al. (2017)	5		6		1	1				13
	Hogrefe et al. (2013)	3	5		1	4	1	1	1		16
Q1 & Q2	Cicone et al. (1979); Duffy et al. (1984); Mol et al. (2013)	3	3	1	7	1			6	4	25
Total % sample Q1		24 (25.3%)	15 (15.8%)	1 (1%)	30 (31.6%)	6 (6.3%)	3 (3.2%)		12 (12.6%)	4 (4.2%)	95
Total % sample Q2		16 (25%)	10 (15.6%)	10 (15.6%)	8 (12.5%)	6 (9.3%)	2 (3.1%)	1 (1.6%)	7 (10.9%)	4 (6.3%)	64
Total % sample Q1 & Q2		37 (27.6%)	22 (16.4%)	10 (7.5%)	31 (23.1%)	11 (8.2%)	5 (3.7%)	1 (0.7%)	13 (9.7%)	4 (3%)	134

participants likely expected that interpreters would have access to their entire communication, and therefore were more reliant on speech than gesture. But silent video playback to interpreters excluded their spoken communication, which is likely to have disadvantaged their communication. This is less of an issue for participants with aphasia who relied more on gesture than speech given the severity of their aphasia. Therefore, discounting this study on methodological grounds, we conclude that gestural communication success is compromised in aphasia compared to healthy language users.

Question 2: to what extent does gesture improve the communication success of people with aphasia?

The second question addressed by this review is the extent to which gesture can improve the communication success of people with aphasia. Four studies, published between 2013 and 2017, examined this question (de Beer et al., 2017; Hogrefe et al., 2013; Mol et al., 2013; Rose et al., 2017). In each study only people with aphasia were tested (i.e., contrary to the Question 1 studies, there were no healthy control participants).

Table 3. Healthy control participant characteristics.

	# Control participants	Age (years): mean (SD)	Age range (years)	# male	Recruitment source
Duffy & Duffy (1984)	4	22, 24, 56, 60		4	
Nispen et al. (2018)	20		32 to 65	5	
Hogrefe et al. (2017)	16	51.1 (11.3)	33 to 72	7	
Mol et al. (2013)	17	54.06 (11.09)	33 to 77	9	Tilburg University

Note. Blank space indicates information was not reported.

Table 4. Interpreter participant characteristics.

		# participant interpreters	# male	Age (years): mean (SD)	Age range (years)	Recruitment source
Q1	Duffy & Duffy (1984)	6	1			
	Nispen et al. (2018)	273		21 (4)		Tilburg University and Hogeschool Rotterdam
	Hogrefe et al. (2017)	Unclear ~18 ??				
Q2	de Beer et al. (2017)	60	4	22.72 (4.01)	min = 19 max = 42	Undergraduates – La Trobe University
	Rose et al. (2017)	67				Undergraduates – La Trobe University
	Hogrefe et al. (2013)	18	9	34 (?)	min = 21 max = 60	Not reported
Q1 & Q2	Mol et al. (2013)	109				Tilburg University

Note. Blank cell indicates information was not reported in article

Table 5. Outcomes.

	Task	Authors	Communication Success calculation	Conditions	Results
Q1	Picture naming	Duffy & Duffy (1984)	Percentage correctly guessed items for each producer.	PWA-s CONTROL-s	CONTROL accurate 97%, PWA accurate 55% and 57% (participant a & b respectively)
	Picture naming	Nispen et al. (2018)	MCQ: 3 judges per item, average correct per item, average of item average per individual; OQ: correct identification per item, average across items per individual	PWA-s CONTROL-s	CONTROL-s > PWA-s MCQ: $F(1,56) = 33.30$, $p < .001$, $\eta2 = .31$ OQ: $F(1,56) = 56.95$, $p < .001$, $\eta2 = .50$.
	Story retell	Hogrefe et al. (2017)	Number correctly guessed responses divided by total responses given per individual	PWA CONTROL CONTROL-s	PWA > CONTROL Mann Whitney U, $Z = \_2.6$, $p < 0.01$ CONTROL-s > PWA Mann Whitney U, $Z = \_3.8$, $p < 0.001$
	Scenario test	Mol et al. (2013)	Number correctly guessed responses divided by total responses given for each modality per individual	PWA CONTROL CONTROL-s	CONTROL > PWA (moderate aphasia) for clips presented in all modalities (visual $F(1, 29) = 4.39$, $p < .05$, h p2 = .13; audio $F(1, 29) = 18.77$, $p < .001$, h p2 = .39; audiovisual $F(1, 29) = 18.71$, $p < .001$, h p2 = .39) CONTROL-s > PWA (moderate aphasia) in all comparable modalities (visual-visual $F(1, 29) = 69.53$, $p < .001$, h p2 = .71; audiovisual-visual $F(1, 29) = 13.56$, $p < .01$, h p2 = .32)
Q2	Conversation	de Beer et al. (2017)	Percentage correctly guessed items for MCQ and OQ	Gesture + speech Speech only	G+S > S $Z = -6.729$, $p = .00$[a]
	Conversation	Rose et al. (2017)	Total score on OQ or total number correct choices on MCQ for each producer	Gesture + speech Speech only Co-speech gesture	G+S > G G+S > S OQ: $F(2, 132) = 91.84$, $p < 0.001$, $r = 0.64$ S > G; MCQ: $F(2, 132) = 12.60$, $p < .001$, $r = 0.04$;
	Story retell	Hogrefe et al. (2013)	Mean communication success multiplied by mean confidence rating for each producer	Co-speech gesture Silently gesture Speech only	G < G-s $t(15) = -3.40$, $p < .005$ S ~ G-s (Spearman, rho = .55, $p < .05$)
	Scenario test	Mol et al. (2013)	Number correctly guessed responses divided by total responses given for each modality per individual	Gesture + speech Speech only	G+S > S *Severe aphasia: $F(1, 28) = 12.54$, $p < .01$, h p 2 = .31 ^Moderate aphasia: $F(1, 28) = 11.12$, $p < .01$, h p 2 = .28

Study design

All four studies followed the same basic experimental format outlined in Question 1: producers with aphasia communicated a referent which healthy adult "interpreters" later tried to identify. The referents and testing format varied across studies.

Conversational samples

de Beer et al. (2017) and Rose et al. (2017) used recordings of participants with aphasia in conversation (taken from the Aphasia Bank database; MacWhinney et al., 2011). The experimenters selected clips where a gesture was produced. Selection criteria varied across studies (see methods Rose et al., 2017 and de Beer et al., 2017). Recordings from de Beer et al. (2017) were presented to interpreters either with or without audio (i.e., gesture + speech or gesture only), while Rose et al. (2017) included a speech only condition (i.e., gesture + speech, gesture only or speech only). Interpreters wrote their interpretation of the clip in an unconstrained open-ended format, and then responded to a constrained multiple-choice question. The multiple-choice questions consisted of the target message plus four distractor messages (designed by the researchers). In Rose et al. (2017), one point was awarded for selecting the correct response, and 0 points for any of the four other response options. de Beer et al. (2017) awarded the correct response (message from gesture + speech) with 3 points, a gesture and speech distractor with 2 points, the speech only message with 1 point, and 0 points for the speech only distractor.

Scenario test

Mol et al. (2013) required participants with aphasia to communicate two pictorial scenarios (sampled from an experimental version of the Scenario Test; Meulen et al., 2010). Gesture and speech were permitted, although no explicit instructions were given. Video recordings of producers were presented with both video and audio (audio+video), video only (no sound), or audio only (no video). Interpreters selected from the two scenarios which scenario was being communicated. Each presentation type (audio+video, audio only, video only) was judged by a different set of interpreters.

Participant characteristics

Characteristics of People with Aphasia

All four studies reviewed included a small sample of participants with aphasia (N = 10 - 25; see Table 1 for participant demographics). The average age of participants across studies was 57 years (SD = 11 years). There were more male participants with aphasia than female (average 64% male). Producers with aphasia from de Beer et al. (2017) and Rose et al. (2017) were sampled from the Aphasia Bank database (MacWhinney et al., 2011). Although the participants sampled in these studies differed in age and aphasia severity, it is possible there was an overlap in the producers sampled across studies. In the remaining two studies, producers with aphasia were recruited from hospital (Hogrefe et al., 2013) and community rehabilitation centers (Hogrefe et al., 2013; Mol et al., 2013).

All four studies tested a heterogeneous sample of aphasia syndromes, with non-fluent aphasia the most common Table 2. Inclusion criteria across studies was broad (i.e., "stroke resulting in acquired aphasia"), with the exception of de Beer et al. (2017) who sampled only participants with aphasia presenting with a primary production deficit, relatively preserved receptive processing and no history of depression.

Descriptive statistics for producers with aphasia are reported in Table 1. The minimum time post-stroke varied across studies, with the average time post injury being 60 months (SD = 51). Across studies, a range of assessment measures for aphasia severity and limb apraxia were used. The primary language of the participants with aphasia varied across studies (English = 2, Rose et al., 2017 & de Beer et al., 2017; German = 1, Hogrefe et al., 2013; Dutch = 1, Mol et al., 2013). In addition, there was a large range of aphasia presentations reflected in the participants sampled.

Interpreter participant characteristics

Demographic information was not consistently reported. The number of interpreters varied between 18 (Hogrefe et al., 2013) and 109 (Mol et al., 2013), see Table 4. In each study interpreters were unknown to the producers with aphasia.

Outcomes

Communication success was operationalised differently across studies, see Table 5. Statistical approaches also varied across studies: Wilcoxon signed-ranks tests (de Beer et al., 2017); paired sample t-tests (Hogrefe et al., 2013); ANOVA (Rose et al., 2017; Mol et al., 2013).

We start by examining the results when people with aphasia were permitted to communicate in any modality available to them. To determine if gesture contributed to communication success, communication success in the gesture and speech modalities was compared to the speech only modality. Here, the clips presented to the interpreters that included the audio and visual channels (i.e., gesture and speech) were interpreted with greater success than the audio-only clips (i.e., speech-only; Rose et al., 2017; de Beer et al., 2017). Note that in Mol et al. (2013), this pattern of results was observed for participants with severe aphasia on one scenario in the Scenario Test (accident scenario; on the sweater scenario there was a null effect of the communication condition). For participants with moderate aphasia, gesture plus speech outperformed speech-only on the other scenario (sweater scenario; on the accident scenario there was a null effect of the communication condition). Overall, the inclusion of gestures by people with aphasia improved communication success beyond that of spoken expression alone.

To determine if speech contributed to communication success, Rose et al. (2017) compared communication success in the gesture and speech modalities (audio + visual) to the gesture only modality (video-only). The authors found that clips presented with both the audio and visual channels (i.e., gesture and speech) were more successfully interpreted than clips communicated by gesture alone (Rose et al., 2017). This indicates that the inclusion of speech improved communication success beyond that of gesture alone.

To determine the relative contribution of speech and gesture to communication success Rose et al. (2017) compared communication success in the speech only modality (audio-only) to the gesture only modality (video-only). They found that communication success was higher for speech than for gesture, concluding that speech is more important to communication success than gesture. However, we argue this conclusion should be discounted for methodological reasons. In this study, the producers expected the interpreters to have access to their entire communication, i.e., their gestures and their speech. Had they known their speech would not be available to the interpreters they may have relied more on the gesture modality to compensate for the absence of the speech channel. This was confirmed in Hogrefe et al. (2013) who showed that communication success was higher when participants were instructed to communicate exclusively using gesture (i.e., a silent gesture condition) compared to when permitted to use gesture and speech and only their gestures were shown to interpreters. Examining communication success when participants with aphasia are instructed to communicate exclusively using gesture or exclusively using speech allows a direct comparison between the gesture and speech modalities. This was tested by Hogrefe et al. (2013). Here, the authors found that communication success in the gesture modality was comparable to the speech-only modality. Thus, these studies suggest an important contribution by both gesture and speech to the communication success of people with aphasia. Taken together, we conclude that the communication success of people with aphasia is enhanced by gesture.

Question 3: To what extent does aphasia severity, apraxia and semantic processing moderate the communication success of gesture?

Aphasia severity

The relationship between aphasia severity and communication success was examined across several studies included in this review. Note that higher scores on tests of aphasia severity indicate milder aphasia, and lower scores indicate more severe aphasia. Consistent with aphasia being a language impairment, we would expect that more severe aphasia will be associated with lower communication success in the speech modality (i.e., a positive relationship between aphasia severity and communication success). The relationship between aphasia severity and communication success in the gesture modality is less clear. If aphasia severity is associated with an impairment in gesture production, there will be a positive relationship between aphasia severity and communication success. By contrast, if gesture production is unaffected by aphasia severity there will be no statistical evidence of a relationship between aphasia severity and communication success. To examine the relationship between aphasia severity and communication success, Mol et al. (2013) analysed aphasia severity categorically (low vs high severity). The other studies treated aphasia severity as a continuous variable using correlational analyses (de Beer et al., 2017; Rose et al., 2017; Hogrefe et al., 2013, 2017; Nispen et al., 2018) and regression (Nispen et al., 2018). The results are summarised in Table 6.

Consistent with aphasia being a language impairment, three of the four studies found that more severe aphasia was associated with lower communication success in the speech modality (Hogrefe et al., 2013, 2017; Mol et al., 2013). de Beer et al. (2017) found no relationship between aphasia severity and the communication success of speech. Of primary interest to the current review is the extent to which communication success in the gesture modality is affected by aphasia severity. In studies where participants with aphasia were permitted to communicate in any modality (gesture+speech), and interpreters viewed the video-only recordings (gesture-only), there was no statistical evidence

Table 6. Relationship between measures of aphasia severity and communication success.

			Gesture + speech	Speech	Gesture	Gesture-silent restricted
Correlation	de Beer et al. (2017)	WAB-AQ	$r_s = -.055$	$r_s = .146$		
	Rose et al. (2017)	WAB-AQ	OQ: $r_s = 0.57$ MCQ: $r_s = 0.04$	OQ: $r_s = 0.62$ MCQ: $r_s = 0.64$	OQ: $r_s = - 0.04$ MCQ: $r_s = - 0.41$	
	Hogrefe et al. (2013)	AAT verbal comprehension		$r_s = 0.85$*	$r = - 0.34$	$r = 0.25$
	Hogrefe et al. (2017)	AAT naming & Token test			Naming: $r = 0.34$ Token Test: $r = 0.11$	
Regression	Nispen et al. (2018)	AAT				Authors indicate severity was not a significant contributor in regression, however results not reported
ANOVA	Mol et al. (2013)	ANELT	$F(1, 14) = 199.39$, $p < .001$	$F(1, 14) = 7.68$, $p < .02$	$F(1, 14) = 163.46$, $p < .001$	

Note. Bold text indicates significant correlation at $p<0.05$ level; * indicates significant at $p<0.001$ level. WAB-AQ = Western Aphasia Battery – Aphasia Quotient (Kertesz, 2007); AAT = Akense Aphasia Test (Graetz et al., 1991); ANELT = Amsterdam-Nijmegen Everyday Language Test; OQ = open ended question response format; MCQ = multiple choice question response format.

of a relationship between aphasia severity and communication success in three of the four studies reviewed (Rose et al., 2017; Hogrefe et al., 2013, 2017). Mol et al. (2013) found that more severe aphasia was associated with lower communication success in the gesture modality. In the two studies where people with aphasia communicated exclusively using gesture (i.e., a silent gesture condition), and interpreters viewed the video-only recordings, there was no statistical evidence of a relationship between aphasia severity and communication success (Hogrefe et al., 2013; Nispen et al., 2018). So, whereas a majority of studies (three of four) found that aphasia severity was associated with lower communication success in the speech modality, a majority of studies (four of five) found no evidence of a relationship between aphasia severity and communication success in the gesture modality. We conclude that gesture is less affected by aphasia severity than speech.

Apraxia

The relationship between limb apraxia and communication success was examined in four studies (Nispen et al., 2018; Hogrefe et al., 2013; 2017; Mol et al., 2013), see Table 1. Consistent with limb apraxia being an impairment in a person's ability to make purposeful movements, we hypothesised that more severe apraxia will be associated with lower communication success in the gesture modality. Three studies measured limb apraxia with the Pantomime to Command Task, in which participants are asked to show how they would use a tool, e.g., a toothbrush (Goldenberg et al., 2003, 2007). Here, the studies found that more severe apraxia was associated with lower communication success (Nispen et al., 2018; Hogrefe et al., 2013, 2017). This relationship remained when extended to regression analyses that controlled for the influence of several other variables (Hogrefe et al., 2013; Nispen et al., 2018). Mol et al. (2013) measured limb apraxia with a non-specific "clinical assessment of apraxia". Consistent with the results of the Pantomime to Command Task, the authors found that more severe apraxia was associated with lower communication success. We therefore conclude that more severe apraxia impedes communication success in the gesture modality.

Semantic processing

The relationship between semantic processing and communication success was examined in three studies (Hogrefe et al., 2013, 2017; Nispen et al., 2018). With semantic processing limitations impacting the ability to derive meaning from similar concepts, it follows that impaired semantic processing will be associated with lower communication success in the gesture modality.

Hogrefe et al. (2013, 2017) used subtests two and three from the BOSU (Bogenhausener Semantik-Untersuchung, BOSU; Glindemann et al., 2002), whereas Nispen et al. (2018) measured semantic processing with the Semantic Association Test (SAT; Visch-Brink, 2005). For each study, more impaired semantic processing scores were associated with lower communication success (Hogrefe et al., 2013, 2017; Nispen et al., 2018). However, there was no statistical evidence of a relationship between semantic processing and communication success when the influence of several other variables were controlled for using regression analyses (Hogrefe et al., 2013; Nispen et al., 2018). We therefore conclude that deficits to semantic processing in aphasia do not impede communication success in the gesture modality.

Discussion

Using a systematic review, we examined the communicative benefit of gesture for people with aphasia. We asked two questions: (1) is the communication success of gesture compromised in people with aphasia compared to healthy language users? and, (2) to what extent does gesture improve the communication success of people with aphasia? Due to the heterogeneity of aphasia presentation, and questions about how this might affect gesture production, we also asked a third question: (3) to what extent does aphasia severity, apraxia and semantic processing moderate the communication success of gesture?

Question 1: is the communication success of gesture compromised in people with aphasia compared to healthy language users?

Four studies were identified that compared the communication success of gesture in people with aphasia and healthy (control) language users (Duffy et al., 1984; Hogrefe et al., 2017; Mol et al., 2013; Nispen et al., 2018). Based on this literature, we concluded that people with aphasia gesture, but their communication success is compromised compared to healthy language users. This conclusion aligns with early research suggesting that gesture production is impaired in aphasia (e.g., Cicone et al., 1979), and theoretical models that argue for the non-independence of speech and gesture (AR Sketch Model, de Ruiter, 2017).

Question 2: to what extent does gesture improve the communication success of people with aphasia?

Four studies were identified that explored the relative contribution of speech and gesture to communication success among people with aphasia (de Beer et al., 2017; Hogrefe et al., 2013; Mol et al., 2013; Rose et al., 2017). We found the communication of people with aphasia is more successful when the gesture and speech modalities are combined (multimodal) compared to either modality (speech or gesture) in isolation. This finding provides strong evidence of the value of multimodal communication in aphasia. To determine the relative contribution of each modality, Hogrefe et al. (2013) assessed the communication success of people with aphasia when restricted to either speech or gesture production. They found the communication success of gesture was comparable to speech, indicating that each modality contributes equally to the communication success of people with aphasia. Taken together, we conclude that the communication success of people with aphasia is enhanced by gesture. Gesture and speech both contribute to communication success, and appear to contribute equally, although this conclusion is based on a single, small study.

The literature indicates that people with aphasia gesture at a higher rate (Butterworth et al., 1981; Hadar et al., 1998; Sekine et al., 2013; Sekine & Rose, 2013) and produce more iconic gestures (Carlomagno & Cristilli, 2006; Cicone et al., 1979; Cocks et al., 2013; Pritchard et al., 2015; Sekine et al., 2013) than healthy language users. Our review indicates that the higher gesture rate and greater use of iconic gestures will improve communication success of people with aphasia (de Beer et al., 2020; Rose et al., 2017). We conclude that gesture can take on a compensatory role when language is impaired (Ahlsén, 1991; Beland & Ska, 1992). This conclusion aligns with the predictions of the original Sketch Model (de Ruiter, 2000), which argues that gesture and speech are conceptually related, but separable in so far as they follow different production pathways, and so can compensate for one another. Together with the results of Question 1, we conclude that although the gestures of people with aphasia are less successfully interpreted than non-brain injured adults, the gestures produced improve the communication success of people with aphasia beyond that of speech alone. We conclude that gesture is a valuable modality for improving the communication success of people with aphasia (see also Peirce et al., 2019).

Question 3: to what extent does aphasia severity, apraxia and semantic processing moderate the communication success of gesture?

Due to the substantial heterogeneity in aphasia presentation, studies that include measures of aphasia severity, apraxia severity, and semantic processing deficits were evaluated with respect to their impact on the communication success of gesture. The studies reviewed showed no evidence that the communication success of gesture was affected by aphasia severity or by semantic processing deficits. By contrast, apraxia severity was consistently found to impede the communication success of gesture.

Evidence that aphasia severity did not impede the communication success of gesture is at odds with arguments for a parallel breakdown of speech and gesture in aphasia (Cicone et al., 1979; Duffy et al., 1984; Mol et al., 2013), and instead fits with the original Sketch Model (de Ruiter, 2000). The separability of the communication modalities is consistent with the finding that gesture frequency increases with aphasia severity (Herrmann et al., 1989; Hogrefe et al., 2012) and that gesture use improves communication success. Taken together, these findings suggest the capacity for effective gesture production is preserved across the different levels of aphasia severity, allowing gesture to play a compensatory role in communication.

Prior research indicates that semantic processing deficits in aphasia limit the frequency, types and utility of the gestures produced (Cocks et al., 2013; Hogrefe et al., 2012, 2013; Kong et al., 2015). Our review does not support a relationship between semantic processing deficits and successful communication in the gesture modality. We note that only two studies explored this question (Hogrefe et al., 2013, 2017; Nispen et al., 2018), and neither found a correlation between semantic processing ability and gesture communication success when other variables were accounted for. We tentatively conclude that successful gestural communication is unaffected by semantic processing deficits in aphasia, but more research is needed to confidently establish the nature of this relationship.

Finally, consistent with limb apraxia being an impairment in a person's ability to make purposeful movements (Hogrefe et al., 2013; Mol et al., 2013; Nispen et al., 2016), more severe limb apraxia was consistently found to impede gestural communication success. So, whereas limb apraxia is unrelated to gesture frequency (Feyereisen, 1988; Rose & Douglas, 2003), the studies reviewed indicate that it does impede gestural communication success.

Strengths, Limitations and Future Directions

The systematic review identified a small number of research articles (N=7) that addressed questions around the communication success of the gestures produced by people with aphasia. On initial inspection, conclusions about how aphasia affects the communication success of gesture are mixed (Mol et al., 2013; Nispen et al., 2018; Rose et al., 2017). However, this systematic review resolved these inconsistencies, triangulating findings across the research field, and showed a clear pattern of results: although the communication success of gesture is compromised, gesture improves the communication success of people with aphasia.

The studies reviewed were mostly correlational, varied substantially in the participant inclusion criteria used and relied on small samples of participants (but see Smith & Little, 2018 who argue in favour of small N designs). These are common limitations associated with studying clinical populations that can make drawing firm conclusions difficult. Therefore, future research using more advanced statistical techniques (e.g., regression analyses that can control for extraneous variables), more consistent participant inclusion criteria, and similar methodologies, could increase our confidence in the conclusions made. Furthermore, more studies—including those with small sample sizes—that address these limitations, will allow for future meta-analysis.

Our review highlights that the task instructions used in some of the studies may have compromised the findings reported. For example, in several studies examining the impact of aphasia on gestural communication success, participants were instructed to communicate in an unconstrained way (i.e., in any modality), but were not told that only their gestures would be shown to the interpreters. Audience design accounts of interpersonal communication stress that producers tailor their message to their audience (Clark, 1996; Bell, 1984). In the context of the studies reviewed, producers would have expected their speech and gesture to be available to their audience. Under this expectation, producers may have relied more heavily on co-speech gestures compared to task instructions that made clear that only their gestures would be shown to interpreters (in which case they may have relied more heavily on speech-replacing gestures). It follows that these instructions may have impeded message design and lowered communication success. In fact, evidence indicates that when the task instructions align with the communication context of the interpreter, communication is more successful (Hogrefe et al., 2013). Future research should ensure the task instructions for participants align with the communication context of the interpreter to ensure that producers' messages can be appropriately designed.

Our review returned two unexpected findings: aphasia severity and semantic processing deficits were unrelated to the gestural communication success of people with aphasia. These null findings should be treated as preliminary due to the small number of studies that addressed these questions. More research is needed to confidently establish the nature of this relationship.

Conclusion

The systematic review addresses inconsistencies in the literature concerning whether the capacity to produce meaningful gestures is compromised in aphasia, and the extent to which gesture can improve the communication success of people with aphasia. Our review concludes that although communication success by gesture is compromised among people with aphasia (relative to healthy controls), gesture use enhances communication success. These findings align with multimodal approaches to aphasia therapy (Clough & Duff, 2020; Pierce et al., 2019) and support the use of gesture as a therapeutic strategy to improve the communication of people with aphasia (Pierce et al., 2019).

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Nicolas Fay http://orcid.org/0000-0001-9866-2800

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