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Gesture's Role in the Communication of Adults With Different Types of Aphasia

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ABSTRACT

Purpose: Adults with aphasia gesture more than adults without aphasia. However, less is known about the role of gesture in different discourse contexts for individuals with different types of aphasia. In this study, we asked whether patterns of speech and gesture production of individuals with aphasia vary by aphasia and discourse type and also differ from the speech and gestures produced by adults without aphasia.
Method: We compared the amount, diversity, and complexity of speech and gesture production in adults with anomic or Broca's aphasia and adults with no aphasia (n = 20/group) in their first- versus third-person narratives.
Results: Adults with Broca's aphasia showed the lowest performance in their amount, diversity, and complexity of speech production, followed by adults with anomic aphasia and adults without aphasia. This pattern was reversed for gesture production. Speech and gesture production also varied by discourse context. Adults with either type of aphasia used a lower amount of and less diverse speech in third-person than in first-person narratives; this pattern was also reversed for gesture production.
Conclusions: Overall, our results provide evidence for a compensatory role of gesture in aphasia communication. Adults with Broca's aphasia, who showed the greatest speech production difficulties, also relied most on gesture, and this pattern was particularly pronounced in the third-person narrative context.

Aphasia is a communication disorder that is typically caused by a stroke (Alexander & Hillis, 2008; Hallowell, 2017). The stroke results in damage to brain areas that are responsible for language. The damage leads to difficulty in communication that is frequently observed in speech output (Alexander & Hillis, 2008; Hallowell, 2017). Importantly, adults with aphasia gesture more than adults without aphasia, likely to compensate for their difficulties in speech production (Carlomagno & Cristilli, 2006; Cocks et al., 2013; de Beer et al., 2019; Sekine et al., 2013). However, we know relatively less about the broader function of gesture in different types of aphasia, especially in different discourse production contexts.

In this study, we focused on the speech (i.e., spoken language output) and gestures produced by individuals with either Broca's or anomic aphasia, as well as adults without aphasia. *Broca's aphasia* is a type of nonfluent aphasia characterized by limited speech output. Adults with Broca's aphasia show pronounced difficulties in their production of grammatical speech and their lexical access of content words (e.g., nouns, verbs; Alexander & Hillis, 2008; Hallowell, 2017). *Anomic aphasia* is a type of fluent aphasia characterized by relatively intact grammatical speech production. At the same time, adults with anomic aphasia show difficulties in their retrieval of content words (e.g., Alexander & Hillis, 2008; Hallowell, 2017).

Our goal in this study is to determine whether the pattern of gesture use is affected by the extent of production and lexical access difficulties individuals with different types of aphasia (anomic, Broca's) show in speech in different discourse contexts (first- vs. third-person narratives).

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A broader understanding of gesture's role across aphasia and discourse types has the potential to serve as a valuable tool for enhancing strategies for communication and therapy in clinical settings.

Overall Patterns of Speech and Gesture Production in Aphasia

Adults without aphasia use their hands frequently when talking, thus producing co-speech gestures (McNeill, 1992). Speech and gesture form a tightly integrated system, with gesture either augmenting the conceptual content already expressed in speech or adding new conceptual content that is not in speech (e.g., de Ruiter, 2000; Kita & Özyürek, 2003; McNeill, 1992). Unlike adult speakers without aphasia, adults with aphasia experience difficulties in speech production (e.g., Cicone et al., 1979; Hogrefe et al., 2013), raising two possibilities for their gesture production. They might show the same difficulties in gesture production as they do in speech and produce fewer gestures. Alternatively, they might use gesture more than adults without aphasia to compensate for the difficulties they encounter in speech production. Importantly, most of the existing research has provided evidence for the latter possibility, suggesting that adults with aphasia rely on gesture more than adults without aphasia (Carlomagno & Cristilli, 2006; Cocks et al., 2013; de Beer et al., 2019; Feyereisen, 1983; Le May et al., 1988; Sekine et al., 2013).

As existing evidence suggests, adults with aphasia use a more extensive set of gesture types than adults without aphasia (Sekine et al., 2013). These gestures cover a full range from the relatively less complex deictic gestures to indicate concrete referents (e.g., point at cat) to the relatively more complex iconic gestures (e.g., moving the hand backward to convey the *past*) and pantomimes (e.g., acting as if driving a car without speech) that depict actions and more abstract concepts (Cocks et al., 2013; de Beer et al., 2019; Kistner et al., 2020). Adults without aphasia produce most of their gestures with accompanying speech (McNeill, 1992). In contrast, adults with aphasia rely on gestures without speech (i.e., silent gestures) more frequently. They use silent gestures to compensate for the difficulties they encounter in either word retrieval (e.g., Hadar et al., 1998; Pritchard et al., 2013) or speech production (van Nispen et al., 2017).

The close relation between gesture and speech in aphasia has been explained by different theoretical models, including the sketch model (de Ruiter, 2000) and the lexical retrieval model (Rauscher et al., 1996). The sketch model asserts that speech and gesture originate from two separate but interrelated systems. As such, when one system does not function well, the other system takes over. The evidence for this model comes from studies that have shown that adults with aphasia primarily rely on silent gestures (also known as pantomimes) to convey their intended meanings when they cannot do so with their words (Lott, 1999; van Nispen et al., 2017). The lexical retrieval hypothesis, on the other hand, proposes that producing a symbolic gesture helps with word retrieval for the speaker. Evidence for this theory comes from several studies involving both individuals with and without aphasia. For example, it has been shown that speech production becomes more dysfluent when speakers are not allowed to gesture (Rauscher et al., 1996). Conversely, speakers resolve the tip-of-the-tongue problems more quickly when they gesture while speaking (Beattie & Coughlan, 1999). There is also research suggesting that gesture might play a facilitative role in individuals with aphasia by helping them retrieve words (Kistner et al., 2019; Lanyon & Rose, 2009; Rose & Douglas, 2001).

These two models serve as useful complementary frameworks in understanding the function of gesture in the communications of adults with aphasia who show considerable individual variability in their gesture production (Lanyon & Rose, 2009; Mol et al., 2013; Sekine et al., 2013). One potential factor that contributes to variability in gesture use is the extent of word retrieval difficulty (i.e., lexical retrieval; Dell et al., 1997; Friedmann et al., 2013). The nature and severity of word-finding difficulties vary based on the type and severity of aphasia as well as the location of the lesion (Friedmann et al., 2013; Hillis et al., 2002; Kiran & Thompson, 2003). More importantly, earlier research in adults with aphasia has shown a close relationship between the extent of lexical retrieval deficits and the amount of compensatory gesture use (Kistner et al., 2019; Lanyon & Rose, 2009). When adults with aphasia experience greater challenges in retrieving specific words, they produce more gestures. These gestures, in turn, play multiple roles in communication: They not only convey intended meanings not expressed in speech but also facilitate word retrieval (Kistner et al., 2019; Lanyon & Rose, 2009; van Nispen et al., 2017). These findings thus show patterns consistent with the predictions of the lexical retrieval theory.

Another factor that has been argued to contribute to variability in gesture production is the fluency of speech production (Sekine et al., 2013). Overall, adults with aphasia who have greater difficulties in speech production (e.g., Broca's aphasia) gesture more (e.g., Feyereisen, 1983; Sekine et al., 2013). They also produce more complex gestures (e.g., iconics, pantomimes) and used these gestures either to add further information to speech or to replace speech (Sekine et al., 2013). These findings provide support for the sketch model of gesture production, which views gesture and speech as separate but interrelated systems.

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A third yet relatively less examined factor that contributes to variability in gesture production is the type of discourse task that is used in the elicitation of responses (de Beer et al., 2019; Fergadiotis & Wright, 2011; Kistner et al., 2020; Lott, 1999; Stark, 2019). Researchers have primarily used two types of discourse tasks to elicit speech and gestures from adults with aphasia, namely, explanations and narratives (Carlomagno & Cristilli, 2006; Cocks et al., 2013; de Beer et al., 2019; Fergadiotis & Wright, 2011; Kistner et al., 2020; Sekine et al., 2013). The two most commonly studied explanation tasks include picture descriptions (e.g., explaining what is happening in a sequence of pictures) and procedural descriptions (e.g., explaining how to make a sandwich). The two most commonly used narrative tasks, on the other hand, include first-person (i.e., talking about self) and third-person (i.e., talking about another person) narratives (Boschi et al., 2017). The studies that compared gesture production in different types of narratives (first-person narratives about one's profession or family vs. third-person narratives based on cartoon descriptions) showed that adults with aphasia produce more gestures in third-person than in first-person narratives (Lott, 1999). They also produce a greater amount of the more complex iconic gestures in third-person than in first-person narratives (de Beer et al., 2019). These differences were considered to be an outcome of the greater linguistic demands imposed by third-person narratives, particularly for individuals with aphasia (e.g., de Beer et al., 2019; Lott, 1999).

The existing research thus suggests that the extent of difficulty associated with lexical retrieval and speech production, along with the relative difficulty of the discourse context, might play an important role in patterns of gesture production in adults with different types of aphasia. In addition, even though we know that adults with different types of aphasia vary in their speech production in different discourse contexts (Alexander & Hillis, 2008; Hallowell, 2017), no research has yet examined whether similar discourse context–based effects are evident in gesture production of individuals with different types of aphasia. Below, we provide a more detailed overview of the findings on speech and gesture production in the two narrative tasks (first person vs. third person) by individuals with two different subtypes of aphasia (Broca's, anomic)—the two variables that form the focus of our study—and as compared to individuals without aphasia.

Patterns of Speech and Gesture Production in the Narratives of Adults With Aphasia

Studies focusing on *third-person narrative tasks* (e.g., narrations based on picture books or cartoons) showed that adults with aphasia produce a lower amount of (i.e., word tokens) and less diverse (i.e., word types) speech than adults without aphasia (Fergadiotis & Wright, 2011; Fromm et al., 2017; Stark, 2019; Ulatowska et al., 1983; Webster et al., 2007; but see Cocks et al., 2013; Stark, 2019, for lack of group differences). This pattern was also evident in the complexity of speech, typically measured by the mean length of utterance (MLU; Fromm et al., 2017; Stark, 2019). Studies that examined patterns of speech production in *first-person narrative tasks* (i.e., interviews about personal events such as the impact of aphasia on life, goals for recovery) largely showed similar results. Individuals with aphasia used a lower amount of speech—also with less diversity and complexity—than individuals without aphasia, comparable in age (Bastiaanse et al., 1996; Bryant et al., 2013; Glosser et al., 1986; Wachal & Spreen, 1973).

There were only a few studies that compared speech production in adults with different types of aphasia in each narrative context. Adults with Broca's aphasia showed a lower amount of and less diverse and complex (as measured by MLU) speech production than adults with anomic aphasia in their production of third-person narratives (Cahana-Amitay & Jenkins, 2018; Gordon & Clough, 2020; Sekine et al., 2013). There is no study that has yet examined differences in speech production, specifically in the first-person narratives of individuals with Broca's versus anomic aphasia. However, previous work that focused on the broader category of adults with fluent (e.g., anomic) versus nonfluent (e.g., Broca's) aphasia — without any specification of subtype—showed a lower amount of and less complex speech production in adults with nonfluent aphasia in their first-person narratives (Grande et al., 2008; Wagenaar et al., 1975). Overall, previous work on adults with versus without aphasia as well as with Broca's versus anomic aphasia provides some evidence of group differences in the amount, diversity, and complexity of speech production in both first-person and third-person narrative tasks.

Turning to *gesture*, the few existing studies in third-person narratives reported differences with greater gesture production in adults with aphasia compared to adults without aphasia (Carlomagno & Cristilli, 2006; Cocks et al., 2013; de Beer et al., 2019; Sekine et al., 2013). At the same time, we do not yet know whether this group difference extends to the diversity of meanings conveyed in gesture (i.e., number of different gesture referents; e.g., point at dog vs. point at cat). Gesture production followed largely similar patterns in studies that focused on first-person narratives, with a greater amount of gestures used by adults with aphasia than by age-comparable adults without aphasia (de Beer et al., 2019; Feyereisen, 1983, but see Kistner et al., 2020). The two groups also differed in the types of gestures that they produced in their

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first-person narratives: Adults with aphasia produced a greater amount of pantomimes and iconic gestures than adults without aphasia (de Beer et al., 2019; Kistner et al., 2020). Only one study examined the relation between the information conveyed by gesture and the accompanying speech (i.e., gesture + speech combinations) in first-person narratives, showing that both adults with and without aphasia primarily used gestures to reinforce what they already conveyed in speech (e.g., "cup" + point at cup), with no group differences. However, adults with aphasia also used different types of gestures (i.e., iconic gestures, emblems, deictics) quite frequently to mark what was absent in their speech—a pattern that was almost never observed in adults without aphasia (van Nispen et al., 2017).

Only a few studies examined gesture production in adults with different types of aphasia in each narrative context. Adults with Broca's aphasia produced more gestures and used more complex gesture types (e.g., iconics, pantomimes) than adults with anomic aphasia in both third-person (Sekine & Rose, 2013) and first-person (e.g., Feyereisen, 1983; Sekine et al., 2013) narrative production contexts. We do not yet know whether this difference is also evident in the diversity of gesture or complexity of gesture + speech production. The only exception is one study that examined gesture + speech complexity between the broader category of adults with fluent versus nonfluent aphasia without a specification of subtypes within each. Adults with nonfluent aphasia relied more on the more complex supplementary gesture + speech combinations; they used gestures to either add information to their speech or replace their speech than adults with fluent aphasia in their first-person narratives (Lott, 1999).

Overall, previous work on adults with versus without aphasia as well as with Broca's versus anomic aphasia provides some evidence of group differences in the amount of gesture production in both first-person and third-person narrative tasks. At the same time, the majority of the relatively sparse research was small-scale, focusing exclusively on the amount and types of gestures (iconic vs. deictic). There is no existing work that has yet examined the diversity of meanings conveyed in gestures or gesture's informational relationship to speech (i.e., gesture + speech combinations) in different narrative contexts.

Apart from the relatively sparse research that has examined gesture production separately in each narrative context, there are no studies that compare gesture production in the first- versus third-person narrative contexts. The two narrative tasks have been shown to place distinct communicative demands on speakers, with a greater cognitive and linguistic effort involved in telling third-person than first-person narratives (de Beer et al., 2019; Hadley, 1998; Lott, 1999). Different from the unidirectional third-person narratives in which the experimenter presumes the role of the listener, first-person narratives involve more conversation-like interaction between communicative partners. This, in turn, allowed for a more dynamic communicative exchange, with the participant responding to multiple questions about personal events. Also, compared to first-person narratives, third-person narratives require the ability to convey predetermined content within a structured and coherent framework with the use of specific vocabulary. This, in turn, may result in higher word-finding difficulties for individuals with aphasia (Boschi et al., 2017; de Beer et al., 2019; Duong et al., 2005; Hadley, 1998). In addition, narrative elicitations are also commonly used by therapists in clinical settings to gain insight into naturalistic communication skills of adults with aphasia both at initial and post-intervention assessments (Bryant et al., 2016; Wallace et al., 2017). The common use of narrative elicitation in clinical settings, in turn, designates it as a highly relevant discourse context to improve communications of adults with aphasia in such settings. As such, understanding the differential demands each narrative task imposes on adults with different types of aphasia becomes particularly important in the design and evaluation of assessments in a clinical setting.

Current Study

Adults with different types of aphasia vary in their speech and gesture production (e.g., Sekine et al., 2013). At the same time, earlier research mostly compared adults with and without aphasia, collapsing across different aphasia types (Cocks et al., 2013; de Beer et al., 2019; Feyereisen, 1983; Kistner et al., 2020). Even less is known about the impact of different discourse contexts on speech and gesture production of adults with different types of aphasia. The only study that systematically compared productions in first- versus third-person narratives collapsed across individuals with different types of aphasia (de Beer et al., 2019; see also Lott, 1999, for anecdotal reports). Even though existing research largely suggests that gesture plays a compensatory role in aphasia (Lanyon & Rose, 2009; Sekine et al., 2013), we still do not know what function gesture serves in adults with different types of aphasia, who markedly differ in their speech fluency and lexical retrieval abilities, particularly when communicating in different discourse contexts. More specifically, there is no existing work providing a multifaceted approach to gesture's role in communication for adults with aphasia that examines both gesture on its own (meanings conveyed through gestures, use of different gesture types) and gestures in relation to speech (informational relation gesture holds to speech) in different subtypes of aphasia (i.e., Broca's vs. anomic aphasia) and in different discourse

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contexts (i.e., first- vs. third-person narratives). A fuller account of gesture's role in aphasia communication by aphasia type and discourse type has several important clinical implications. First, it provides the first step in developing effective multimodal assessment tools that are tailored to the capabilities of each aphasia patient in a given discourse context. Second, it provides a much-needed knowledge base for the development of more informed intervention strategies for aphasia patients. More specifically, it provides a detailed description of both the strengths and weaknesses associated with the use of gesture (with or without speech) as an intervention tool for different types of aphasia patients in helping them improve their communicative range.

In this study, we focused on the speech and gestures produced by adults with anomic aphasia (n = 20) and adults with Broca's aphasia (n = 20), along with adults with no aphasia (n = 20) in two different discourse genres: first- and third-person narratives. These aphasia types constitute two of the most common types of aphasia, allowing for the attainment of a larger and more homogeneous sample. These two groups also provided a good basis for comparison as they differ in their patterns of speech production and lexical retrieval abilities, with more pronounced difficulties in both abilities in the Broca's than in the anomic aphasia group (Alexander & Hillis, 2008; Hallowell, 2017).

We asked two questions. We first asked (a) whether patterns of speech production, namely, amount, diversity, and complexity of speech, would differ by group and discourse context. We predicted that, based on earlier work (Fergadiotis & Wright, 2011; Hallowell, 2017), adults with Broca's aphasia would produce the lowest amount, diversity, and complexity of speech, followed by adults with anomic and adults with no aphasia across discourse contexts. We also predicted that the third-person narrative context would impose greater communicative demands (Boschi et al., 2017; de Beer et al., 2019; Duong et al., 2005; Hadley, 1998), resulting in a lower amount of and less diverse and complex speech in third-person than in first-person narratives—a pattern that we expected to be more pronounced in individuals with aphasia.

We next asked (b) whether patterns of gesture production, namely, amount, diversity, and complexity of gesture, would differ by group and discourse context. Based on earlier work that suggested a compensatory role for gestures in aphasia communication (Feyereisen, 1983; van Nispen et al., 2017), we expected the reverse pattern for gesture: We predicted that adults with Broca's aphasia would produce a greater amount, diversity, and complexity of gesture, followed by adults with anomic and adults with no aphasia across contexts. Similar to speech, we also predicted that adults would produce a greater amount, diversity, and complexity of gestures in third-person narratives due to the more challenging nature of third-person accounts (de Beer et al., 2019; Hadley, 1998), and we expected this pattern to be more pronounced for adults with aphasia.

Method

Participants

The sample came from an archival database: https://aphasia.talkbank.org/ (TalkBank, n.d.), which is a multimedia database of discourse samples obtained from adults with and without aphasia (MacWhinney et al., 2011). In this study, we selected three groups: 20 adults with anomic aphasia (M_{age} = 60 years, SD = 10, 10 men), 20 adults with Broca's aphasia (M_{age} = 56 years, SD = 13, 10 men), and 20 adults without aphasia (i.e., neurotypical adults; M_{age} = 54 years, SD = 12, 10 men) who were comparable in gender; age, $F(2, 59) = 1.48$, $p = .24$; and education (i.e., years of schooling), $F(2, 58) = 0.98$, $p = .38$. The participants were Caucasian (75%–100%) or African American (10%–20%). The sample size of 20 per group was based on similar earlier work on speech and gesture production (Kistner et al., 2020) that showed significant main and interaction effects ($p < .05$) with medium-to-large effect sizes (η_p^2 = .40–.55). The inclusion criteria for all groups were as follows: (a) being a monolingual English speaker, (b) having no coexisting neurodegenerative disorder or depression, (c) having normal visual and hearing acuity, (d) gesturing at least once in each narrative task, and (e) the visibility of gestures in the video-recordings. Individuals without aphasia also had the additional inclusion criteria of not having a neurological condition (e.g., stroke). All individuals with aphasia had a single, unilateral, left-hemisphere stroke as verified by neuroimaging results or a clear medical diagnosis, and all were at least 6 months postonset. There was no difference in the time post aphasia onset for adults with anomic versus Broca's aphasia, M_{anomic} = 5 years, SD = 4 vs. $M_{\text{Broca's}}$ = 6 years, SD = 6, $F(1, 39) = 0.36$, $p = .55$. We only included adults with mild-to-moderate aphasia, as assessed by the Western Aphasia Battery–Revised (WAB-R; Kertesz, 2007), with scores of M = 85, SD = 7, and M = 60, SD = 7, for the individuals with anomic and Broca's aphasia, respectively (see Appendix A for further details on the characteristics of each participant with aphasia in our sample). Our decision to exclude adults with severe aphasia was based on the difficulties they typically encounter in speech production—particularly in extended speech forms such as narratives—and in gesture

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production due to the frequent co-occurrence of limb apraxia (Doyle et al., 1998; Hogrefe et al., 2013; Mol et al., 2013).

Data Collection

The data were collected in aphasia centers around the United States by using the AphasiaBank protocol, the details of which are available at https://aphasia.talkbank.org/. Informed consent was obtained at the time of data collection by the original investigators as part of their institution's ethical review board regulations; these data were later stored in AphasiaBank archives in password-protected servers for future research projects on secondary data analysis. Our access and use of these archival data was approved by an American research university institutional review board that holds a Federalwide Assurance of Compliance with the Office for Human Research Protections. All data transcription and coding were carried out in accordance with the Code of Ethics for the protection of human research participants.

The original aphasia protocol consisted of discourse tasks that elicited speech and gesture; standardized assessments (e.g., WAB-R; Kertesz, 2007); and a demographic survey that gathered information about gender, age, race, handedness, education, occupation, language status, and time post aphasia onset. In this study, we focused on narrative productions, examining the contrast between first-person narratives (i.e., personal narrative accounts) and third-person narratives (i.e., stories involving fictional characters). In first-person narratives, adults with aphasia were asked questions about their speech, stroke history, recovery from stroke, and important events in their lives; adults without aphasia were asked questions about any illnesses or injuries they had in the past, their recovery, their experiences with people with communication difficulties, and important events in their lives. Each question was followed by a standard set of prompts (e.g., "Are you having trouble with your talking?" "Do you remember your stroke?") if the participant could not respond to the initial question within 10 s. In third-person narratives, all participants were presented with a wordless picture book depicting the story of Cinderella (Disney, 2002) and asked to tell a story in their own words based on what they saw. In cases where a participant's response was fewer than three utterances, the experimenter prompted the participant with further questions (e.g., "Did Cinderella go to the ball and meet the prince?") after a 10-s no response period.

Data Transcription, Coding, and Reliability

Speech. All spoken responses were transcribed, using the Codes for the Human Analysis of Transcripts (CHAT) system according to the CHAT system guidelines (MacWhinney, 2000) and segmented into utterances. An utterance was defined as a unit of speech separated by syntactic marking (i.e., full sentences), intonation, or a pause (MacWhinney, 2000). We further tabulated speech production for amount, diversity, and complexity, using the Computerized Language Analysis program (MacWhinney, 2000). We used the total number of words as a measure of *amount*, the number of unique words (i.e., word types; e.g., "cat" vs. "dog" vs. "walk" vs. "sleep") as a measure of *diversity*, and the number of words per utterance (i.e., MLU) as a measure of *complexity* for speech production. For example, if an adult said "cat" three times; "dog," five times; and "walk," two times 2 times, he would receive a score of 10 for speech amount and 3 for speech diversity. We treated words with the same stem but with different derivational morphemes (e.g., "play" vs. "player") as different word types and words with the same stem but with different inflectional morphemes (e.g., "play" vs. "plays") as the same word type.

Gesture. We coded all gestures that accompanied each speech utterance (i.e., co-speech gesture) and that were produced on their own without speech (i.e., silent gesture), following earlier work. We relied on pauses between hand movements as well as changes in handshape form in detecting movements as distinct gestures, following earlier work (Özçalışkan et al., 2016, 2018). We treated linked hand movements that were produced with the same handshape form without a pause as one gesture (e.g., hopping downward facing palm left to right to convey dripping a ball across), and we coded linked hand movements that had different handshape forms with a pause in between as different gestures (e.g., hopping downward facing palm in place as if dripping a ball and then sliding sideways palm left to right as if marking trajectory of action).

Each gesture was coded further for its meaning, its type, and the informational relation it held to the accompanying speech (i.e., gesture + speech), following earlier work (Cicone et al., 1979; Kendon, 1980; McNeill, 1992; Özçalışkan & Goldin-Meadow, 2005; Sekine & Rose, 2013). *Gesture meaning* referred to the entity or the concept the gesture characterized or indicated (e.g., hold up raised arms above the head to indicate tall person, point at cup to indicate cup). We relied on gesture form (i.e., handshape of gesture); the context of production (i.e., the topic of discourse); and, if available, the speech that accompanied, preceded, or followed the gesture in assigning meaning to gestures. *Gesture type* referred to the form of gesture and included the following: deictic gestures that indicated concrete or abstract entities (e.g., point at pen to indicate pen, point to space behind body to indicate past time), iconic gestures that characterized features or actions associated with concrete or abstract entities (e.g., hold cupped hand in the air to characterize *a round object*,

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move palm backward to mark times *past*), emblems that conveyed culturally prescribed meanings (e.g., shake head to convey negation), pantomimes that were silent enactments of actions (e.g., move fisted palm back and forth in front of the body to convey cutting bread), number and letter gestures (e.g., *trace number 3 in* the *air*, trace letter L in air), and beats that added emphasis to speech (e.g., *flick thumbs*; see Appendix B for details on coding of gestures into types). Gesture + speech types referred to the informational relation between gesture and speech in co-speech gestures and were coded into four types, following earlier work (Özçalışkan & Goldin-Meadow, 2005; Özçalışkan et al., 2017): reinforcing combinations in which gesture conveyed the same information as speech (e.g., "desk" + point at a desk), disambiguating combinations in which gesture clarified information in speech (e.g., "there" + point to right), supplementary combinations in which gesture added new information to speech (e.g., "he goes" + rest head on palm to convey sleep), and emphasizing combinations in which gesture emphasized or marked speech boundaries. We coded all gestures that were semantically or temporally (in the case of beats) related to a speech segment (i.e., a word, a phrase) that immediately preceded or succeeded or overlapped with the gesture as a gesture + speech combination.

We further tabulated gesture production for amount, diversity, and complexity. We used the number of gestures as a measure of amount and the number of unique referents conveyed in gesture (e.g., point at *book* vs. point at *table*) as a measure of diversity for gesture production. We also counted the number of each type of gesture (iconic, pantomime, number–letter, emblem, deictic, beat) and gesture + speech combination (reinforcing, supplementary, disambiguating, emphasizing) as measures of complexity for gesture production. We classified iconic, pantomime, number, letter, and emblem gestures as more complex than deictic and beat gestures and supplementary gesture + speech combinations as more complex than reinforcing, emphasizing, and disambiguating gesture + speech combinations, following earlier work (Ozturk et al., 2021; Pınar et al., 2021).

Reliability for gesture coding was assessed by a trained independent coder, who coded a randomly selected 20% of the video-recordings. The agreement between coders was 91% for the identification of gestures (i.e., whether a hand movement is gesture), 93% for assigning meaning to gestures, 92% for the classification of the gestures into types, and 89% for the classification of the gesture + speech combinations into types.

Data Analysis

The amount, diversity, and complexity of speech and gesture were tallied for each participant. We observed considerable within-group variability in the production of speech and gesture; we, therefore, converted all raw scores of gestures produced by each participant into proportions; we then transformed speech and gesture measures using either square root transformations (i.e., gesture complexity and gesture + speech complexity, which had a higher incidence of scores with 0 values) or log transformations (all remaining measures) and conducted all analyses on transformed scores. To account for the variability in speech production across participants, we used gesture-to-word ratios (gestures produced per 100 words) in our analyses of gesture production, following earlier work (Feyereisen, 1983; Sekine et al., 2013).

We first examined the influence of context and group, using a set of two-way analyses of variance (ANOVAs) with group (anomic aphasia, Broca's aphasia, no aphasia) as between-subjects factors and discourse context (first person, third person) as within-subject factors, separately for amount, diversity, and complexity of speech production (three different ANOVAs) and amount, diversity, and complexity of gesture production (three different ANOVAs). We followed each two-way ANOVA that yielded significant group effects and interactions with follow-up multiple comparisons, using Bonferroni corrections set at $p < .016$. For two measures that were not normally distributed (speech complexity, gesture + speech complexity), we further confirmed statistical significance with nonparametric techniques (Kruskal–Wallis, Wilcoxon signed-ranks test), which showed the same patterns; we therefore only reported the statistical results based on ANOVAs. To further determine how variability in participant characteristics of our aphasia sample related to speech and gesture production, we conducted a series of Pearson correlations examining the relation between three different aphasia measures, namely, aphasia severity (as indexed by WAB Aphasia Quotient), speech fluency (as indexed by WAB Spontaneous Speech Fluency score), and naming ability (as indexed by Boston Naming Test–Short Form score; Lansing et al., 1999) in relation to patterns of speech and gesture production.

Results

Patterns of Speech Production

Beginning with the amount of speech production, we found a main effect of group, a main effect of discourse context, but no interaction between group and discourse context. In line with our expectations, first-person narratives elicited a greater amount of speech than third-person narratives across groups. More important, adults with Broca's aphasia produced a lower amount of speech

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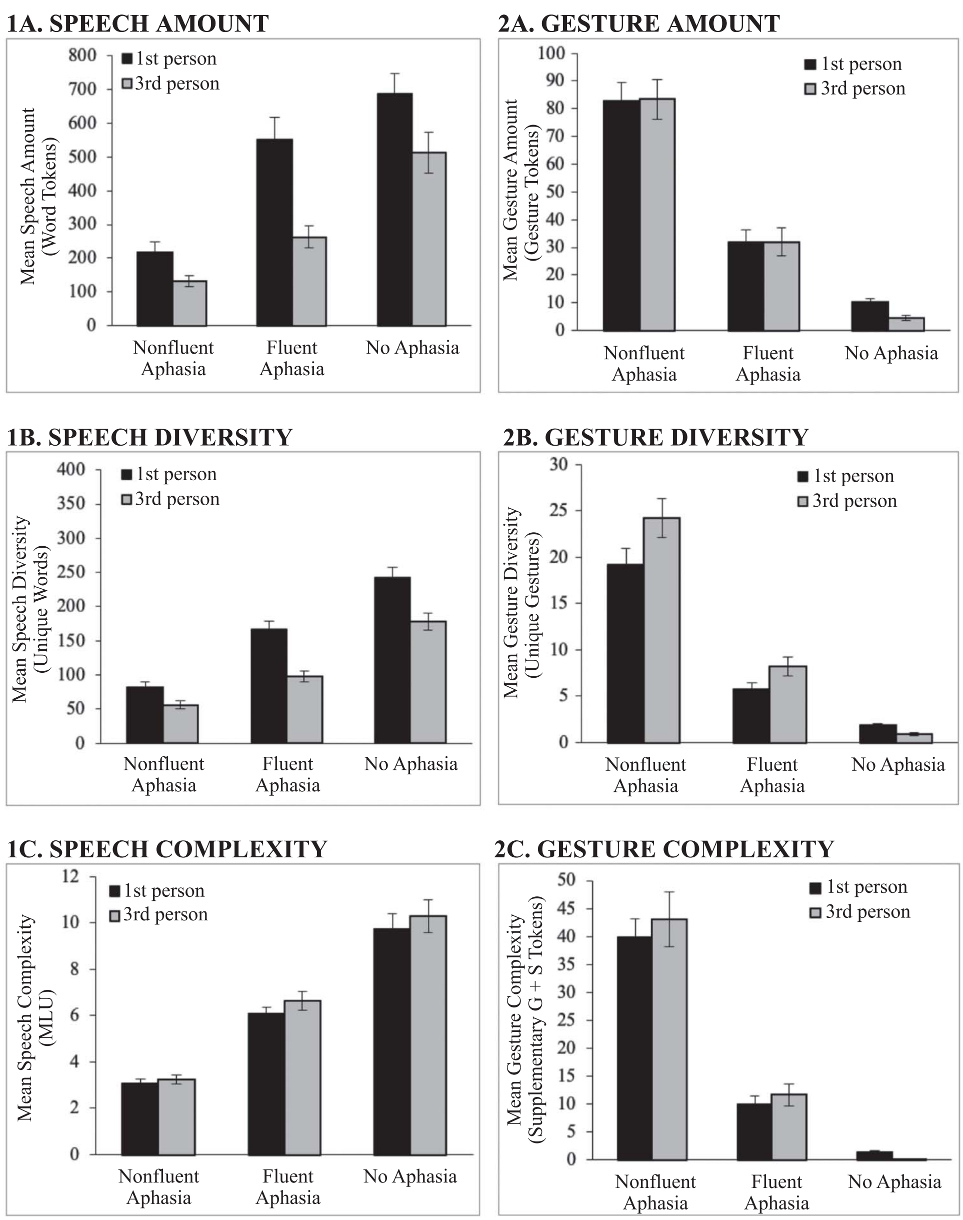
than adults with anomic aphasia ($p < .001$), who, in turn, produced a lower amount of speech than adults with no aphasia ($p = .003$) across the two narrative contexts (see Figure 1, Panel 1A).

The diversity of speech production followed a similar pattern, with a main effect of group, a main effect of discourse type, but no interaction between group and discourse type. As expected, first-person narrative context elicited more diverse speech than third-person narrative context across groups. In line with our predictions, adults with Broca's aphasia produced less diverse speech (i.e., fewer word types) than adults with anomic aphasia ($p < .001$), who, in turn, produced less diverse speech than adults with no aphasia ($p < .001$) across discourse contexts (see Figure 1, Panel 1B).

The patterns for complexity of speech production remained the same: The complexity of speech—as measured by MLU—showed a main effect of group, a main effect

Figure 1. Mean amount (1A and 2A), diversity (1B and 2B), and complexity (1C and 2C) of speech and gesture production by adults with nonfluent aphasia, with fluent aphasia, and without aphasia in first-person (dark bars) and third-person (light bars) narratives. Gesture measures refer to gestures produced per 100 words; error bars represent standard error (note that the scales of the figures are different in each panel). MLU = mean length of utterance; G + S = gesture + speech.



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of discourse type, but no interaction between group and discourse type. Third-person narrative context elicited more complex speech than first-person narrative context across groups. In line with our predictions, adults with Broca's aphasia produced less complex speech than adults with anomic aphasia ($p < .001$), who, in turn, produced less complex speech than adults with no aphasia across contexts ($p < .001$; see Figure 1, Panel 1C). In summary, our results provided evidence for both group and discourse context differences in the amount, diversity, and complexity of speech production, in line with our predictions (see the upper half of Table 2 for a full summary of the statistical results for speech production).

Patterns of Gesture Production

Beginning with the amount of gesture production, we found a main effect of group, a main effect of discourse context, and an interaction between group and discourse context. Looking across discourse contexts, adults with Broca's aphasia produced more gestures than adults with anomic aphasia ($p < .001$), who, in turn, produced more gestures than adults without aphasia ($p < .001$)—a pattern consistent with our predictions. Looking across groups, third-person narratives elicited fewer numbers of gestures than first-person narratives. However, as revealed by the interaction, this difference was only significant for individuals without aphasia ($p < .001$). Individuals with both types of aphasia were comparable in their production of gesture in the two discourse contexts (see Figure 1, Panel 2A).

Turning to diversity of gesture production, we also found a main effect of group, a main effect of discourse type, and an interaction between group and discourse type. As expected, adults with Broca's aphasia produced greater diversity of unique gestures than adults with anomic aphasia ($p < .001$), who, in turn, produced greater diversity of unique gestures than adults without aphasia ($p < .001$) across contexts. Looking across groups, third-person narratives elicited a less diverse set of gestures than first-person narratives. However, as suggested by the interaction, this difference was only significant for individuals without aphasia ($p < .001$). In contrast, third-person narratives resulted in greater diversity of gesture production for both groups of adults with aphasia (anomic aphasia: $p < .001$; Broca's aphasia: $p = .007$; see Figure 1, Panel 2B), thus showing a pattern consistent with our predictions.

The patterns for the complexity of gesture production were largely similar. Beginning with the complexity of gesture based on gesture types (i.e., iconic, pantomime, number, letter, and emblem gestures), there was a main effect of group, a main effect of discourse type, and a significant interaction between group and discourse type. Looking across discourse contexts and in line with our predictions, adults with Broca's aphasia produced a greater number of the more complex gestures than adults with anomic aphasia (M = 103.08, SD = 44.76 vs. M = 28.49, SD = 17.97; $p < .001$), who, in turn, produced more of such gestures than adults without aphasia (M = 3.97, SD = 2.6; $p < .001$), following our predictions. Looking across groups, third-person narratives elicited fewer numbers of the more complex gestures than first-person narratives (M = 73.42, SD = 36.24 vs. M = 61.67, SD = 29.09). However, as revealed by the interaction, this difference was only significant for individuals without aphasia (M = 3.23, SD = 1.74 vs. M = 0.74, SD = 0.86; $p < .001$). Individuals with both types of aphasia were comparable in their production of complex gestures in the two discourse contexts (Broca's aphasia: M = 56.20, SD = 25.84 vs. M = 46.88, SD = 18.92; anomic aphasia: M = 13.99, SD = 8.66 vs. M = 14.05, SD = 9.31; see Table 1)—a pattern that differed from our predictions.

Table 1. Mean production of different types of gestures and gesture + speech combinations produced by adults with and without aphasia (*SD*).

Variable	Broca's aphasia		Anomic aphasia		No aphasia	
	1st person	3rd person	1st person	3rd person	1st person	3rd person
Gesture types						
Beat	10.55 (7.05)	13.35 (11.02)	12.35 (11.13)	12.42 (11.76)	6.64 (4.43)	3.61 (3.72)
Deictic	16.09 (9.71)	23.22 (16.39)	5.34 (4.32)	5.61 (5.46)	0.52 (0.46)	0.19 (0.22)
Emblem	35.51 (18.37)	23.71 (12.78)	10.81 (7.63)	9.34 (7.79)	2.24 (1.36)	0.55 (0.61)
Iconic	11.81 (7.39)	14.77 (11.60)	2.19 (1.79)	3.58 (3.63)	0.93 (0.99)	0.17 (0.38)
Number and letter	7.21 (8.46)	6.15 (7.89)	0.89 (0.97)	1.04 (1.50)	0.06 (0.19)	0.01 (0.05)
Pantomime	1.66 (2.31)	2.23 (2.51)	0.09 (0.15)	0.08 (0.20)	None	None
Gesture + speech types						
Disambiguating	2.41 (2.51)	3.05 (4.09)	1.32 (1.62)	1.02 (1.89)	0.16 (0.19)	0.02 (0.07)
Emphasizing	10.33 (6.89)	12.87 (10.43)	12.16 (10.83)	12.15 (11.56)	6.63 (4.45)	3.56 (3.67)
Reinforcing	15.92 (8.28)	13.85 (6.13)	6.22 (2.88)	5.78 (3.70)	2.11 (1.28)	0.73 (0.86)
Supplementary	39.89 (14.88)	43.00 (21.86)	9.92 (7.32)	11.67 (8.55)	1.35 (1.08)	0.12 (0.15)

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Turning last to the complexity of gesture + speech combinations (i.e., supplementary gesture + speech), we also found a main effect of group, a significant interaction between group and discourse type, but not a main effect of discourse type. Looking across discourse contexts, adults with Broca's aphasia produced a greater number of the more complex supplementary gesture + speech combinations than adults with anomic aphasia ($p < .001$), who, in turn, produced more of such combinations than adults without aphasia ($p < .001$), following our prediction. However, third-person narratives elicited fewer numbers of the more complex supplementary gesture + speech combinations than first-person narratives, but only for adults without aphasia as revealed by a Group × Discourse Type interaction ($p < .001$). Individuals with both types of aphasia were comparable in their production of the more complex gesture + speech combinations in the two discourse contexts (see Figure 1, Panel 2C; also see the lower half of Table 1 for a summary of the statistical results for gesture production).

All three groups produced each type of gesture, with the only exception of pantomimes and number and letter gestures that were only or almost only produced by adults with aphasia (see Appendix A). A majority of the gestures produced by adults without aphasia were accompanied by speech (co-speech gesture; 99%)—a pattern that was also true for adults with aphasia (anomic: 96%, Broca's: 89%). At the same time, adults with aphasia produced considerably more gestures without speech (anomic: 4%, Broca's: 11%) than adults without aphasia, further highlighting gesture's unique contribution to communication in this group.

In summary, adults with Broca's aphasia differed from adults with anomic aphasia, who, in turn, differed from adults without aphasia in all three measures of gesture production (amount, diversity, and complexity) across the two narrative tasks—a pattern in line with our predictions. Adults with aphasia also used a more diverse gesture lexicon (i.e., gestured about a greater variety of referents) in their third-person narratives than in their first-person narratives—a pattern that was also in line with our predictions, thus suggesting a compensatory role for gesture. The relative distribution of different gesture types also showed group-based variability, with greater production of gestures without speech in the two aphasia groups compared to adults without aphasia (see Table 2).

Table 2. Summary table for statistics on speech and gesture production.

Speech	*df*	df_{error}	*F*	*p*	η_p^2
Speech amount					
Group	2	57	49.43	< .001	.63
Discourse context	1	57	36.06	< .001	.39
Group × Discourse Context	2	57	2.35	.104	
Speech diversity	2	57	72.45	< .001	.72
Group	1	57	50.72	< .001	.47
Discourse context					
Group × Discourse Context	2	57	1.46	.241	
Speech complexity					
Group	2	57	113.92	< .001	.80
Discourse context	1	57	5.66	.021	.09
Group × Discourse Context	2	57	0.16	.851	
Gesture					
Gesture amount					
Group	2	57	166.81	< .001	.85
Discourse context	1	57	15.92	< .001	.22
Group × Discourse Context	2	57	14.72	< .001	.34
Gesture diversity					
Group	2	57	226.14	< .001	.89
Discourse context	1	57	4.19	.045	.07
Group × Discourse Context	2	57	29.49	< .001	.51
Gesture complexity (gesture types)					
Group	2	57	155.46	< .001	.84
Discourse context	1	57	18.58	< .001	.25
Group × Discourse Context	2	57	4.67	.013	.14
Gesture complexity (gesture + speech types)					
Group	2	57	176.79	< .001	.86
Discourse context	1	57	1.25	.268	
Group × Discourse Context	2	57	4.30	.018	.13

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Given the compensatory role gesture played in individuals with aphasia, we further probed the relation between speech fluency and measures of both speech and gesture production in the two aphasia groups in our sample. Spontaneous speech fluency scores (as assessed by WAB Spontaneous Speech Fluency) showed strong positive correlations with all three measures of speech production (amount: r = .62, diversity: r = .72, and complexity: r = .81; ps < .001) and moderate-to-strong negative correlations with all three measures of gesture production (amount: r = −.61, diversity: r = −.66, and complexity: r = −.58; ps < .001), suggesting a close inverse relation between speech fluency and gesture production. This inverse relation—although evident in both groups—was more pronounced in individuals with Broca's aphasia, suggesting a larger compensatory role for gesture in this group. To further determine whether the higher gesture production observed in adults with aphasia is possibly related to difficulties in naming ability, we also examined the relation between naming ability (as assessed by the Boston Naming Test–Short Form) and overall amount of speech and gesture production. Our results indicated moderate positive correlations with naming ability for both diversity (r = .46, p < .001) and complexity (r = .53, p < .001) of speech and moderate negative correlations with all the three measures of gesture production (amount: r = −.40, diversity: r = −.44, and complexity: r = −.41; ps < .001), suggesting that individuals with aphasia might be using gesture at least partly to label objects that they cannot easily label in speech. The negative correlation between naming ability and gesture production was also slightly more pronounced in individuals with Broca's aphasia, suggesting a greater role for gesture in lexical access in this group.

Given that individuals with Broca's aphasia overall showed more pronounced aphasia symptoms in both speech fluency and naming ability, we next examined whether it was overall severity of aphasia symptomatology that predicted patterns of speech and gesture production. Not surprisingly, aphasia severity (as indexed by WAB Aphasia Quotient—with higher scores indicating lower severity) was positively correlated with all measures of speech production (amount: r = .56, diversity: r = .68, and complexity: r = .78; ps < .001); this pattern was reversed for gesture, however, with moderate negative correlations between aphasia severity and gesture use (amount: r = −.49, diversity: r = −.52, and complexity: r = −.45; ps < .001; see Appendix C for the complete set of correlations across the two aphasia groups). Among all three measures of aphasia characteristics, however, speech fluency showed the strongest positive correlations with speech and strongest negative correlations with gesture production.

Discussion

In this study, we focused on speech and gestures produced by adults with anomic aphasia (n = 20), adults with Broca's aphasia (n = 20), and adults without aphasia (n = 20) in two narrative contexts (first person and third person). We examined whether the production of speech and gesture varied by group and discourse context and found evidence for both. First, looking at group differences, adults with Broca's aphasia produced the lowest amount of and least diverse and complex speech, followed by adults with anomic aphasia, who, in turn, produced a lower amount of and less diverse and complex speech than adults without aphasia across the two narrative contexts. This pattern was reversed for gesture production. Turning next to discourse context differences, third-person narratives elicited lower levels of speech production—for both amount and diversity—than first-person narratives. This pattern was reversed in gesture production, but only for diversity. Individuals with aphasia used gesture to convey a more diverse set of meanings in their third-person narratives as compared to their first-person narratives, suggesting a compensatory role for gesture at the lexical level in third-person narratives.

Telling Narratives in Speech and Gesture: Adults With Anomic Aphasia, Broca's Aphasia, and No Aphasia Differ

In line with earlier work (Gordon & Clough, 2020; Grande et al., 2008; Stark, 2019) and with our predictions, we found that adults with Broca's aphasia showed the greatest difficulties in their speech production compared to adults with anomic aphasia, who, in turn, performed lower in speech production compared to adults without aphasia across the two narrative contexts. These differences became evident not only in the amount and complexity of speech production—replicating earlier work (Fromm et al., 2017; Grande et al., 2008)—but also extended to the diversity of speech production, as shown for the first time in our study. What might explain these differences? One of the biggest challenges that adults with aphasia face is frequent word-finding difficulties during narrative tasks—a challenge that is particularly pronounced for adults with Broca's aphasia compared to adults with anomic aphasia. Importantly, when faced with the difficulty of finding a word (i.e., the tip-of-the-tongue phenomenon; Goodglass et al., 1976), adults with aphasia often tried to convey the semantic meaning through gesture—a pattern that was more commonly observed among adults with Broca's aphasia than anomic aphasia in our study. Gesture production by group followed largely the opposite pattern to speech production. Adults with Broca's aphasia showed the greatest

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advantage in their production of gesture—amount, diversity, complexity—followed by adults with anomic aphasia and then adults without aphasia. Moreover, there were moderate-to-strong negative correlations between speech fluency and all three measures of gesture production in individuals with aphasia—a pattern that was also more pronounced for individuals with Broca's aphasia.

These findings concur with previous findings that showed greater gesture production in adults with aphasia in general (e.g., Carlomagno & Cristilli, 2006; Feyereisen, 1983) and adults with Broca's aphasia in particular (Sekine et al., 2013). Our study extended this earlier work by also showing that adults with Broca's aphasia relied on gesture more than adults with anomic aphasia. One novel contribution of our study was that it showed for the first time that adults with aphasia—anomic and Broca's—showed greater diversity in their gesture vocabulary (i.e., unique referents conveyed in gesture, e.g., point at cat vs. point at dog) than adults without aphasia. This pattern was particularly evident for adults with Broca's aphasia, who exhibited the greatest difficulties in speech production, further suggesting that the gestures produced by adults with aphasia convey substantive information that compensates for difficulties in speech production.

Similar to an earlier study exploring gesture use in third-person narratives (Sekine et al., 2013), we found that both adults with anomic and Broca's aphasia employed a full range of gesture types in their third-person narratives—a pattern that also extended to their first-person narratives in our study. Adults with aphasia also produced some gestures that were not produced by adults without aphasia, namely, deictic gestures that were directed to oneself (e.g., point at self), pantomimes (e.g., moving semicupped empty palm in circles to convey WAVING WAND, slumping body forward forcefully to convey FALLING), and letter gestures that labeled referents (e.g., writing JULY with the index finger).

In line with some of the findings of the earlier studies (Cocks et al., 2013; de Beer et al., 2019; Kistner et al., 2020), we found that adults with Broca's aphasia produced the highest number of complex gestures (e.g., iconics), followed by adults with anomic aphasia, who, in turn, produced higher numbers of complex gestures than adults without aphasia. This pattern was reversed for beat gestures, which are simpler gestures that do not convey any semantic meaning. Beat gestures mostly accompanied fluent speech and were frequently used by both adults with anomic aphasia and adults with no aphasia to guide the flow of their speech production. An earlier study (Kistner et al., 2020) reported that adults with aphasia produce a fewer number of beat gestures than adults without aphasia. Our study has shown this to be true for adults with Broca's aphasia, but not for adults with anomic aphasia, who produced a greater number of beat gestures than adults without aphasia. Also, in line with our predictions, we found that both adults with Broca's and anomic aphasia used deictic gestures quite frequently to refer to abstract or concrete referents (e.g., pointing to the air to convey IMAGINARY PRINCESS, pointing to the face to convey FACE) across narratives, a usage that was rarely observed in communications of adults without aphasia.

In line with earlier work (van Nispen et al., 2017), we also found that adults with aphasia used a greater number of gestures to convey additional information that was not found in their speech. Our study also extended this work, showing that adults with aphasia, particularly the ones with Broca's aphasia, used gesture more to add further information to their speech than adults without aphasia. More specifically, 58% of the gesture + speech combinations produced by adults with Broca's aphasia were supplementary, adding further information to speech. Such supplementary gesture + speech combinations were less frequent among adults with anomic aphasia, accounting for 35% of their productions; they were also relatively infrequent among adults without aphasia (9% of gesture + speech combinations), who used a greater portion of their gestures to either emphasize (67%) or reinforce (22%) their speech. Adults with anomic aphasia also used gesture to compensate for their difficulties in speech production—although not as frequently as adults with Broca's aphasia. They used gesture to add arguments (e.g., "talk" + hold fisted hand next to ear for PHONE, "prince saw" + palms cupped together for SLIPPER) or predicates (e.g., "not singing, but it is" + moves downward facing palms in a sweeping motion to convey DANCING, "he said" + moves palms next to feet backward as if PUTTING ON A SHOE) to their spoken descriptions, thus following a pattern akin to adults with Broca's aphasia. These findings align well with the sketch model (de Ruiter, 2000) of gesture production: When individuals with aphasia experienced limitations with speech production, they used gestures to compensate for the difficulties in speech production. In other words, when speech production was interrupted, gesture took on a significant role in communication, as suggested by a strong negative relation between speech fluency and the amount and diversity of gesture production in individuals with aphasia in our study. These findings thus suggest that gesture serves as a communicative tool that compensates for speech difficulties for individuals with different types of aphasia.

Individuals in both aphasia groups also used a greater number of gestures to convey the same information as their speech (i.e., reinforcing gesture + speech

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combinations, e.g., "hat" + place hand above head as if HAT) compared to adults without aphasia, who, instead, primarily relied on gestures to emphasize their speech with beat gestures. One possible explanation for the greater reliance on reinforcing gesture + speech combinations in this group might be the lexical access difficulties they encountered (Krauss et al., 2000). As suggested by the lexical retrieval model, the increased use of gestures that convey semantic meanings might have helped facilitate word retrieval in individuals with aphasia (Kistner et al., 2019; Lanyon & Rose, 2009; Rose & Douglas, 2001).

Another interesting difference that we observed between the three groups in gesture production was the relative distribution of silent gestures (i.e., gestures that were produced without speech; Özçalışkan et al., 2016). The incidence of silent gestures was more pronounced in both groups of individuals with aphasia than the ones with no aphasia. In these instances, gesture replaced speech, and this pattern was more evident in individuals with aphasia who showed greater speech production difficulties (i.e., Broca's). The difference in the use of silent gestures in the two aphasia groups raises the possibility that severity of the aphasia symptomatology might be the underlying factor for gesture production. This was, in fact, evident in our data with positive correlations between the degree of aphasia severity and the amount of gesture production in individuals with aphasia. Adults who had more severe aphasia symptoms (as measured by WAB Aphasia Quotient) were also more likely to produce more gestures, including silent gestures ($r = .47$, $p = .002$).

In addition to the influence of aphasia severity, it is important to recognize the effects of speech fluency and lexical retrieval ability on differences in gesture production. Our correlational analyses revealed that gesture production was influenced by both speech fluency and lexical retrieval ability (assessed by the Boston Naming Test). In fact, speech fluency had a stronger impact on gesture production ($r = -.605$, $p < .001$) than naming ability ($r = -.391$, $p = .013$) in our study—a pattern that aligns well with Sekine et al.'s (2013) earlier findings.

In summary, gestures served different functions for adults with versus without aphasia. While adults without aphasia mostly used their gestures to emphasize their speech, adults with aphasia used gesture more to supplement their speech. As our findings suggest, adults with Broca's aphasia who had more significant lexical retrieval difficulties and less fluent speech showed the greatest reliance on gesture. Our findings thus suggest that the compensatory role of gesture was proportional to participants' speech fluency and lexical retrieval abilities.

Telling Narratives in Speech and Gesture: First-Person and Third-Person Narratives Differ

Our study showed—for the first time—that the type of narrative impacted speech production. In line with our predictions, both adults with and without aphasia produced a lower amount of speech with a less diverse lexicon in their third-person narratives than in their first-person narratives. One likely explanation for this difference could be the greater communicative and cognitive demands third-person narratives impose on speakers. Narrating a story from a third-person perspective (i.e., Cinderella story) might have required the speakers not only to remember the order of events and tell them in a cohesive way (e.g., first, the Fairy Godmother assists Cinderella to go to the ball, and then, Cinderella dances with prince at the ball) but also to recall specific vocabulary items that are not frequently used in daily communication (e.g., stepsisters, ball, Fairy Godmother, and magic wand). The narration from a first-person perspective (i.e., personal events, e.g., going to the doctor), which provided the speaker with greater freedom to choose what to say and which words to use, did not impose such demands. One interesting finding that was not in line with our prediction was that third-person narratives elicited more complex speech than first-person narratives, even though the difference was relatively small. This difference might be an outcome of the nature of the third-person narrative task, where the content was predetermined, and speakers needed to include certain unique details. In fact, speakers used a greater amount of descriptors (e.g., adjectives, adverbs) to convey those details in their third-person narratives, which might have made their sentences slightly longer (e.g., "the man went to find Cinderella again by using the lost shoe," "and the oldest stepsister tries on the shoe and it's too small," "she left for the party showing up and dazzled everyone including the prince who immediately wanted to dance with her making the sisters very angry").

In summary, both adults with and without aphasia showed the same pattern of differences in their speech production in the two narrative tasks: They all produced a lower amount of speech with less diverse vocabulary in their third-person narratives, but they also all produced more complex speech in their third-person narratives compared to their first-person narratives. These patterns might suggest that narrating from a third-person perspective imposes greater communicative constraints with regard to the content of the talk, thus lowering the amount and diversity of speech while increasing its complexity. These findings also raise some questions for future research. Both first- and third-person narratives show wide variability in topic choice, a variability that might result in differences in

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speech production, particularly in individuals with aphasia. For example, producing a first-person narrative about a previous hospital experience compared to one about a prior birthday party celebration might place different vocabulary demands, even though both are based on first-person event experiences. As such, future studies are needed to further tease apart the contribution of topic variability within first- versus third-person narratives; this will help clarify the effects of topic complexity within each discourse type and its consequences for speech and gesture production.

Adults with or without aphasia did not differ in the amount of their gesture production in the two narrative tasks—a pattern consistent with earlier work (de Beer et al., 2019). They, however, differed in the diversity of the meanings they conveyed in gesture: Both adults with anomic and Broca's aphasia used a more diverse gesture lexicon (i.e., gesture about a greater variety of referents) in their third-person than first-person narratives, suggesting that gesture's compensatory role increased with the task demands (i.e., specific vocabulary demands and increased word-finding difficulties associated with third-person narratives). This, in turn, might have resulted in gesture serving as a helpful tool to overcome lexical access difficulties. A pattern akin to this one, in fact, has been shown in earlier work for conversations of adults with aphasia (van Nispen et al., 2017). The gestures—especially representational gestures such as iconics and pantomimes—that conveyed diverse semantic meanings might have facilitated word retrieval (Krauss et al., 2000) and/or served communicative functions in place of speech (de Ruiter, 2000). These findings provide evidence for a semantic integration between gesture and speech, where gesture provides a tool to convey a different but related set of meanings that the speaker cannot express in speech.

To further understand the communicative role of increased representational gestures in third-person narratives, we further examined the relation these gestures held to accompanying speech in individuals with aphasia. Adults with Broca's aphasia used most of these different types of representational gestures (74%) to convey information that was absent in their speech—a pattern that was still evident but slightly less pronounced in adults with anomic aphasia, with 50% of gestures conveying meanings not found in speech. These findings are consistent with the sketch model (de Ruiter, 2000): When speech became unavailable, gesture carried the communicative burden, at rates proportional to difficulties individuals with aphasia experienced in speech fluency and lexical retrieval. These findings thus suggest that the majority of the gestures employed by adults with aphasia, particularly with Broca's aphasia, serve as a communicative tool that compensates for their speech difficulties, especially during periods of communication breakdown.

In summary, our results provide evidence for gesture–speech integration, namely, that gesture and speech form a tightly integrated semantic network, with each conveying a different but semantically related set of meanings and, in turn, allowing individuals with aphasia to expand their communicative range. Our findings also highlight that gesture plays a powerful but varying role in relation to speech across different groups. It mostly augments spoken words (i.e., beats, reinforcing gesture + speech combinations) for adults without aphasia. In contrast, it eases access to words (e.g., iconic gesture) for individuals with anomic or Broca's aphasia, and it replaces words for individuals with Broca's aphasia (e.g., pantomimes, supplementary gesture + speech combinations).

One of the potential limitations of this study was that the AphasiaBank database did not have information about limb apraxia or cognitive profiles of participants, which might have affected gesture production (Kang et al., 2016; Mol et al., 2013). Overall, research suggests that individuals with more severe aphasia are at greater risk for comorbid cognitive difficulties (Murray, 2012). In addition, limb apraxia frequently co-occurs with severe aphasia and more variability in speech production. We therefore excluded individuals with severe aphasia (i.e., global, Wernicke's, and transcortical sensory aphasia), focusing more on moderate and mild forms of aphasia in our study (Broca's and anomic aphasia). Future studies that focus on individuals with other aphasia types are needed to determine whether the compensatory role of gesture we observed in our study also extends to other aphasia types.

Overall, our study provides a comprehensive account of gesture and speech production in two groups of individuals with aphasia and as compared to individuals without aphasia across different narrative contexts. Our results showed that gestures play an important compensatory role in the communications of adults with both anomic and Broca's aphasia, with greater speech difficulties associated with greater gesture production. The compensatory role of gestures in aphasia was evident across two types of narrative contexts, with more demanding contexts eliciting a more diverse set of meanings in gesture: Adults with anomic and Broca's aphasia both relied more on gesture to compensate for their word retrieval difficulties in their third-person narratives. Therefore, our findings suggest that, at least for adults with mild-to-moderate aphasia and with relatively good comprehension skills, gestures stay intact and function as a compensatory tool for communication. These findings thus highlight gesture and speech as interdependent communicative systems for individuals with aphasia, with gesture serving an important complementary role in aphasia communication.

We expect the data from our study would provide several valuable pieces of information that could be

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applied to clinical settings: First, our study showed that individuals with aphasia conveyed substantive information in gesture that was not conveyed in their speech, using gesture as a venue to expand their communicative range. This finding has several important implications, including (a) dedicating greater attention to gestures produced by individuals with aphasia in clinical contexts and (b) designating it as a mutually acceptable alternative communication medium between patient and clinician to enhance motivation for participation in communicative exchanges. Second, our study showed that gesture could offer insight into processes that govern language production in individuals with aphasia, processes that might be opaque to traditional analyses of speech alone. As such, assessment of communicative ability in a clinical setting should focus not only on speech but also on gesture by treating gesture as an integral aspect of communicative ability. Furthermore, armed with such knowledge, clinicians might be in a better position to devise interventions that build on the strengths that adults with aphasia exhibit in their gestures, which, in turn, would yield more positive language production outcomes. Third, our study showed that the compensatory role of gesture for speech production difficulties showed variability based on discourse context as well as aphasia type. This finding highlights the importance of communicative context when evaluating the speech production of individuals with aphasia and incorporating gesture as an alternative medium of communication to improve communication in clinical settings. This might be a particularly important finding given earlier work that has suggested that the expression of knowledge in gesture in a visual–motor format may facilitate the translation of this knowledge into a verbal form (Kita et al., 2017). Fourth, our findings regarding gesture patterns in aphasia provide valuable information to clinicians that can inform the choice of strategies for using gesture as part of an intervention program. For example, adults with Broca's aphasia relied heavily on iconic gestures that supplemented their speech as a way to compensate for their speech production difficulties. Importantly, this compensation increased with the increased linguistic demands of third-person narratives. Clinicians can improve communication by encouraging individuals with Broca's aphasia to use iconic gestures more frequently. These compensatory gestures could be especially helpful in more challenging tasks to supplement and/or replace speech, enhancing communication. Our results also showed that adults with anomic aphasia used iconic gestures frequently during word retrieval difficulties, especially gestures that reinforce speech. Therefore, clinicians can encourage adults with anomic aphasia to use more iconic gestures during communication, especially when they have difficulty retrieving particular words.

Overall, our findings provide information about a set of key factors that contribute to variability in speech and gesture production of individuals with different types of aphasia in different discourse contexts. This information can help devise more effective speech therapy strategies that incorporate different types of gestures and gesture + speech combinations, targeted at improving communication of adults with aphasia.

Data Availability Statement

The video-recordings are available at https://aphasia.talkbank.org/. Anonymized quantitative summaries of coded data and coding manuals are available upon request.

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Appendix A

Aphasia-Related Characteristics of Participants With Aphasia

Participant	Age	Time post onset	Aphasia severity (WAB AQ)	Apraxia of speech	Hemiparesis	Naming ability (BNT)	Fluency (WAB SSF)
Anomic aphasia							
P#1	41.7	4.30	92.8	Y	Y	13	9
P#2	54.5	10.20	79.6	N	N	9	6
P#3	52.4	2.25	90.6	N	Y	8	8
P#4	59.5	14.80	93.2	N	N	4	9
P#5	58.3	12.00	92.7	Y	N	13	9
P#6	66	1.30	87.8	Y	Y	8	9
P#7	78	0.50	85.1	N	Y	11	8
P#8	54.2	12.00	91.8	N	N	10	10
P#9	48.9	3.80	68.5	N	Y	7	5
P#10	69.4	5.20	82.8	N	N	15	9
P#11	79.6	3.00	74.4	U	N	7	5
P#12	72	4.00	73.3	Y	Y	13	6
P#13	63.3	3.10	78.3	N	U	7	8
P#14	71.2	11.20	84.0	N	N	10	9
P#15	52.3	4.20	90.8	Y	Y	13	9
P#16	50.7	0.50	87.4	N	N	5	9
P#17	59.1	4.70	89.2	N	N	15	9
P#18	60.3	4.50	85.6	N	N	8	8
P#19	54.6	4.60	93.4	N	Y	12	9
P#20	63.2	0.75	89.5	N	Y	15	9
Broca's aphasia							
P#21	69.9	11.80	63.9	Y	Y	6	2
P#22	52.2	5.10	67	Y	Y	9	4
P#23	47.9	9.80	57.5	Y	Y	4	4
P#24	64.5	16.00	60.7	Y	N	10	4
P#25	60.3	3.30	54.6	N	N	5	4
P#26	55	1.60	54	Y	N	5	4
P#27	25.6	1.25	61.4	N	Y	7	4
P#28	78.3	25.75	52.5	Y	N	2	4
P#29	58.8	11.25	64.8	Y	N	4	4
P#30	55.2	3.20	66.3	Y	N	3	4
P#31	62.7	3.75	58.1	Y	N	1	4
P#32	54.7	2.30	59.4	Y	N	8	4
P#33	57.2	7.90	63.9	Y	N	4	4
P#34	53.9	8.50	54.6	N	N	2	4
P#35	37.8	1.00	54.7	N	Y	5	2
P#36	31.8	1.90	72.8	Y	N	9	4
P#37	70.5	5.80	54.3	N	N	3	3
P#38	54.9	9.10	72.2	Y	Y	11	4
P#39	52.7	4.70	69.4	Y	N	6	4
P#40	55.2	3.00	57.6	Y	Y	6	4

Note. WAB AQ = Western Aphasia Battery Aphasia Quotient; BNT = Boston Naming Test–Short Form; WAB SSF = Western Aphasia Battery Spontaneous Speech Fluency; P = participant; Y = yes; N = no; U = unavailable.

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Appendix B

Descriptions of Gesture Types Produced in Co-Speech Gesture and Silent Gesture With Examples From the Data*

Gesture type	Description	Examples
ICONIC Concrete iconic[1]	Characterizes features and actions associated with concrete entities	Move open the palm back and forth to convey SWEEPING Draw a circle with the index finger in the air to convey the SHAPE OF A CLOCK
Metaphoric iconic[1]	Characterizes features and actions associated with abstract entities	Hold cupped hand in the air to convey AN IDEA Move open the palm backward to convey PAST TIMES
PANTOMIME[1]	Whole-body enactments of actions	Hop both fists in front of the body as if RIDING A HORSE CARRIAGE Move the body side to side while swinging the arms as if DANCING
NUMBER[2]	Indicates numbers by showing fingers or writing with finger on a surface or in the air	Hold up the index and middle fingers together to convey TWO Trace number eight in the air with the index finger to convey EIGHT
LETTER[2]	Indicates letters by writing with fingers on a surface or in the air	Write PT (physical therapy) in the air with the index finger Trace letter S with the index finger on the table
EMBLEM[3]	Characterizes culturally prescribed meanings	Hold up the thumb to indicate OKAY Flip palms in front of the body to convey I DON'T KNOW
DEICTIC Concrete deictic[1]	Indicates concrete referents in physical referential space	Point at the leg to indicate LEG Point at the shoe to indicate SHOE
Abstract deictic[1]	Indicates imaginary referents in physical referential space	Point at empty space to indicate IMAGINARY CINDERELLA Point toward the right side of the body to indicate IMAGINARY LOCATION
Self-deictic[4]	Indicates self	Point to chest to indicate SELF
BEAT[1]	Marks speech boundaries or emphasizes speech	Flick fingers for EMPHASIS

Note. Each gesture was categorized into one of the types outlined in Appendix A above, based on gesture types identified in earlier work ([1]McNeill, 1992. [2]Cicone et al., 1979. [3]Kendon, 1980. [4]Sekine & Rose, 2013.). After coding, concrete deictic, abstract deictic, and self-deictic gestures were collapsed into a single "deictic gesture" category; concrete iconic and metaphoric iconic gestures were collapsed into a single "iconic gesture" category; number and letter gestures were also combined to form a single category as "number and letter gesture"; and the other gesture types were counted in their own category (pantomime, emblem, beat).

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Appendix C

Correlation Matrix Between Aphasia Characteristics and Measures of Speech and Gesture Production

Variable	A_severity	S_fluency	B_Naming	S_amount	S_diversity	S_complexity	G_amount	G_diversity	G_complexity	G + S_complexity
A_severity	1									
S_fluency	.925**	1								
B_Naming	.677**	.623**	1							
S_amount	.564**	.621**	.311	1						
S_diversity	.682**	.720**	.457**	.943**	1					
S_complexity	.780**	.805**	.527**	.712**	.792**	**1**				
G_amount	–.493**	–.607**	–.396**	–.504**	–.573**	–.573**	**1**			
G_diversity	–.524**	–.655**	–.441**	–.595**	–.681**	–.610**	.938**	1		
G_complexity	–.452**	–.581**	–.413**	–.486**	–.569**	–.486**	.930**	.961**	**1**	
G+S_complexity	–.479**	–.599**	–.385**	–.465**	–.543**	–.500**	.971**	.929**	.956**	

Note. A_severity = aphasia severity; S = speech; B_Naming = Boston Naming; G = gesture; G+S = gesture + speech.

**p < .001.

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