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Iconic gesture use during discourse production in latent aphasia

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ABSTRACT

Background & Aims: People with latent aphasia, who have had a dominant hemisphere brain injury yet score above standardized test cut-offs for aphasia, demonstrate significant communication differences during discourse compared to cognitively healthy adults. To further characterize communication differences, this study is the first to compare spontaneous co-speech gesture production during spoken discourse in people with latent aphasia and cognitively healthy adults.
Methods & Procedures: We leveraged AphasiaBank database videos to code iconic gestures during the Cinderella story retell and the Sandwich procedural narrative from 32 people with latent aphasia and 32 cognitively healthy adults. Gestures were coded for their relationship ("function") to speech: redundant, supplementary, or essential to understanding the spoken message. We investigated differences in gesture frequency and function both between groups and discourse types. We further characterized how these patterns related to neuropsychological information and language measures.
Outcomes & Results: Individuals with latent aphasia produced more iconic gestures than cognitively healthy adults, but only in the Sandwich task. While cognitively healthy adults produced gestures of the same function (typically, redundant with speech) and frequency across tasks, individuals with latent aphasia produced more gestures in Sandwich than Cinderella discourse tasks. This task difference was correlated with aphasia severity. Within the latent aphasia group, redundant gestures were more frequent in Cinderella than in the Sandwich task. Redundant gestures correlated with number of words produced, wh ile supplementary and essential gestures were associated with speaking duration in the Sandwich task, but no gesture-language associations were found in the Cinderella task for individuals with latent aphasia.
Conclusions: For the first time, we characterized co-speech gesture use in persons with latent aphasia. Our findings highlight that persons with latent aphasia, despite having subtle impairments of language, rely on iconic gesture to convey critical information more

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often than their peers. This is a pattern also shown in persons with clinical aphasia. Group differences in discourse production and gesture use underscore the need for multimodal communication support for individuals with latent aphasia. Gesture, often used in aphasia therapy to aid word retrieval and convey additional information, must be further investigated to understand daily communication barriers and inform targeted therapies for latent aphasia.

Introduction

Latent aphasia refers to a mild form of aphasia where individuals with acquired brain injury (e.g., stroke, traumatic brain injury) score above standardized clinical cut-offs but still experience subtle language impairments that affect everyday communication. Assessing latent aphasia is challenging because the impairments are not easily detected through traditional static neuropsychological testing (e.g., standardized aphasia batteries), yet they significantly impact the person's ability to communicate effectively (Cavanaugh & Haley, 2020; Salis & De De, 2022; Silkes et al., 2021; Zhang et al., 2024). While terminology has varied in describing persons who have had a dominant hemisphere stroke but score above typical "aphasia" cut offs on standard language batteries, the term "latent" has a long history of use (e.g., Boller, 1968) and is recently gaining considerable traction (e.g., Stark et al., 2024; Zhang et al., 2024). This label is preferred for two main reasons: first, it does not adhere to classification by a single standardized assessment (e.g., these individuals are often described as "not aphasic by WAB [Western Aphasia Battery]" yet the WAB is not universally used); second, the communication changes in this group are indeed latent (De De & Hoover, 2021; De De & Salis, 2020; Martzoukou et al., 2023; Salis & De De, 2022; Silkes et al., 2021; Zhang et al., 2024). From the Latin root *latēre*, meaning "to lie hidden", the term "latent" accurately describes how impairments are subtle and may only be observed when communication scenarios of sufficient complexity, like discourse, bring them to light.

For example, Cavanaugh and Haley (2020) interviewed persons with latent aphasia about the impact of their speech and language on domains of the Aphasia-Framework for Outcome Measurement (A-FROM), which includes life participation, personal identity and attitudes, environment, and language and speech impairment. Persons with latent aphasia discussed having reduced social participation and engagement in meaningful activities due to changes in their language and communication. They also reported being self-conscious about their impairments and experiencing various speech and language difficulties such as anomia, needing to write things down, making more mistakes when not exclusively focused on producing speech, needing to prepare ahead of time to communicate effectively, needing to perform one task at a time, being slower to respond in conversational settings, feeling the need to put in increased effort to communicate, and having difficulty explaining complex ideas. Given these communication challenges, it is crucial for research to explore alternative ways to support effective communication for persons with latent aphasia.

One area gaining increasing attention in the study of aphasia is the role of iconic co-speech gestures, which are gestures where hand movements carry semantic content closely tied to speech, such as mimicking the shape of an object with one's hands (Kendon, 2011; McNeill, 1996). According to the Kendon continuum of gestures (Kendon, 1982; McNeill, 1992), iconic gestures are part of a larger category – representational gestures – which depict, stand in for, or convey semantic meaning about an object, action, or concept. Other members of the representational gesture category include metaphoric gestures, which visually encode abstract ideas (e.g., cupping hands together to show an "idea") and, sometimes, deictic gestures, which are pointing gestures that can be utilized to direct attention toward a concrete referent (e.g., pointing to a light in the room when one is talking about "turning on the lights"). Representational gestures stand in contrast to non-representational gestures, such as beat gestures, which are simple, often repetitive movements linked to speech rhythm but not meaning (e.g., tapping a hand to the syllables in a word). Additionally, there are emblems, which are culturally and linguistically specific gestures with conventionalized forms and meanings (e.g., in the USA, a thumbs up typically indicates "okay").

Iconic gestures are especially relevant for conveying meaning in populations with language impairments, such as aphasia. To date, the literature evaluating co-speech gesture in spontaneous speech has largely excluded persons with latent aphasia. Studying the use and function of gesturing in latent aphasia will improve characterization of the latent phenotype and improve clinical services available to this population, which is traditionally underserved because these individuals do not fit the typical aphasia classification.

Cognitively healthy adults routinely use iconic gestures to facilitate both speech production and comprehension (Kandana Arachchige et al., 2021; Mcneill, 1986), and iconic gestures have received considerable attention in research because they often visually reflect the meaning conveyed in accompanying spoken words (Hadar & Krauss, 1999). Iconic gestures serve multiple communicative functions, ranging from reinforcing spoken language content to supplementing it by providing additional meaning (Hadar & Butterworth, 1997). For instance, a gesture mimicking the shape or size of an object can help clarify a description that is incomplete or ambiguous in speech. Research demonstrates that individuals with aphasia, even in mild forms, often increase their use of representational and iconic gestures (e.g., Dipper et al., 2015; Kistner et al., 2019; Pritchard et al., 2013; van Nispen et al., 2017). Thus, studying the ways in which gestures function alongside naturalistic speech provides insight into how people with latent aphasia navigate communication challenges in everyday interactions.

The extent to which gesture directly improves word finding is debated (e.g., Dipper et al., 2011 vs. Kistner et al., 2019). For example, research in persons with aphasia has suggested that gesture production is significantly higher during word retrieval and that the resolution of word retrieval is more frequent when a gesture is present, but this effect is highly individual (Lanyon & Rose, 2009; Pritchard et al., 2013). An analysis of conversational speech in persons with aphasia suggested that semantically rich gestures were frequently employed alongside resolved word finding difficulties (Kistner et al., 2019). Others have suggested that iconic gestures may help with word finding only in cases of weak verbal working memory (Gillespie et al., 2014; Morsella & Krauss, 2004). Additionally, increased aphasia severity and more severe word finding impairments have been associated with more frequent use of iconic gestures to supplement speech (Kong, Law, Wat, et al., 2015; Stark & Oeding, 2024).

It should be noted, however, that the impact of gesture on word finding has not been established as causal, with evidence from aphasia (Kong et al., 2019) and cognitively healthy adults (Beattie & Coughlan, 1999) demonstrating that iconically gesturing during word finding difficulty does not necessarily result in a resolution. One reason for this is the theoretical basis of gesture and speech's connection – for example, McNeill's growth point theory (1992) suggests that the gesture's stroke phase (i.e., the part of the gesture carrying the main meaning) often coincides with the most important or stressed word (or words) that express the concept the gesture depicts. If that concept is packed into a single, semantically rich word (e.g., a key verb or noun), one may see a neat alignment of gesture and that one word, and this may be related to the evidence suggesting that iconic gestures support word finding (McNeill, 1992). However, more commonly in naturalistic communication, the concept might span a phrase, and the gesture will be timed around that larger unit. For instance, when someone says, "She carefully opened the old chest in the attic", they might lift both hands as if gripping a lid and then mimic raising it throughout the phrase, rather than timing the gesture to a single word like "opened".

Although iconic gestures may not always resolve word-finding difficulties, they can still play a crucial role in communication, particularly when language impairments are present. In latent aphasia, individuals do not typically exhibit overt language deficits during structured tests, yet spontaneous speech reveals subtle impairments such as impaired sentence construction, longer formulation time, longer silent pauses, slower speech rate, fewer utterances, and impaired retrieval of contextually relevant words (e.g., De De & Salis, 2020; Fromm et al., 2017; Salis & De De, 2022; Zhang et al., 2024). Because iconic gestures help speakers maintain fluency and communicate effectively even when they struggle to find the right words, it stands to reason that individuals with latent aphasia may, like their peers with clinical aphasia, demonstrate an increased use of gestures compared to cognitively healthy peers.

In summary, much of the existing research on co-speech gesture use and function focuses on individuals with moderate to severe aphasia, leaving a significant gap in understanding the use of gestures in latent aphasia. Although there is some research on the function of gesture in aphasia – that is, whether the gesture is redundant with or supplementary to speech – this is restricted to populations with more severe aphasia than what is observed in latent aphasia. Furthermore, many studies evaluating gesture production and its relationship with speech rely on experimental paradigms that introduce specific manipulations – for instance, by restricting gesture use, increasing linguistic or cognitive load, or explicitly instructing participants to gesture (see Clough & Duff, 2020; Stark et al., 2021 for reviews of these challenges and suggestions for improvement). These controlled designs are valuable for testing causal relationships but often constrain the spontaneity of communication. While the current study uses monologic narrative tasks that still carry some degree of experimental control – for example, through standardized prompts and a lack of interlocutor – they allow for open-ended, self-generated responses that more closely approximate naturalistic communication than heavily manipulated experimental tasks. Unlike scripted or highly structured interactions, narratives elicit extended speech with relatively unconstrained gesture use, offering insight into how individuals communicate when they have autonomy over content and form. This is particularly important for individuals with mild or latent aphasia, whose language difficulties may be subtle or context dependent. Although gesture use in more severe aphasia is well documented (e.g., Kong et al., 2017; Kong, Law, Wat, et al., 2015; Stark & Cofoid, 2022), the role of gesture in mild aphasia is less understood. Existing evidence suggests that even when overt language deficits are minimal, gesture may support or compensate for subtle impairments – underscoring the importance of studying gesture in contexts that allow those behaviors to emerge naturally (Kroenke et al., 2013).

This study aims to address some of these research gaps, comparing iconic gestures made by participants with latent aphasia (PwLA) and carefully matched cognitive healthy adults (CHA) during two monologic discourse tasks: a fictional story retell task and a procedural narrative task. We investigate three research questions:

(1) To what extent does frequency of iconic gesture production differ between PwLA and CHA, and are these differences influenced by the type of discourse task?
(2) To what extent do the functions of iconic gestures produced differ between PwLA and CHA? Here we focused on the qualitative relation of the gestures to spoken language, including redundant, supplementary, or essential gestures relative to discourse content.
(3) To what extent do the frequency and function of iconic gestures relate to measures of speech and language ability in PwLA?

Methodology and design

Study design

This was a retrospective, observational study that analyzed cross-sectional corpus data from the AphasiaBank database (MacWhinney et al., 2011), which is a free, password protected multimedia database available that contains recorded videos of language assessments from persons with and without aphasia. Discourse samples were retrieved from the AphasiaBank database in early 2024 (MacWhinney et al., 2011). All AphasiaBank data were provided by investigators who had their own established Institutional Review Boards that oversaw informed consent. Trained gesture coders used the online Browsable Database on AphasiaBank, which time locks spoken utterances with the video (and therefore the gesture production) of each participant. From these videos, raters coded and analyzed the gestures produced by participants in two selected discourse samples. The details of the study are outlined below.

Discourse tasks

We examined gestures from two spontaneous speech discourse tasks from the AphasiaBank protocol (MacWhinney et al., 2011). We used “Cinderella” (Grimes, 2005) and “Sandwich” tasks (MacWhinney et al., 2011) due to prior evidence that these task demands encourage spontaneous gesture use (Sekine & Rose, 2013; Stark & Cofoid, 2022).

Narrative task

The Cinderella task is a fictional story retell task from the narrative discourse genre. Participants were shown a picture book of the Cinderella story (Grimes, 2005). The task instructions were as follows: "I'm going to ask you to tell a story. Have you ever heard the story of Cinderella? Do you remember much about it? These pictures might remind you of how it goes. Take a look at the pictures and then I'll put the book away and ask you to tell me the story in your own words". After the participant looked through the book, the book was removed, and the examiner prompted the participant: "Now tell me as much of the story of Cinderella as you can. You can use any details you know about the story, as well as the pictures you just looked at". If the participant gave a response of fewer than three utterances, the examiner would prompt them after 10 seconds: "What happened next?" or "Go on". This continued until the participant concluded the story.

Procedural task

The Sandwich task is a procedural narrative task from the procedural discourse genre (MacWhinney et al., 2011). Participants were prompted to describe how to make a peanut butter and jelly sandwich. No visual aids were provided. The task instructions were as follows: "Let's move on to something a little different. Tell me how you would make a peanut butter and jelly sandwich". If the participant did not give a response for 10 seconds, then the examiner gave a second prompt: "If you were feeling hungry for a peanut butter and jelly sandwich, how would you make it?"

Participants

Inclusion criteria for both groups included speaking English as their primary language and having audiovisual data available for both tasks. For participants who had multiple time points available in AphasiaBank, we only included data from their first time point that met our inclusion criteria.

Participants with latent aphasia (PwLA)

We included in our analysis discourse videos from all PwLA in the database, defined as being persons with a confirmed left hemisphere stroke etiology who presented with a score of 93.8–100 on the Western Aphasia Battery – Revised or Bedside (Kertesz, 2006). Following these parameters, this study included a total of 32 PwLA.

Cognitively healthy adults (CHA)

We included in our analysis discourse videos from a sample of matched cognitively healthy adults (CHA) who scored within normal limits on a standard cognitive battery, either the Mini Mental State Exam (Folstein et al., 1975) or the Montreal Cognitive Assessment (Nasreddine et al., 2014; the collection of these varies by contributing site). CHA participants were matched to PwLA based on age, sex, race, handedness, and years of education. Given the number of matching variables, we first matched participants on sex. All other variables were matched as closely as possible, but perfect matches were not possible for all participants within the constraints of the database. Where multiple possible matches existed for a PwLA, the CHA who matched most closely across all variables was selected. Following these parameters, this study included a total of 32 CHA.

Comparing the groups

In total, this study included a total of 64 participants: 32 CHA and 32 PwLA. The participant groups did not differ based on age (CHA $M = 61.69$ years, PwLA $M = 61.61$ years; $t = -.03$, $p = .98$) or education (CHA $M = 15.66$ years, PwLA $M = 16.16$ years; $t = -.66$, $p = .51$). Each group had 21 females and 11 males. Participants and their demographic data are reported in Table 1.

Spoken language measures from discourse

Because iconic gestures can convey meaning or support retrieval at the single word level, and can also support communication across several words or a full utterance (McNeill et al., 1990), we opted to extract the following verbal discourse measures using the "EVAL" and "corelex" commands in the Computerized Language ANalysis (CLAN) software available from AphasiaBank:

Words per minute (WPM) : defined as the total number of words produced (tokens) divided by the duration of the sample in minutes.

Mean Length of Utterance (MLU) : defined as the average number of words per utterance.

NTokens : defined as the total number of words produced in the sample.

Sample Duration : defined as the length of the sample in seconds.

Moving Average Type/Token Ratio (MATTR) : a measure of lexical diversity which improves on some of the weaknesses of the traditional type/token ratio (TTR). In aphasia research, varying lengths and fragmented speech samples can distort traditional TTR measures (Fergadiotis et al., 2013). MATTR reduces this issue by analyzing multiple small windows of speech, giving a more reliable picture of lexical diversity and helping to capture subtle language impairments that might be masked by overall sample length (Cunningham & Haley, 2020). Rather than dividing the number of unique words produced (types) by the tokens in the entire sample, MATTR calculates the TTR using a pre-defined "window" which is shifted through the sample word-by-word (e.g., Fergadiotis et al., 2015). After the TTR for each window is calculated, the average of the TTRs is computed for the final reported value. The length of the window used in this analysis was 12 tokens, which represented the length of the shortest sample in the dataset.

Proposition Density (PD): calculated as the ratio of propositions to tokens in the sample. CLAN calculates proposition density according to the procedures of Computerized Propositional Idea Density Rater (CPIDR 3: Covington, 2007; Fromm et al., 2016).

Number of Core Lexical Items Produced: the number of core lexical items produced was calculated using previously published lists for the Cinderella and Sandwich stories (Dalton et al., 2019). Briefly, a single point is awarded for each core lexical item produced regardless of the number of times it is produced in the sample. Production of synonyms of core lexical items do not receive credit, but inflected forms of core lexical items do. The maximum number of core lexical items for the Cinderella task is 94, and the maximum for the Sandwich task is 25.

Proportion of Lexical Errors: calculated as the percentage of word-level errors (i.e., paraphasias) in the sample divided by the number of tokens.

Table 1. Participant demographics.

Cognitively Healthy Adults						Individuals with Latent Aphasia						
Participant	Age	Gender	Race	Handedness	Years of Education	Participant	Age	Gender	Race	Handedness	Years of Education	WAB AQ
richardson16a	27	F	WH	R	14	ACWT04a	26	F	WH	R	16	96
UMD24	34	F	WH	R	18	UNH01a	35.5	F	WH	R	18	95.7
wright99a	41.4	F	HL	R	18	adler03a	47.7	F	HL	R	20	95.8
MSUC07a	48.1	M	WH	R	16	TCU09a	48.9	M	WH	R	16	99.3
wright27a	50.7	F	WH	R	16	elman04a	50.4	F	HL	R	13	97.2
wright42a	53.3	M	WH	R	16	adler22a	51.2	M	WH	R	14	93.8
wright08a	51	F	WH	R	12	kansas04a	52.6	F	WH	R	18	96.4
wright90a	52	F	WH	R	16	fridriksson07a	52.9	F	WH	R	18	97.9
wright40a	52.2	F	WH	R	13	scale16a	53	F	WH	L	15	97.4
UMD16	59	F	HL	R	18	TCU10b	53.5	F	HL	n/a	n/a	95.1
richardson58	49	F	AA	U	14	MSU02a	55.1	F	AA	R	12	94.8
wright50a	56.8	F	WH	R	14	adler07a	57.4	F	WH	R	16	95.6
MSUC02a	58.4	F	WH	R	16	wozniak06a	58.3	F	WH	R	16	95
wright26a	58.6	F	WH	R	14	kurland04a	58.3	F	WH	R	14	95
wright01a	61.1	F	WH	R	12	kansas07a	59.2	F	WH	A	14	96.1
UNH1025	61	F	WH	U	18	kurland06a	59.6	F	WH	R	17.5	95
capilouto19a	60.7	M	WH	R	16	ACWT07a	61.5	M	WH	R	18	95
wright52a	64.1	M	WH	R	20	kurland05a	62.3	M	WH	R	16	99.6
wright93a	63.6	M	HL	R	14	whiteside17a	63	M	WH	R	16	95.1
wright63a	62.1	F	WH	R	16	UNH11b	65.1	F	WH	n/a	n/a	94.3
UMD14	67	F	WH	R	25	tucson18a	66.9	F	WH	R	20	97.6
capilouto48a	71.4	M	WH	R	18	williamson13a	69.5	M	WH	R	19	99
capilouto38a	71.8	M	WH	R	20	williamson10a	72	M	WH	R	20	95.2
capilouto49a	73.6	M	WH	R	16	kansas03a	73.4	M	WH	R	16	95
wright68a	79.2	M	WH	R	12	williamson05a	74.6	M	WH	R	12	94.8
wright71a	76.6	F	WH	R	16	scale21a	75.6	F	WH	R	20	94.4
capilouto26a	77	M	WH	L	18	tucson01a	76.1	M	WH	L	17	97.6
wright03a	76	F	WH	R	18	scale20a	77.4	F	WH	R	21	94.8
wright77a	77	F	WH	R	13	tucson04a	78	F	WH	R	12	96
capilouto41a	77.8	F	WH	R	12	fridriksson11a	78.4	F	WH	R	12	99.6
capilouto36a	80.1	M	WH	R	10	UNH03c	80.1	M	WH	n/a	n/a	95.2
capilouto16a	79.9	F	WH	L	12	whiteside18a	80.7	F	WH	R	12	98.9

Note: WAB AQ = Western Aphasia Battery – Revised Aphasia Quotient. Gender: F = female; *M* = male. Race: AA = African American/Black; HL = hispanic or Latino; WH = white/non-Hispanic. Handedness: L = left-handed; *R* = right-handed. n/a = no data available.

Gesture coding of discourse

Two graduate research assistants (E.M. and E.P.) were trained to identify iconic gestures and code whether each gesture's function was redundant, supplementary, or essential to the spoken language. Because our goal was to pinpoint how gesture enhances communication, we classified iconic gestures into two functions – redundant or supplementary. We chose only two categories because prior work with multiple function categories shows wide variability in rater reliability. For instance, in a large study of Cantonese speakers with aphasia, (Kong, Law, Kwan, et al., 2015; Kong, Law, Wat, et al., 2015) identified eight function categories: "providing additional information to message conveyed", "enhancing the speech content", "providing alternative means to communication", "guiding and controlling the flow of speech", "reinforcing the intonation or prosody to speech", "assisting lexical retrieval", "assisting sentence re-construction", and "no specific function deduced". The reliability for identifying these functions across raters was variable, with Kendall tau coefficients ranging from 0.39 (poor) to 1.0 (excellent). Also, some function categories were much more represented than others. For example, in persons with aphasia, iconic gestures tended to be 74.5% used to "enhance the speech content" and 22.1% to "provide additional information to message conveyed", with other categories ranging from 0–3.4%. Similarly, in a large sample of persons with aphasia whose iconic gestures were tagged for function, van Nispen et al. (2017) elected to use only three categories for function: "similar" (gestures conveyed information similar to information conveyed in speech), "additional" (gestures conveyed information additional to speech), and "essential" (gestures conveyed information absent in speech and were essential for understanding the speaker's message). The reliability between coders for function was moderate (Cohen's kappa = .78) though the reliability for identifying iconic gestures, more generally, was excellent (Cohen's kappa = .88). This variation, along with the low prevalence of certain functions, underscores the need to reduce gesture function categories to enhance rater consistency and improve data robustness when examining how gesture function relates to aphasia.

For this study, we defined a gesture unit as the duration from the start of a movement until the hand(s) returned to its original resting position or there was a change in hand shape or trajectory (Jacobs & Garnham, 2007; McNeill, 1996). Non-iconic gestures, such as beats, and other non-gesture movements, such as self-adjustments, were not coded. Iconic gestures were defined as gestures that convey meaning that is related to the content of the spoken language.

Two function categories were used:

Redundant

Gesture provides the same information as co-occurring speech. This reflects Kong et al. (2015)'s "enhance" category to some extent and more closely resembles van Nispen et al. (2017)'s "similar" category.

Supplementary

Gesture conveys information distinct from that produced in co-occurring speech. The gesture may be used to add, disambiguate, or replace speech. This category compiles

Table 2. Gesture coding reliability.

Gesture Function	ICC	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	F value	df1	df2	p value
Redundant	0.880	0.742	0.946	15.1	23	23.3	<0.001
Supplementary	0.313	−0.090	0.630	1.91	23	23.7	0.061
Essential	0.852	0.691	0.933	12.5	23	24	<0.001
Total	0.888	0.762	0.950	16.7	23	23.9	<0.001

Note: ICC = Intraclass Correlation.

many of Kong et al. (2015)'s categories (e.g., "adding to" and "aids in lexical retrieval") and more closely resembles van Nispen et al. (2017)'s "additional" category.

Deviating from van Nispen et al. (2017) slightly, we elected to code essential gestures as a subcategory of supplementary gestures. Thus, all essential gestures in our coding scheme are also supplementary gestures. In van Nispen et al. (2017), they teased apart "additional" from "essential". We define essential in the same way as van Nispen et al. (2017) – essential gestures are supplementary gestures used to convey information absent from speech that is necessary for understanding the message.

Thus, this coding scheme required a binary decision for each iconic gesture: Is it redundant or supplementary? For gestures that were supplementary, an additional judgment was made: Is it essential or not? Examples of this coding system have been described by Stark and Oeding (2024).

The gesture coders read pertinent articles on gesture use in aphasia, reviewed a gesture coding manual developed for this study, and coded a training sample of six CHA and five PwLA not included in the study sample. Inter-rater reliability of > 90% was required before coders progressed to the study sample's data.

The coders completed randomly assigned participants, evenly distributed between the coders (*N* = 16 participants per group). Inter-rater reliability was conducted on a random sampling of 24 participants. Intraclass correlation coefficients (ICC) demonstrated that coders achieved excellent reliability for total number of iconic gestures (ICC = .888), good reliability for redundant (ICC = .880) and essential gestures (ICC = .852), and poor reliability on supplementary gestures (ICC = .313), using the definitions established by Koo and Li (2016; see Table 2). Of note, the poor supplementary gesture reliability was due to a disagreement between raters over whether a total of two or three supplementary gestures were produced across the entire reliability sample. This minor discrepancy, involving a very infrequent gesture type in our dataset, led to the low inter-rater reliability upon initial examination. The coders came to full consensus upon reviewing and discussing rating discrepancies.

Statistical analysis

Descriptive statistics were calculated for each group to describe patterns of gesture use in Cinderella and Sandwich tasks. To investigate these differences in gesture use, which address research questions 1–2, we conducted a series of linear regression models in the R statistical programming environment with the lme4 package (Bates et al., 2015). Parallel model structures were used, varying the outcome measure based on our gesture coding system. The outcome measures were thus each of the four gesture codes: total iconic gestures, redundant gestures, supplementary gestures, and essential gestures. Since each gesture variable was analyzed independently, there was no need to model the dependencies between nested gesture variables (e.g., all essential gestures are also considered supplementary). Fixed effects included task (Cinderella vs. Sandwich), group (CHA vs. PwLA), and a task x group interaction. Models controlling for aphasia severity did not converge due to a lack of variation in this sample (WAB-AQ = 93.80–99.60). Effect sizes were examined using partial η^2 (Ben-Shachar et al., 2020). For planned pairwise comparison tests, we used the emmeans package and the Tukey adjustment for multiple comparison correction (Lenth, 2021). To evaluate model performance, we applied leave-one-out cross-validation (LOOCV) to account for potential overfitting of the data with our modest sample size.

To address research question 3, we examined associations between gesture production and spoken language measures derived from the Cinderella and Sandwich discourse tasks, as described above. Each spoken language measure was compared to gesture functions (redundant, supplementary, essential) for each task using non-parametric Spearman correlation tests. All reported *p* values have been corrected for multiple comparisons using Bonferroni corrections.

Results

Gesture coding for each task is reported for all participants in the Supplementary Materials. As anticipated, there was substantial variability in frequency of gesture use across participants in both groups. Across the 128 total observations (2 tasks x 32 participants per group x 2 groups), a total of 9 trials (7%) were not analyzed due to missing data (e.g., hands were out of frame or participant opted not to complete a task). The results will be discussed as they relate to our three research questions.

Frequency of iconic gesture production

Research question 1 was: To what extent does frequency of iconic gesture production differ between PwLA and CHA, and are these differences influenced by the type of discourse task? Figure 1 summarizes the raw data of gesture frequency plotted by participant group and discourse task.

Based on our regression results, we found an overall main effect of task but not group in predicting total frequency of iconic gestures. Moreover, we found a significant group by task interaction. This interaction effect has a moderate effect size. The full model results, including main effects, interactions, and their effect sizes, can be found in Table 3. Planned pairwise comparisons revealed that this interaction was driven by two findings. First, participant groups differed in the number of gestures produced on the Sandwich task, such that PwLA produced significantly more iconic gestures than matched CHA ($\beta = 3.20$, $SE = .991$, $t = 3.229$, $p = .009$). There was no difference between groups in gestures during Cinderella task, but PwLA ($M = .07$, $SD = .30$) produced numerically fewer gestures than CHA ($M = .57$, $SD = 3.36$). Second, within the PwLA group, there was a significant difference in gestures produced on each task, such that PwLA produced significantly more iconic gestures on Sandwich than Cinderella tasks ($\beta = 4.925$, $SE = 1.00$, $t = -4.927$, $p < .001$). No other pairwise findings were significant after correcting for multiple

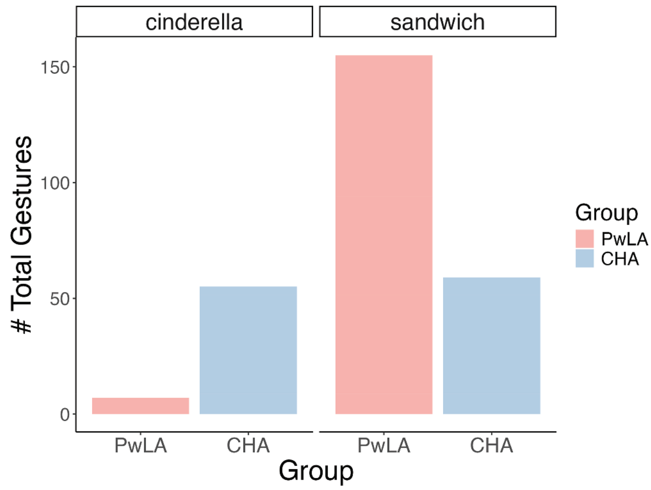

Figure 1. Total iconic gesture frequency by group and task. *Note*: Significant differences included a main effect of task as well as an interaction between group and task. Significant pairwise comparisons included a group difference on the Sandwich task and a task difference within the latent aphasia group. PwLA = participants with latent aphasia. CHA = cognitively healthy adults.

Table 3. Total iconic gesture frequency by group and task.

	β	SE	t value	p value	η^2 (partial)
(Intercept)	0.241	0.713	0.339	0.736	
Group	1.592	1.000	1.592	0.114	0.060
Task	4.925	1.000	4.927	<0.001	0.250
Group : Task	−4.792	1.408	−3.404	0.001	0.110

Note: β = estimate. SE = standard error. η^2 (partial) = effect size measure. Group = cognitively health adults vs. individuals with latent aphasia. Task = Cinderella vs. Sandwich.

comparisons. Leave-one-out cross-validation indicated moderate predictive accuracy, where some variability in the data remains unexplained ($RMSE = 2.80$, $R^2 = .41$, $MAE = 1.52$). This indicates that the model has predictive power and explains a substantial portion of variance in the data. However, there remains room for model improvement in both precision and overall accuracy.

Parallel models were run with outcome measures of redundant, supplementary, and essential gestures. The results were consistent across all models, including main effects, interaction effects, and pairwise comparisons that reflect the same patterns seen for total gesture use. However, due to the smaller number of observations in each gesture function category, the effect sizes and model fits are not as strong as observed for total number of iconic gestures. Therefore, research question 2 examined gesture function differences in more detail.

Functions of iconic gesture production

Research question 2 was: To what extent do the function of iconic gestures produced (redundant, supplementary, essential) differ between PwLA and CHA, and are these differences influenced by the type of discourse task? Figure 2 summarizes the raw data

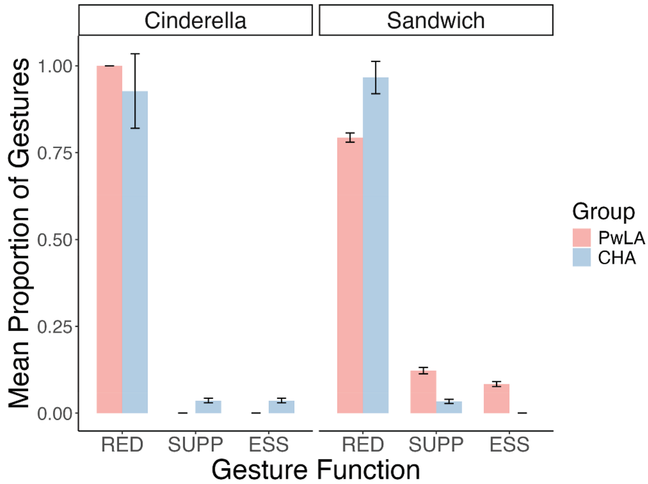

Figure 2. Proportion of gesture functions by group and task. *Note*: Bars plot mean proportion of total iconic gestures. Error bars plot the standard deviations. RED = redundant gestures. SUPP = supplementary gestures. ESS = essential gestures. PwLA = participants with latent aphasia. CHA = cognitively healthy adults.

of proportion of gesture use by function plotted for each participant group and discourse task. These proportions were calculated out of total iconic gestures. We also report the proportion of supplementary gestures that played an essential function in the text below. Most gestures produced were redundant with spoken language for both participant groups in each of the discourse tasks. For the Cinderella task, only one CHA participant and no PwLA produced supplementary or essential gestures. For the one CHA participant who produced supplementary gestures, 100 percent (2/2) of the supplementary gestures were essential to convey the discourse meaning. For the Sandwich task, only one CHA produced supplementary gestures, and 0 percent (0/2) were essential. In contrast, eight PwLA produced supplementary gestures and seven PwLA produced essential gestures on the Sandwich task. Of these PwLA gestures, 68.4 percent (13/19) of the supplementary gestures produced were essential. There were no supplementary or essential gestures produced for CHA in Sandwich task. Given the small number of observations for supplementary and essential gesture use, these results should be interpreted with caution.

After multiple comparison correction using Tukey adjustment (emmeans package; Lenth et al., 2021), six contrasts were identified as significantly different. There was a group-level difference in the Sandwich task, such that PwLA produced significantly fewer redundant gestures than CHA ($\beta = -2.06$, $SE = .50$, $t = 4.11$, $p = .003$). Within the PwLA group, there was a greater proportion of redundant gestures produced in Cinderella compared to the Sandwich task ($\beta = 3.63$, $SE = .50$, $t = 7.22$, $p < .001$). Also within the PwLA group, there were significantly greater proportion of redundant gestures in the Sandwich task than either supplementary ($\beta = 3.25$, $SE = .50$, $t = 6.47$, $p < .001$) or essential gestures ($\beta = 3.44$, $SE = .50$, $t = 6.84$, $p < .001$). Within the CHA group, there were only significant differences in the frequency of gesture type within the Sandwich task: there was a significantly greater proportion of redundant gestures than supplementary ($\beta = 1.72$, $SE = .50$, $t = 3.42$, $p = .03$) or essential gestures ($\beta = 1.78$, $SE = .50$, $t = 3.55$, $p = .02$).

Associations between gestures and spoken language

Research question 3 was: To what extent do frequency and function of iconic gestures relate to measures of speech and language ability in PwLA? First, we examined the relationship between overall aphasia severity (WAB AQ) and differences in gesture use described in research questions 1–2. Upon closer examination of the subset of PwLA who produced essential and supplementary gestures, we see that it is predominantly women (seven females, one male) and there is a correlation between aphasia severity and proportion of supplementary gestures produced ($R = -.718$, $p = .045$; Figure 3), whereby individuals with more mild latent aphasia produce a lower proportion of supplementary gestures. There is a similar but non-significant trend for the proportion of essential gestures produced ($R = -.184$, $p = .664$). Given the small number of participants and the limited range of WAB AQ for PwLA, these correlations must be interpreted with caution. In addition, the subject-level difference in number of redundant gestures produced by PwLA between tasks was positively correlated with overall aphasia severity (WAB-AQ; $R = .380$, $p = .032$; Figure 4) but was not correlated with age at testing, years of education, or VNT (p's > .05). This suggests that individuals with milder aphasia showed a greater difference in redundant gesture use between task types, producing more redundant gestures in the Sandwich task than the Cinderella task.

We next examined the relationship between iconic gesture use and spoken language metrics derived from the Cinderella and Sandwich discourse tasks. For the Cinderella task, redundant gesture frequency was not significantly associated with any spoken language measures derived from discourse for either PwLA or CHA groups. There were no observations of supplementary or essential gestures produced for PwLA in the Cinderella task, so these gesture functions were not compared to Cinderella spoken discourse metrics. There

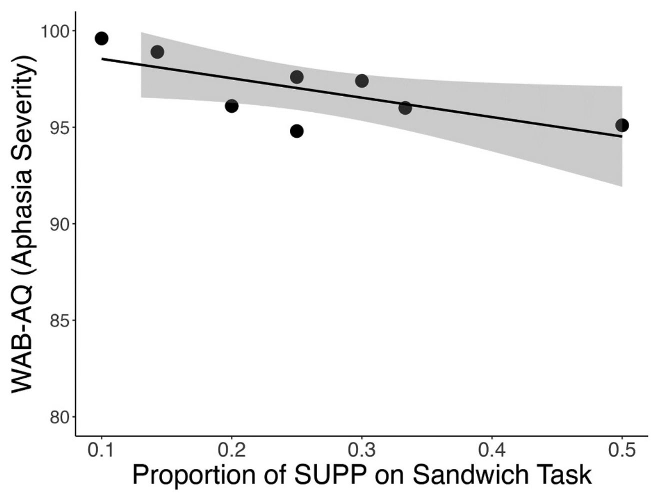

Figure 3. Correlation between proportion of supplementary gestures and aphasia severity. *Note*: Points plot individuals with latent aphasia who produced supplementary gestures. Error bar plots the standard error. WAB-AQ = Western Aphasia Battery – Revised Aphasia Quotient. SUPP = supplementary gestures.

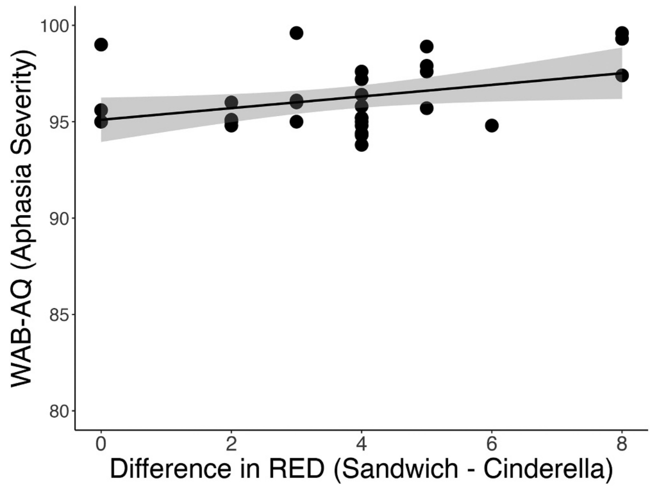

Figure 4. Correlation between task-based difference in redundant gestures and aphasia severity. *Note*: Points plot individuals with latent aphasia who produced redundant gestures. Error bar plots the standard error. WAB-AQ = Western Aphasia Battery-Aphasia Quotient. RED = redundant gestures.

were only two observations of supplementary and essential gestures for CHA, and these were not significantly related to any discourse metrics.

For the Sandwich task, redundant gesture frequency was significantly associated with total number of words produced for both PwLA (r_s = .516, p = .025) and CHA (r_s = .513, p = .031). This correlation was positive, such that greater redundant gesture use was associated with greater number of words. There was a similar trend for total speaking duration, but this relationship did not survive corrections for multiple comparisons (PwLA: r_s = .464, p = .068; CHA: r_s = .423, p = .139). No other discourse-derived measures were significantly related to redundant gesture frequency. For supplementary gesture frequency, we found a significant positive correlation with total speaking duration for PwLA (r_s = .570, p = .007) but not for CHA (r_s = −.097, p = .611). A similar trend for number of words produced did not survive corrections for multiple comparisons for PwLA (r_s = .443, p = .099) and was not related in CHA (r_s = .032, p = .866). For essential gesture frequency in PwLA, there was a significant positive correlation with total speaking duration (r_s = .529, p = .019). CHA produced no essential gestures in the Sandwich task, so this was not examined further. No other discourse-derived measures were related to supplementary or essential gesture use.

Discussion

This study evaluated iconic gesture frequency and function in individuals with latent aphasia and cognitively healthy adults across two discourse tasks. It is important to note that high variability in gesture use is to be expected even among cognitively healthy adults, whose individual differences in gesturing have been linked to cognitive abilities and resources (Chu et al., 2014; Özer & Göksun, 2020). This research is the first to examine the following specific aims in this patient population. First, we examined the extent to which frequency of iconic gesture production differs between participant groups and across discourse tasks. Second, we evaluated the extent to which the specific functions of iconic gestures differed, with a focus on whether gestures were redundant, supplementary, or essential to spoken language. Third, we assessed the extent to which the frequency and function of gesture use related to speech and language ability in individuals with latent aphasia. Below, we discuss our results and how these findings relate to accumulating evidence of gesture usage in aphasia, as well as the important clinical implications of this work.

Regarding frequency of iconic gesture production, we found a significant interaction between discourse task and group. On the Sandwich procedural task (but not on the Cinderella narrative task), participants with latent aphasia produced significantly more iconic gestures than matched cognitively healthy participants. Notably, there was also a main effect of discourse task but not an overall difference based on participant group. This pattern of findings showed a moderate effect size and was consistent across total iconic gesture frequency, and each individual gesture function type: redundant, supplementary, and essential. These findings align with results in persons with more severe aphasia, which has generally found that individuals with more severe aphasia and anomia produce more frequent iconic gestures during discourse (Kong et al., 2017; Stark & Oeding, 2024). However, there has also been evidence to suggest that iconic gesture production frequency is not always related to aphasia severity (Sekine & Rose, 2013). It has furthermore been shown that individuals with clinical aphasia produce iconic gestures more frequently during procedural narratives (Sandwich task) than other discourse types (Broken Window picture sequence narrative; Stark & Cofoid, 2022). This supports the common use of procedural tasks to evaluate gesture, even in individuals with latent aphasia.

One explanation for gesture differences across tasks is that the Sandwich task may engage more spatial imagery and vocabulary, both of which have been correlated with increased iconic gesture frequency (Hostetter & Alibali, 2019; Kita & Lausberg, 2008; Pritchard et al., 2015). According to the Gesture-for-Conceptualization framework and its information packaging hypothesis (Kita et al., 2017), gestures help speakers conceptualize and transform spatial or motor information into verbally expressible units. Thus, a task like describing how to make a sandwich inherently triggers more spatial imagery (e.g., moving and layering ingredients), prompting the speaker to produce more iconic gestures that reflect these spatio-motor details.

For our second research question, we examined differences in the function of iconic gestures across discourse tasks and participant groups. We found that most gestures produced were redundant with spoken language for both participant groups in each of the discourse tasks. This is consistent with prior research evaluating redundancy of iconic gestures in speakers with and without aphasia (Kong et al., 2017; Kong, Law, Wat, et al., 2015; van Nispen et al., 2017). For example, van Nispen et al. (2017) showed that 70% of iconic gestures were "similar" to speech, and Kong et al. (2015) showed that 74% of gestures were used to "enhance" (but not add to) speech. It should be noted that van Nispen et al. (2017) and Kong et al. (2015) used non-procedural narratives in their studies: van Nispen et al. (2017) used a personal/autobiographical narrative and Kong et al. (2015) used fictional retells of two familiar stories. Therefore, our results extend these findings to the procedural narrative space as well as to persons with latent aphasia.

We found important significant differences both across tasks and groups for iconic gesture function. First, there was a group-level difference in gesture functions produced in the Sandwich task, where participants with latent aphasia produced significantly less redundant gestures than their cognitively healthy peers. This aligns with previous findings that individuals with greater aphasia severity produce less redundant gestures and an increased rate of supplementary and essential gestures (e.g., Stark & Oeding, 2024). However, due to the small number of observations for supplementary and essential gesture use, the current findings should be considered preliminary and interpreted with caution until they can be replicated with a larger sample size. Second, two significant results were found within the latent aphasia group: more redundant gestures were produced in the Cinderella than Sandwich task, and within the Sandwich task, more redundant gestures were produced than either supplementary or essential gestures. The high proportion of redundant gestures may suggest that gesture use is facilitating successful lexical retrieval (consistent with Krauss, 1998; Rauscher et al., 1996). However, redundant gestures are not necessary for successful lexical access, which can be facilitated even by gesture observation alone (Murteira & Nickels, 2020; Spigarelli & Macoir, 2024). Furthermore, prior work by Kong and colleagues indicates that, in the absence of prominent language impairments, the default function of iconic gestures is to be redundant with speech (Kong et al., 2017; Kong, Law, Wat, et al., 2015). It is noteworthy that our findings suggest that individuals with latent aphasia may use proportionally more supplementary and essential gestures in tasks that typically involve increased gesture frequency, such as a procedural discourse task. One possible explanation is that increased reliance on non-redundant gestures reflects a shift in communicative strategy, where gestures are used to augment or clarify speech, particularly in contexts requiring more spatial and action-related vocabulary. This interpretation aligns with the Gesture-for-Conceptualization framework (as outlined above) and is consistent with embodied or grounded models of cognition (e.g., Barsalou, 2008; Gentsch et al., 2016), which suggest that gestures function as a form of simulated action, especially when speakers have difficulty expressing spatial concepts through speech alone. Further support for this idea comes from studies by Göksun et al. (2015), Johnson et al. (2013), and Kita and Lausberg (2008), which highlight the crucial role of gestures in conveying action-related content when verbal expression of spatial vocabulary is limited.

Finally, we explored the relationship between iconic gesture use, language impairment, and spoken language measures from the discourse tasks. Despite participants with latent aphasia all scoring above the clinical cut-off on WAB AQ, we found a correlation between WAB AQ performance and proportion of supplementary gestures produced, such that people with subtly more severe latent aphasia (still above standardized cut offs for clinical aphasia) tended to use supplementary gestures more often. In addition, individuals with more mild latent aphasia showed a greater task-based difference in the number of redundant gestures produced, such that they shifted to rely more on non-redundant gestures (supplementary and essential) in the Sandwich task compared to the Cinderella task. While prior research has demonstrated that more severe aphasia (i.e., moderate or severe aphasia as defined by the WAB-R) is associated with a greater proportion of gestures that play a supplementary or essential (vs. redundant) role in connected speech (e.g., Kong, Law, Wat, et al., 2015; Stark & Oeding, 2024), our findings extend this correlation by revealing that even in the mildest cases of aphasia, a subtle severity continuum persists. Prior work in more severe aphasia has used the same procedural task ("Sandwich"; Stark & Oeding, 2024) and similar narrative tasks ("The Hare and the Tortoise" and "The Boy who Cried Wolf" story retells; Kong, Law, Wat, et al., 2015). Although our findings are preliminary and exploratory, it is striking to replicate this same pattern of results with such a limited range of severity in individuals with latent aphasia. Our results support accounts such as rational adaptation (Dresang et al., 2021, 2023, 2024) and the Sketch model of gesture use (de Beer et al., 2020; de Ruiter & de Beer, 2013), which posit that speakers with more severe language impairments have increased reliance on relatively intact gestural modalities to support communication because verbal communication is difficult and cognitively demanding. Given the limited range of severity and number of observations in our dataset, these correlations must be interpreted with caution and investigated further in future research.

We also found several associations between iconic gesture use and spoken language metrics derived from the Cinderella and Sandwich discourse tasks. Due to the main effect of task discussed above, we evaluated relationships between iconic gesture and language metrics by task. We found that gesture frequency was related to spoken language metrics derived from the Sandwich task but not the Cinderella task. Specifically, redundant gestures were positively correlated with number of words produced in the Sandwich task, while both supplementary and essential gestures were positively correlated with speaking duration. It is important to note that there were few observations of supplementary and essential gestures, which may limit sensitivity to detecting correlations. Nevertheless, these findings are again largely consistent with prior evidence from participants with more severe aphasia. For example, Stark and Cofoid (2022) similarly found that participants with aphasia who produced more iconic gestures in the Sandwich task also had longer speaking duration. They also found associations with utterance lengths, which we did not observe here, possibly because individuals with latent aphasia showed less variability in utterance length than prior participants with more severe aphasia. Previous research has also found that words per minute and a greater sample length (measured in tokens) were associated with a higher number of iconic gestures in individuals with aphasia (Stark & Oeding, 2024). In particular, individuals with more severe aphasia, anomia, and with nonfluent aphasia produced a slower rate of speech and fewer tokens, and furthermore these variables were associated with a higher frequency and rate of supplementary and essential gestures. This evidence base supports theories that hypothesize that using (Krauss, 1998; Rauscher et al., 1996) or observing gestures (Murteira & Nickels, 2020) generally facilitates lexical retrieval, and that gestures are used more frequently when spoken language is impaired or made more difficult (de Beer et al., 2020; de Ruiter, 2006; McNeill, 1992). Furthermore, our findings of task-based differences are consistent with accounts that posit gestures function as spatial, action-based language, which people with aphasia use as a compensatory or complementary tool to the spatial language they want to produce (Clough & Duff, 2020; Dresang et al., 2023; Kita & Lausberg, 2008).

Looking across all three research questions, our findings importantly demonstrate significant group by task differences in the number of iconic gestures produced. This critically highlights that although their language impairments may be mild and subclinical, individuals with latent aphasia can experience significant differences in their communication which extend beyond the verbal modality to gesture usage. We provide evidence that individuals with latent aphasia use gesture alongside speech to facilitate or enhance their communication, and they do so in ways that differ from cognitively healthy adults. This study was the first to characterize the specific functions that gestures serve related to spoken language content, as well as how these relate to language impairments and spoken discourse measures. Our findings make significant steps toward increasing scientific and clinical understanding of gestures in latent aphasia.

Clinically, it is essential to incorporate gesture assessment into the evaluation of individuals with latent aphasia. However, surveys of clinical practice reveal that gesture assessment is often overlooked, and many clinicians report a lack of standardized tools to evaluate gesture use effectively (Caute et al., 2025). Most available assessments focus on isolated gestures (e.g., in limb apraxia investigations; in pantomime or mimicry) rather than capturing how gestures integrate with speech in meaningful communication contexts. This limitation highlights the need for more comprehensive and naturalistic assessment tools – such as the City Gesture Checklist (Caute et al., 2021) – that reflect the real-world challenges faced by individuals with latent aphasia.

A recent systematic review of fourteen studies reported benefits of multimodal therapies involving gestures, whereas gesture-only interventions showed mixed results (Spigarelli & Macoir, 2024). In particular, their findings suggest that gesture use leads to better language outcomes when integrated with multimodal therapy strategies, rather than in isolation or as a traditional cueing method. However, most of the existing evidence comes from individuals with moderate to severe aphasia, with some studies including only participants with severe aphasia (Duffy et al., 1984; Hogrefe et al., 2012, 2017). While gesture-based multimodal interventions show promise (e.g., de Kleine et al., 2024; Rose et al., 2013), the focus on more severe cases highlights an unmet need for systematic, gesture-focused therapies tailored to verbal and non-verbal communication needs of individuals with very mild aphasia. Integrating gesture training into speech-language therapy for this population could enhance communication outcomes by equipping individuals with a broader range of strategies to convey meaning and manage their language difficulties.

In conclusion, iconic gestures play a crucial role in supporting communication for individuals with latent aphasia, whose subtle language difficulties may not be detected through standardized testing. Although research has provided valuable insights into gesture use in more severe forms of aphasia, there is a pressing need to investigate how gestures function in latent aphasia to capture the full extent of these individuals' communication challenges. These efforts will contribute to a deeper understanding of multimodal communication and enhance the quality of life for individuals with neurogenic communication disorders, ensuring that their needs are better met in both clinical and everyday settings.

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