Compensatory and Facilitative Gesture Use in People with Aphasia

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COMPENSATORY AND FACILITATIVE GESTURE USE IN PEOPLE WITH APHASIA

By

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Abstract

The focus of this project was to develop a clear and reliable protocol that measured how people with Broca's aphasia use gestures in a facilitative or compensatory manner in comparison to individuals with Wernicke's aphasia. Previous literature has disagreed on the definitions of facilitative and compensatory gestures and has not developed one concise and conventional methodology to represent how individuals with Broca's and Wernicke's aphasia are using gestures across various discourse tasks.

The protocol developed in the current study analyzes the specificity, timing, and function of gestures relative to speech. The Gesture and Speech Specificity scales determine the accuracy and clarity of the gesture or corresponding speech produced. The timing scale determines when the gesture was produced relative to the speech most related to the target of the gesture. Lastly, the Gesture-Speech Relationship Scale represents how informative the gesture was in comparison with the speech produced. These scales represent when gestures are produced, how meaningful they are and whether they serve a compensatory or facilitative function for those with Broca's or Wernicke's aphasia.

On average, people with Broca's aphasia used more specific gestures to compensate for their failures in expressive speech. People with Wernicke's aphasia produced fewer specific gestures and were more likely to produce these gestures coinciding with speech, i.e., as a facilitative strategy. The results from this project suggest that gestures should be used as a strategic component of intervention. Using gestures in a compensatory or facilitative manner can allow for conversation partners to better understand the communication needs of PwA.

Introduction

Gesture Use

Gestures are one of the most important tools that a human can use to communicate and can shape the language and thinking of both their producers and observers. Gestures are used across many different cultures and allow human beings to share and create community amongst each other (Kita 2009; Church & Goldin-Meadow, 2017). Although gesture use can vary between cultures and individual use, the gesture modality serves several communicative functions. These functions include displaying semantic or pragmatic features that are often not expressed within an individual's speech (Church & Goldin-Meadow, 1986).

Gestures can also provide a visual format for the speaker that can help them reduce their own cognitive load (Goldin-Meadow, 1999). Gestures can add information to a speaker's verbal utterance and can even provide information when no speech is being produced. This process has been greatly investigated in gesture research and can help determine how gestures are of use to people who may have verbal communication difficulties. Gesture use can support the learning and social interactions of many different clinical populations such as autism spectrum disorder, Down syndrome, and various language disorders (Lorang et al., 2018; Manwaring et al., 2017; Özçalışkan & Dimitrova, 2013). One population in which gesture use research has become prevalent is in people with aphasia (PwA).

Aphasia

According to the National Aphasia Association, aphasia is an impairment of language that results from damage to the left hemisphere of the brain, typically due to a stroke (National Aphasia Association, 2021). This damage can affect comprehension or create difficulties in word-finding, grammatical formulation, and fluency. The aspects of impairment vary and can range from affecting a single aspect to many aspects of language. An individual's ability to comprehend, repeat or produce speech fluently can determine which type of aphasia that person has. The type they are diagnosed with also helps determine the specific interventions that can be used with this person.

There are two broad types of aphasia that differ based on fluency—fluent and nonfluent. One of the most common types of nonfluent aphasia is Broca's aphasia. The utterances produced by people with Broca's aphasia tend to be short and agrammatic (National Aphasia Association, 2021). Agrammatism is defined as speech that dominantly contains omissions of grammatical elements (Kleist, 1916). An example of speech in this type of aphasia from an interview conducted by Howard Gardner is: "Yes, sure. Me go, er, uh P.T. nine o'cot, speech… two times… read…wr…ripe, er, rike, er, write… practice… getting better" (Tammet, 2010, p. 96). A common fluent type of aphasia is Wernicke's aphasia. Individuals with Wernicke's aphasia may have more proficiency in their ability to produce speech; however, their sentences may be impaired in terms of semantic structure. Here is an example of a sentence produced by an individual with Wernicke's aphasia: "A little tooki tooki goin to-it to him, looki on a little little tooki goin' to him" (McNeill, 2013).

Like non-brain damaged populations, people with aphasia may use other modalities to communicate such as writing, drawing, or gesturing (Clough & Duff, 2020). With the knowledge that gesture use can provide important communication functions that cannot always be expressed verbally, the question here lies in how and in what ways does that gesture provide meaningful information, and how can this impact the aphasic community? To further understand the relationship between gesturing and language impairment, it is important to analyze the types of gestures that exist and theories of gesture use.

Gesture Types

In a study by Sekine and Rose (2013), the relationship between aphasia type and gesture production in PwA was investigated. They compiled a list of gesture types that had been defined throughout previous work. For this project, several of these gesture types are necessary to describe as they serve specific communicative functions (See Table 1).

Table 1. Gesture Types and Definitions

Gesture Type	Definition
Abstract Deictic (McNeill, 1992)	When the individual points or gestures toward an area in the physical space around them and assigns an object or value to that space (e.g., pointing to the space on the table in front of them and saying “girl” to indicate the girl character of the story is in that spatial area as they retell or describe the task).
Iconic Character Viewpoint (CVPT) (McNeill, 1992)	Demonstrates a concrete semantic concept in their form carried out from the character within the story or tasks perspective (e.g., the gesturer moving their arms back and forth as if they were running)
Iconic Observer Viewpoint (OVPT) (McNeill, 1992)	Demonstrates a concrete semantic concept in their form carried out from a third-person perspective (e.g., the gesturer using two fingers moving back and forth to represent two legs running)
Metaphoric (McNeill, 1992)	Conveys an abstract concept (e.g., motioning to the front of back of one’s body to convey the concept of time)
Emblem (Kendon, 1997)	Representing a form or meaning that is conventionally understood within a specific culture (e.g., thumbs-up, indicating “good” or “okay”)
Letter (Cicone et al., 1979)	Tracing letters with fingers on surface in front of them or in the air (e.g., spelling out the word “boat” in the air with their finger)
Number (Cicone et al., 1979)	Using the fingers to display or count numbers (e.g., holding up two fingers to indicate two “evil stepsisters”)

Theoretical Models of Gesture and Speech

The planning, formation, and execution of gestures with and without speech have been theorized within several different models. The first model to note was the Sketch Model of Speech production, developed by De Ruiter (2000), which argues that gestures can function independently of verbal output. According to this model, gesture and speech production are shared at the conceptualization stage but are separated in the formulation stage. In the gesture-formulation stage there is access to the part of working memory where spatial information is stored. Verbal language, however, has access to the part where propositional knowledge is stored (see Figure 1).

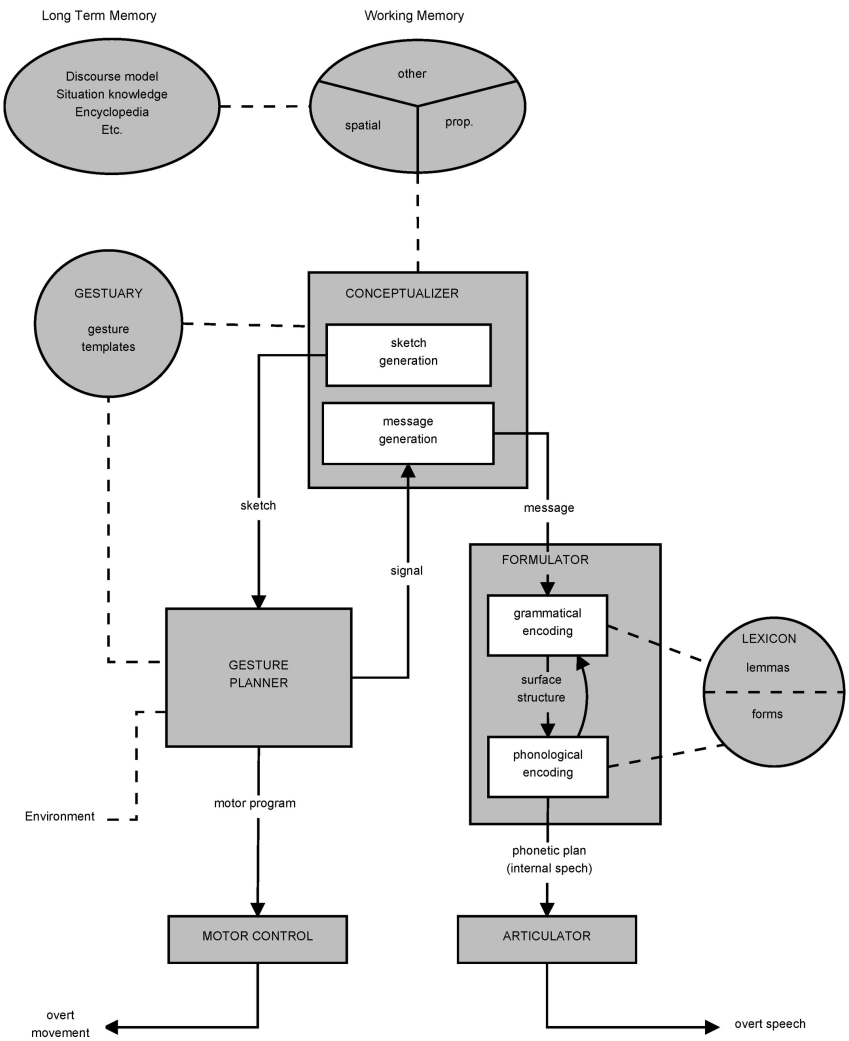


Figure 1. The Sketch Model for gesture and speech production (De Ruiter, 2000, p. 298)

To further understand the connection of these interactions to gesture use the trade-off hypothesis was developed (De Ruiter, 2006; De Ruiter et al., 2012). This trade-off hypothesis claims that, if verbal language is impaired, then communication load is likely to be transferred to the gesture modality. In other words, gesture compensates for speech difficulties. Compensatory gestures convey information that is not present in speech. An example of compensatory gesture use for a typical individual would be that one is having a conversation on the cell phone when another person attempts to ask that individual a question. The person speaking on the phone may be unable to answer verbally; however, they can give the interlocuter a “thumbs-up” gesture meaning “I am good” or hold up their pointer finger indicating that they will be with them in one minute.

However, gestures can also facilitate speech. Gesture use facilitating speech can be thought of in two ways. First, using a gesture *before* a moment of word-retrieval difficulty can help retrieve a word that a speaker is attempting to express or a word similar to it. An example of this would be that an individual is attempting to say the word “ball”. They may have trouble producing that word verbally and so they create a round shape with their hands, showing a visual representation of a ball. This action may trigger a semantic connection in their brain, allowing them to then retrieve that target and verbally produce the word “ball” a few seconds later.

The other definition of facilitative use of gesture is the way in which a gesture can be provided with speech but enhances it by providing the same information in visual format or elaborating on the information that was produced in speech. In a study investigating gesture’s role in language, Goldin-Meadow and Alibali (2013) provided a hypothetical example where a speaker produced the sentence, “The man was wearing a hat”. While expressing this thought verbally, they also moved their hand as if grasping the bill of a baseball cap. In this example, the speaker was able to clarify to the conversation partner which type of hat they were referring to.

Many previous studies support the idea that verbal language and speech production are two separate channels but are highly connected and support this ability to “trade-off” (Mol et al., 2013; Hogrefe, 2013). Although this trade-off is often referred to as all-or-none (i.e., either speech or gesture), it is also possible that gesture use exists on a continuum from compensatory (gesture instead of speech) to facilitative (gesture adding information to speech or redundant with speech).

Gesture Use in Aphasia

PwA use gestures more often relative to typical populations. In a study by Sekine and Rose (2013), the gesture production of a group of PwA and a typical control group was analyzed within story retell tasks retrieved from the AphasiaBank database. These results showed that individuals with aphasia produced a significantly greater number of gestures (94%) compared to typical populations (73%). In a similar article conducted by Sekine et al. (2013), the gesture use of 46 PwA and 10 healthy matched controls were analyzed, and patterns were found based on gesture type use. Overall, the Broca's aphasia (BA) group and Wernicke's aphasia (WA) group produced a greater total number of gestures (BA = 68.7, WA = 116.4, Control = 69.7) as well as a greater number of gestures per 100 words (BA = 39.5, WA = 19.14, Control = 7.38).

The gestures produced by the PwA are also more iconic in nature; therefore, they carried representative and communicative information. Kong et al. (2015) compared the differences in gesture form and function of those with aphasia to a typical control group. It was also found in this study that the aphasic population used content-carrying gestures more often (30.4%) than the typical control group (13.1%). In the study by Sekine and Rose (2013), the control group did not produce any concrete deictic, letter or pantomime gestures. Akhavan et al. (2018) also found that eight PwA tended to use more iconic gestures than 11 age- and education-matched healthy controls to convey semantic information. These studies indicate that PwA produce a wider variety of types of gesture compared to typical populations, that can carry semantic, spatial, and pragmatic information.

In fact, those with Broca's aphasia and Wernicke's aphasia use different types of gestures and, therefore, the gestures they use vary in the information they carry. Sekine and Rose (2013) found that more than half of people with Broca's aphasia produced referential, concrete deictic, iconic observer viewpoint (OVPT), iconic character viewpoint (CVPT), beat, and number gestures. They also were the group when compared to Wernicke's aphasia participants and the typical control group to use the highest number of emblems (22%) and a high number of emblems (35%). This represents that those with Broca's aphasia use gesture to depict more concrete objects or demonstrate the actions of the characters within the narrative tasks. Those with Wernicke's aphasia, however, used a high number of metaphoric gestures (88%) and referential gestures (88%). From analysis of these results, those with Wernicke's aphasia use gestures more abstractly. The differences with which gesture is used in the aphasic population suggest that it is not only the variety of gestures that is of importance but also the different functions gestures serve in relation to speech.

Compensatory and Facilitative Use of Gesture

As indicated earlier, gestures can be used as a tool to compensate for or facilitate speech production. When people with aphasia experience moments of impaired verbal language, gestures may be used to compensate for missing verbal elements. This idea of compensatory function was further confirmed by Akhavan et al. (2018), who found that the people with aphasia produced gestures in a compensatory manner significantly more than the control group ($p = .001$). There was a strong negative correlation between the informativeness of speech and production of compensatory gestures by PwA. This finding indicated that the less informative the speech was, the greater the rate of compensation of information through gesture.

Akhavan et al. (2018) also reported a significant difference in gesture use between resolved and unresolved episodes of word retrieval, indicating that iconic gestures can help facilitate word retrieval. The facilitative use of gesture was also represented in a study performed by Lanyon & Rose (2009). They revealed a significant finding that 71.5% of word retrieval difficulties that were resolved occurred within 0-3 seconds of the gesture onset. Further support for this idea was represented in an article by De Ruiter (2006) that emphasizes gestures can facilitate word production for some individuals with aphasia. These results support the idea that in people with aphasia iconic gestures can help provide information when there is a lack of information provided through speech – particularly in a compensatory or facilitative manner.

As compensatory and facilitative use of gesture has been investigated in previous literature, it can be concluded that there are several different ways that researchers refer to these functions. This can lead to confusion in the future research conducted in this area as the relationship between gestures and speech could be *measured* in many ways and lead to contradicting evidence. For example, previous definitions of "pantomime" specified that this type of gesture is used exclusively in the absence of speech (McNeill, 1992). However, many studies since then have adapted this term to include the pantomime gesture in being produced during speech. This is due to the frequency of word retrieval difficulties people with aphasia have and it was necessary for the definition to be modified to account for this complexity.

Kong et al. (2015) defined the functions of gesture use in their relationship to speech i.e., 1. Providing additional information to the message conveyed, 2. enhancing the language content, 3. providing alternative means of communication, 4. guiding and controlling the speech flow, 5.

reinforcing the intonation or prosody of speech, 6. assisting lexical retrieval, 7. aiding sentence re-construction and 8. no specific function. Akhavan et al. (2018) measured gestures in PwA and healthy controls across the categories of matching speech, complementary to speech, compensatory for speech, facilitating lexical retrieval, or used a social cue. Ahkavan et al. (2018) defined compensation as gestures occurring in the absence of speech. Facilitation is when the gesture helps the speaker retrieve the necessary words (called "restoration" by Rose (2006)). Thus, terms have varied as research in this area has developed. It is important that how these functions of gesture use are defined be succinct to eliminate further confusion.

In conclusion, previous research illustrates that, when an individual is having difficulties retrieving a word, a gesture could be used to represent information not presented in speech (compensatory) or used to further clarify the idea that the speaker is attempting to convey (facilitative). As previously stated, these functions though are not binary (either compensatory or facilitative) but rather exist across a continuum. That is why it is particularly relevant to create an extensive protocol that can measure gestures across this range. By analyzing when and in what manner people with Broca's or Wernicke's aphasia produce gestures, it can be better understood how difference in fluency impacts the use of gesture.

Present Study

The focus of this project was to develop a clear, reliable protocol to measure the facilitative and compensatory use of gestures in people with aphasia. To do so, we aimed to capture the timing of gestures in relation to speech and the specificity, accuracy, and overall function of informativeness of these gestures in the context of picture description, story retell, and procedural narrative tasks. This idea builds upon previous literature, as a clear protocol for how to analyze these aspects of gesture use has not been provided. The definitions were adapted to represent a continuum between facilitative and compensatory gesture use and measure the informativeness of these gestures across this spectrum. The rating system developed for this project (Gesture-Speech Relationship Scale) was adapted from the definitions of gesture function used in Kong et al. (2015) and Akhavan et al. (2018).

It was hypothesized that when comparing the relationship between gesture and speech, individuals with Broca's aphasia would produce more gestures that are compensatory in nature, whereas those with Wernicke's aphasia would use facilitative gestures more. It was hypothesized that those with Broca's aphasia would also produce gestures with greater specificity and accuracy than those with Wernicke's aphasia. To further explain these claims, it is likely that those with Broca's aphasia may rely more on gestures to provide information in moments when they are experiencing expressive difficulties. Therefore, there gestures could be more specific and accurate in comparison to the information, they are attempting to get across to their conversation partner verbally. Those with Broca's aphasia also are more aware of their speech errors and may recognize a difficulty they are having and may therefore use gestures to compensate for the information they are not producing through speech. Individuals with Wernicke's aphasia have more impaired comprehension and they are not as aware of the errors that they make in their speech. Therefore, they may not recognize moments that they could use gestures to further provide specific information that is lacking from their speech production (Javed et al., 2022). Due to this, it is predicted they will be less likely to consciously use gestures to compensate for their speech. In addition, the speech of those with Wernicke's aphasia is more fluent yet contains more errors. It is predicted that when gestures are used by this group, they may serve to provide additional information (i.e., facilitative) that is not represented in their empty speech. People with Wernicke's aphasia also produce gestures that are more vague or abstract and therefore, their gestures will overall be less specific and accurate (Sekine & Rose

Methods

Participants

In this study, four individuals were selected from AphasiaBank, an online database of videotaped speech samples from people with aphasia (PwA). Two of the individuals chosen were diagnosed with Broca's aphasia and the other two were diagnosed with Wernicke's aphasia. These four participants were selected from 40 individuals (20 participants with Broca's aphasia and 20 with Wernicke's aphasia) that were analyzed in a previous project.

These four participants were chosen based on their percentage of gestures they produced within all the utterances they produced across five discourse tasks. For the participants to be considered they must have produced the greatest number of gestures per utterance. They matched were also matched on aphasia severity, gender, age at testing and educational level. Each participant diagnosed with Broca's aphasia was matched to a participant with Wernicke's aphasia that was within three points of their scores on the Aphasia Quotient of the Western Aphasia Battery-Revised (WAB-R AQ, Kertesz, 2007), an assessment of linguistic skills (content, fluency, auditory comprehension, repetition, naming, reading, and writing). The demographic and aphasia characteristics of the selected participants are displayed in Table 2.

Table 2. Participant Demographics

Type of Aphasia	Sex	Age at Testing (years)	Education Level (years)	WAB-R AQ Score (x/100)	Gestures/ Utterance (%)
Broca's	M	58.8	16	64.8	91%
Wernicke's	M	75.8	18	65.1	*118%

Broca's	M	52.8	12	28.1	77%
Wernicke's	M	70.6	12	30.2	86%

*Some utterances contained more than one gesture

Discourse Samples

Transcripts for the participant samples were extracted from five discourse tasks in the AphasiaBank database: three picture description tasks ("Broken Window", "Refused Umbrella", and "Cat Rescue"), one story retell task ("Cinderella"), and one procedural narrative task ("Sandwich"). The picture description tasks included black and white drawings that conveyed a story and/or event. The participants were asked to describe the pictures with a beginning, middle and end. For the story retell task, participants were given a wordless picture book of the Cinderella story and asked to look through the book before being asked to retell the story in their own words without the book. In the procedural narrative task, participants were asked to describe how they would make a peanut butter and jelly sandwich.

Original Utterances

The speech sample transcripts in AphasiaBank were segmented into utterances. For our analysis, any comments on the task by the participant, responses to the clinician, and other non-task-related comments were removed from the utterances. Core utterances were generated by omitting repetitions and revisions.

Gesture Coding

On the transcripts, gestures were originally coded as &=ges. In a previous project, the &=ges codes were further coded to determine the type of gesture being displayed by the participant. There were many different gesture types that were defined in the previous project. However, beat gestures were considered non-meaningful and were not included in the previous project. Concrete deictic gestures involve pointing to an object or picture referent (e.g., pointing to the jar of peanut butter on the picture placed in front of them during the Sandwich Task). Although these were included in the previous project, they were excluded in the current project, as they did not add any semantic content that was not already provided within the picture itself. For the current project the gestures that were analyzed were those that were representational in content. These included abstract deictic, iconic (CVPT, OVPT), metaphoric, emblem, letter, and number.

Coding

Actual Gesture

The Actual Gesture code was merely a description of the gesture. It was included to determine what the gesture was within the coding sheet so one did not have to return to the original video each time to understand what the specific gesture was (See Appendix).

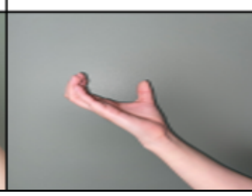
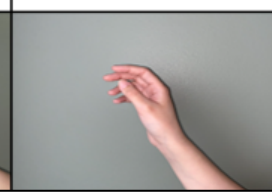
Gesture Target

The Gesture Target was coded primarily based on the idea/representation indicated in the gesture itself. If the gesture was ambiguous, information from the context of the story and the verbal utterance produced during the gesture (if any) were used to help identify the target message (See Appendix).

Gesture Specificity

The gesture that was produced was rated based on a five-point continuous scale (Table 3). This gesture rating indicated the meaningfulness of the gesture provided in relation to the Gesture Target. A gesture was coded as 4 in the Gesture Scale Rating (0-4) column if the gesture was accurately, specifically, and clearly representing the Gesture Target**-** specifically, if it could be determined what the gesture referred to if it stood alone within the context of task. A gesture was coded as 3 in the Gesture Scale Rating (0-4) column if the gesture was accurately representing the Gesture Target but was vague or unclear. A gesture was coded as 2 in the Gesture Scale Rating (0-4) column if the gesture was not accurate but was related to the Gesture Target. A gesture was coded as 1 in the Gesture Scale Rating (0-4) column if the gesture was inaccurate and unrelated or too vague to know what is being indicated in relation to the Gesture Target. A gesture was coded as 0 in the Gesture Scale Rating (0-4) column if the gesture was coded as *None* in the Actual Gesture column.

Table 3. Gesture Specificity Scale

4 Specific and Accurate Gesture	**3** Vague and Accurate Gesture	**2** Inaccurate and Related Gesture	**1** Inaccurate and Unrelated Gesture	**0** Unknown (UK)
				

Actual Speech

The Actual Speech referred to the verbal part of the core utterance displayed in the Core Utterance column. This Actual Speech was extracted from the core utterances to exclude the gesture codes and other extraneous codes (See Appendix).

Corresponding Speech

Corresponding Speech was the word or phrase from the Actual Speech column that most conveyed the semantic meaning of the Actual Gesture. If there was not a word or phrase that corresponds it would be coded as *None*. The code in this column was as concise as possible and only indicated what existed in the Actual Gesture (See Appendix).

Speech Specificity

The speech that was produced was rated based on a five-point continuous scale (Table 4). This speech rating indicated meaningfulness of the Corresponding Speech provided. The speech was coded as 4 in the Speech Scale Rating (0-4) column if the speech was accurate, specific, and clear. The speech was coded as 3 in the Speech Scale Rating (0-4) column if the speech was accurately representing the Corresponding Speech but was vague or unclear. The speech was coded as 2 in the Speech Scale Rating (0-4) column if the speech was not accurate but was related to the Corresponding Speech. The speech was coded as 1 in the Speech Scale Rating (0-4) column if the speech was inaccurate and unrelated or too vague to know what was being indicated in relation to the Corresponding Speech. The speech was coded as 0 in the Speech Scale Rating (0-4) column if the speech was coded as *None* in the Actual Speech.

Table 4. Speech Specificity Scale

4 Specific and Accurate Speech	**3** Vague and Accurate Speech	**2** Inaccurate and Related Speech	**1** Inaccurate and Unrelated Speech	**0** None
“Kicking the ball”	”Kicking the thing”	”Kicking the goal”	”Kicking the water”	”Kicking the…”

Gesture-Target Timing

The Gesture-Target Timing column indicates when the Actual Gesture began based on its temporal location to the Corresponding Speech. These codes consisted of: *Before Speech, With Speech, After Speech,* or *In Absence of Speech* (See Appendix).

Gesture-Speech Relationship

The relationship between the Actual Gesture and Corresponding Speech that was produced was rated based on a five-point continuous scale (Table 5). The definition of providing substantive information to the listener is that the gesture gives information in addition to the language content, as seen in the 2 rating of the Gesture-Speech relationship on the scale. The definition of enhancing the language content is that the gesture gives the same meaning to the language content, as seen in the 1 rating of the gesture-speech relationship on the scale. The definition of providing alternative means of communication is the gesture carries meaning in the absence of speech, - as seen in the 3 and 4 ratings of the gesture-speech relationship on the scale.

The Gesture-Speech Relationship was coded as 4 if the Corresponding Speech was absent and the Actual Gesture was accurate, specific, and clear. The Gesture-Speech Relationship was coded as 3 if Speech Target was absent and the Gesture Target that was provided was accurate but vague or unclear. The Gesture-Speech Relation was coded as a 2 if there was Speech Target but the gesture added meaningful information that the speech did not convey. The Gesture-Speech Relationship was coded as a 1 if the Corresponding Speech provided the same information as the Gesture Target. The Gesture-Speech Relationship was coded as a 0 if the Gesture Target detracts or was too vague to add anything to the Corresponding Speech.

Table 5. Speech, Gestures, and Gesture-Speech Relationship Scales

Speech				
4	3	2	1	0
Accurate, specific, and clear	Accurate but vague or unclear	Inaccurate but related	Inaccurate and unrelated or too vague to know	Absent
Gestures				
4	3	2	1	0

Accurate, specific, transparent	Accurate but vague or unclear	Inaccurate but related	Inaccurate and unrelated or too vague to know	NA
Gesture-Speech Relationship (after Kong et al., 2015)				
4	3	2	1	0
Clear Actual Gesture provided in the absence of Corresponding Speech	Vague/unclear Actual Gesture provided in the absence of Corresponding Speech	Actual Gesture adds information to Corresponding Speech	Actual Gesture provides same information as Corresponding Speech	Actual Gesture detracts from Corresponding Speech or is too vague to add anything

Coding Process

To begin the coding process, the author developed a protocol document and updated this throughout the coding training process. The protocol was explained to two undergraduate students as they were trained in the protocol and used to test reliability of the methodology. First, a sample of 10 randomly selected utterances was selected from both an individual with Broca's aphasia and an individual with Wernicke's aphasia. These two participants were also randomly selected from a list of 40 participants used in a previous project. This set of 20 randomly selected utterances was coded by all three coders in person at the same time. From here any difficulties using the protocol or disagreements in coding were discussed and edited. Then, another 20 utterances (10 utterances per person with aphasia) were randomly selected from the same participants with aphasia (excluding the previous utterances coded). From here, each coder independently coded the utterances. Agreement on the gesture and speech scales was determined based on the results of these codes.

Initial reliability on the gesture and speech codes was low, in part because there was a lack of agreement on the Gesture Target, which affected coding of the specificity of the gesture and the corresponding speech. The Gesture Target is an inference of the idea or object the gesture is trying to convey based on the context of the story. However, because the Gesture

Target could be interpreted as multiple ideas, this created variable interpretations by the coders. In addition, gestures from PwA could be vague and it could be difficult to interpret. Based on the low agreement reliability between the three coders, several meetings took place to discuss differences in independent decisions. The protocol was updated based on these disagreements and it was decided that a consensus of the Actual Gesture, Gesture Target and Corresponding Speech coding between the three coders was necessary. From here, the three coders met to come to a consensus on these three categories.

Once consensus was achieved on the Gesture Target and Corresponding Speech, coders independently rated the Gesture Specificity Scale, Speech Specificity Scale and the Gesture-Speech Relationship Scale, and the Gesture Speech Timing Scale. Later, we also analyzed the impact of aphasia type on reliability of each of the rating scales. Independent samples t-tests were performed to compare the mean ratings of the Broca's aphasia group and the Wernicke's aphasia group, averaged across the three raters, on the Gesture Specificity Scale, Speech Specificity Scale and the Gesture-Speech Relationship Scale. On the Gesture Speech Timing Scale, the proportion of the total number of gestures was calculated for rating category (*before, with, after, in absence of speech*) and compared between aphasia type (BA, WA). A chi-square test was used to test whether the distribution of ratings differed by type of aphasia.

Results

Mean ratings of the Broca's aphasia group and the Wernicke's aphasia group on the Gesture Specificity Scale, Speech Specificity Scale, and the Gesture-Speech Relationship Scale, averaged across the three raters, are shown in Figure 1 and Table 6.

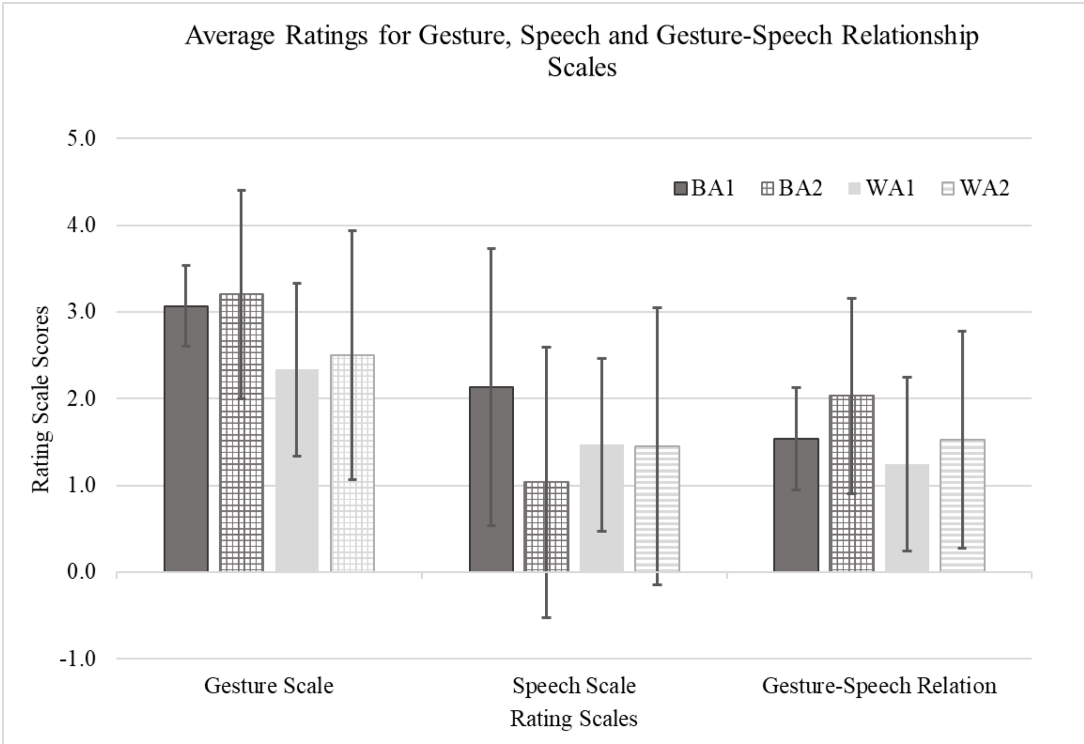


Figure 1. Average Ratings across Gesture Specificity, Speech Specificity and Gesture-Speech Relationship Scales. (Error bars indicate Standard Deviations)

The independent samples t-tests showed that the difference between groups in the Gesture Specificity Scale was significant (p = 0.038) with the Broca's aphasia group producing more specific gestures than participants in the Wernicke's aphasia group. However, the difference between groups for the Speech Specificity Scale (p = 0.793) and the Gesture Speech Relationship Scale (p = 0.176) did not reach significance.

Table 6. Average Scale Rating Scores by Aphasia Type

	BA Mean (SD)	WA Mean (SD)	t-test *p* value
Gesture Specificity	3.1 (0.89)	2.4 (1.43)	0.038
Speech Specificity	1.6 (1.64)	1.5 (1.60)	0.793
Gesture-Speech Relationship	1.8 (0.91)	1.4 (1.15)	0.176

The chi-square analysis on the Gesture Timing Rating Scores demonstrated that a very similar pattern was shown by both types of aphasia ($p = .827$). For both groups the most common time to produce gestures was with Corresponding Speech followed closely by gestures in the absence of Corresponding Speech.

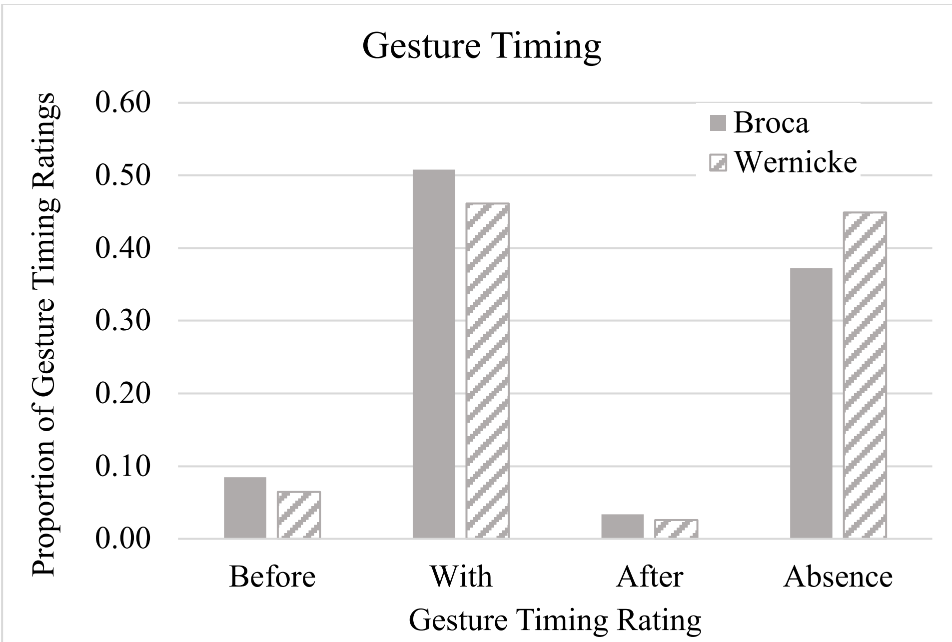


Figure 2. Gesture timing results for Broca's and Wernicke's groups

To determine the impact of rating type and aphasia type on reliability among the three coders, an agreement scale was determined. This agreement scale consisted of three codes: 2 = all coders agree, 1 = 2 out of 3 coders agree and 0 = no coders agree. Thus, higher scores indicate better agreement. The inter-rater agreement was determined for each participant (Figure 3). Broad patterns of these agreement ratings seem to be indicative of variability between both aphasia type and of individual participants.

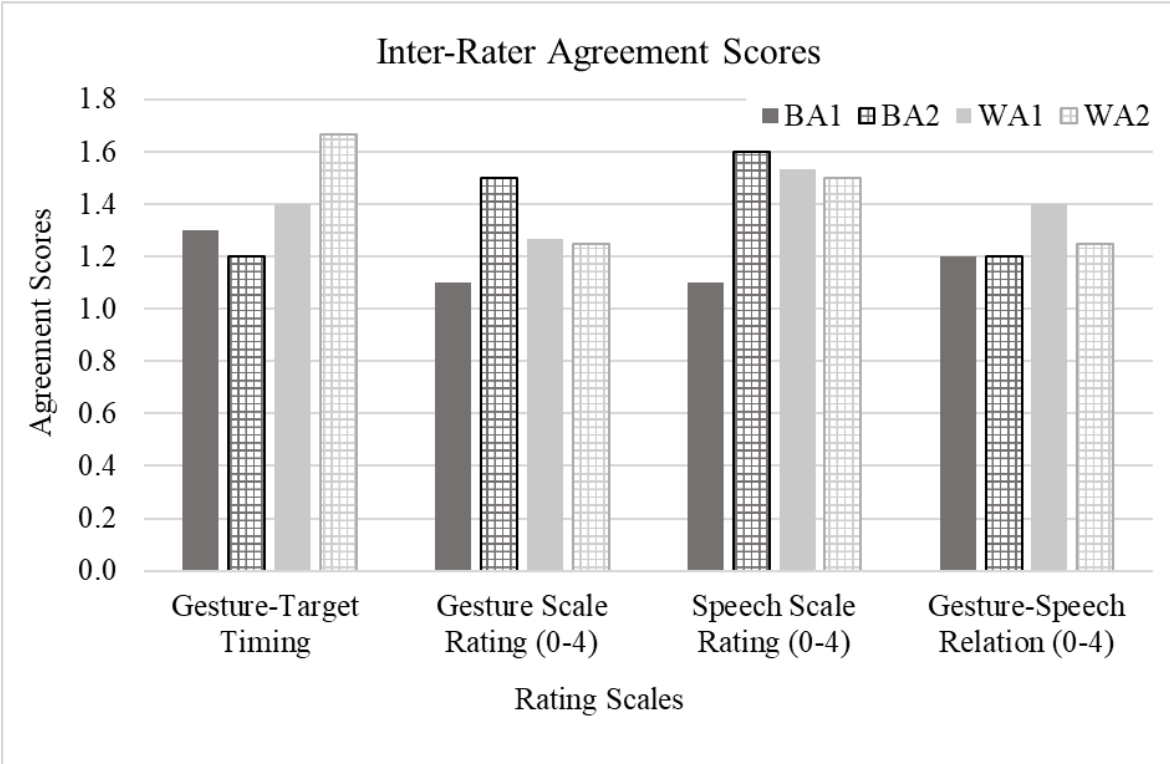


Figure 3. Inter-rater agreement scores for each individual and each rating scale.

Discussion

In this project, we developed a concise protocol that can be used to further code and analyze functions of gesture use in people with Broca's and Wernicke's aphasia. Using this protocol, we examined how individuals from these two populations used gestures in a compensatory or facilitative manner relative to their speech. We also measured the specificity of gestures and speech to represent whether gestures were more informative than speech.

Using this coding system, the data from four individuals (2 with Broca's aphasia and 2 with Wernicke's aphasia) partially supported our initial hypotheses. It was hypothesized that those with Broca's aphasia would produce gestures that were more informative than their speech, therefore using gestures as a compensatory strategy. Secondly, it was hypothesized that those with Wernicke's aphasia would produce gestures that provide additional information to their speech, i.e., facilitative gestures. On average, those with Broca's aphasia scored higher on the Gesture Specificity Scale than those with Wernicke's aphasia indicating greater gesture specificity for the BA group. For the Speech Specificity Scale, those with Broca's and Wernicke's aphasia produced speech that was similar in specificity. The results from the Gesture-Speech Relationship Scale indicated that those with Broca's aphasia were slightly more likely to produce gestures with greater specificity in the absence of Corresponding Speech; however, this difference was not significant. This does not provide support for the hypothesis that those with Broca's aphasia would use gestures that were more informative than their speech compared to those with Wernicke's aphasia.

The Gesture Timing results showed that those with both Broca's and Wernicke's aphasia produced most of their gestures either *with* speech or *in absence of speech*. The finding that those with Wernicke's aphasia produced a large proportion of gestures when the Corresponding Speech was rated as *None* was surprising and did not support our original hypothesis that those with Wernicke's aphasia would produce gestures in a facilitative manner (i.e., with speech). Examining the responses of those with Wernicke's aphasia, however, revealed that they tended to produce speech that was vague, and the target could not be clearly identified. Therefore, no Corresponding Speech was identifiable. When there was no Corresponding Speech, the Gesture Timing Scale was coded as *in absence of speech*. This is a possible explanation as to why the results of the Gesture Timing Scale indicated those with Wernicke's aphasia producing a greater number of gestures i*n absence of speech* compared to those with Broca's aphasia.

Limitations

One limitation of the current project was the lack of reliability of the protocol. Throughout the process of training two coders on this methodology, one barrier was the overall vagueness of gesture production in people with aphasia. Due to this, it was necessary for the coders to achieve a consensus on the gesture target before rating the gestures' specificity or relationship to Corresponding Speech on the rating scales. For future use of this protocol, it is crucial that sources of disagreement be identified so that the reliability is improved. Another limitation to this current project was the small sample size. To greater support these claims more data will need to be collected from a larger sample of this population.

The other limitation that was represented in the above discussion is due to the nature of aphasic speech and gesture. There is no way of telling exactly what message the PwA is attempting to convey and therefore the coding process becomes circular. In the current project, the Corresponding Speech and the Gesture-Timing Scale were built off each other due to the necessity of judging the gesture based on its relationship to speech. When a participant with aphasia produced speech that was too vague to understand the meaning of, the gesture was identified as having no Corresponding Speech. In future use of this methodology, if the Corresponding Speech of a gesture is too vague to understand that data should be excluded from further coding. Instead, the parameters around Corresponding Speech should be reconsidered to account for the vague speech production that often occurs within an expressive language impairment.

Conclusion

This project generated a protocol that is replicable and can be used to investigate how accurately and specifically PwA use gestures. The Gesture Specificity Scale was useful in providing this information and further reliability of the use of these rating scales can support the relationship between gesture and speech. The creation of this protocol was able to build upon the previous methodology used in this area of research and provide concise measurement scales to be used in further coding of gestures in people with aphasia. The evidence displayed in this project is at the beginning stages of providing possible clinical tools that can be used in assessing gesture use for people with aphasia, particularly those with Broca's and Wernicke's aphasia. Through the analysis of when PwA use gestures and the information that these gestures can provide, clinicians and conversation partners can better understand the communication needs and provide support for the betterment of this population's language production.

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Appendix

Table A1. Identifying elements from participant with Broca's aphasia.

Task	Utt #	Original utterance	Core utterance	Actual Speech	Actual Gesture
Window	8	man " &=ges:look uhoh . ? [+gram] ?	man [look#cvpt] {uhoh} [#int]	man {uhoh}	hand, palm facing down on front of forehead

Table A2. Rating system of identified speech and gesture from participant with Broca's aphasia.

Consensus – Gesture Target	Consensus - Corresponding Speech	Gesture-Target Timing	Gesture Scale Rating (0-4)	Speech Scale Rating (0-4)	Gesture-Speech Relation (0-4)
look	none	In absence of speech	4	0	0

Table B1. Identifying elements from participant with Wernicke's aphasia.

Narrative	Utt #	Participant	Original utterance	Core utterance	Actual Speech	Actual Gesture
Sandwich	9	WA	&=points:peanut_butter &a &a and you &ba put [//] wipe [:spread] [%s:r] a &=ges:spreading spate [%ur:uk] of peanut butter on . ?	[peanutbutter#point] you wipe a [spread#cvpt] spate of peanut butter on	you wipe a spate of peanut butter on	spread with finger

Table B2. Rating system of identified speech and gesture from participant with Wernicke's aphasia.

Consensus - Gesture Target	Consensus - Corresponding Speech	Gesture-Target Timing	Gesture Scale Rating (0-4)	Speech Scale Rating (0-4)	Gesture-Speech Relation (0-4)
wipe	wipe	With speech	4	4	1