Task-specific iconic gesturing during spoken discourse in aphasia

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Abstract

Purpose: Identify main effect of task, as well as roles of spoken language and biographical details, on iconic gesture production during spontaneous speech in persons with and without aphasia.

Method: Employing the AphasiaBank database, we coded iconic gestures in N=75 speakers with aphasia (PWA group) and N=35 matched non-brain-damaged speakers (NBD group) on two discourse tasks: a procedural narrative and a picture sequence, expositional narrative.

Results: More iconic gestures, at a higher frequency, were produced during the procedural narrative for both subject groups. There was not a significant difference in iconic gesture production, or by task, in nonfluent as compared with fluent subtypes of aphasia. In PWA, iconic gesture frequency correlated with overall spoken output, as well as utterance-level errors and total dysfluencies. Iconic gesture production was correlated with aphasia duration, but not with other biographical metrics, such as aphasia severity or age.

Conclusions: Whilst speech-language pathologists have long utilized gesture in therapy for post-stroke aphasia, due to its possible facilitatory role in spoken language, there has been considerably less work in understanding how gesture differs across naturalistic tasks, and how we can best utilize this information to better assess and treat gesture in aphasia. Further, our results contribute to gesture theory, in particular about the role of gesture across naturalistic tasks, and its relationship with spoken language.

Introduction

Gesture is a powerful tool that accompanies and, sometimes, replaces speech. Gesture can disambiguate, add information to, or offer redundant information to speech. In the case of persons with acquired aphasia – a language disorder – gestures may serve a particularly communicative purpose, in that gestures may be one means of compensating for spoken language difficulties or, indeed, may serve as a mechanism to overcome word finding difficulties (reminiscent of what Luria termed inter-systemic reorganization (Luria, 1970)) (Dipper et al., 2015; Hadar & Butterworth, 1997; Krauss, 1998; Rose & Douglas, 2001). As such, gesture has been used in speech-language treatments for post-stroke aphasia, to improve and enhance use of gestures as a compensatory communication modality and to accelerate recovery of language, though evidence for its effectiveness remains unclear (Rose et al., 2013).

Gestures lie along a continuum, ranging from gestures with no linguistic association or properties ('gesticulation') to gestures emphasizing semantic content in speech (‘language-like gestures,’ including iconic gestures), to gestures conveying meaning in the absence of speech (‘pantomimes’), to gestures holding independent status as symbolic forms (‘emblems,’ e.g., the “OK” sign), to signed language, which is a rule-based language. McNeil has termed this gesture scale Kendon’s Continuum (McNeil, 1992). Of interest to the current study are language-like gestures, which comprise further categories, including pointing/deictics, metaphorics, iconics, and beats. For the purposes of a succinct introduction, we will focus on iconic gestures.

Iconic gestures are related to the content of speech and have a form (e.g., motion, hand-shape, location) that is related to this content (Hadar & Butterworth, 1997). These types of gestures are particularly interesting to evaluate in aphasia, because evidence suggests that they reflect the facilitation of lexical processing by employing linguistically-related, but pre-linguistic, conceptual information (Hadar & Butterworth, 1997). That is, even if some lexical processes are disrupted (e.g., lexical selection, phonological selection), if the pre-linguistic conceptualization process is intact, iconic gestures can be accurately produced to accompany, disambiguate, or add to speech. This is important because many persons with aphasia have intact pre-linguistic conceptualization (e.g., mild-moderate Broca's aphasia, anomic aphasia, conduction aphasia), and thus may successfully employ iconic gestures to supplement otherwise impoverished speech.

For example, in a single case study of a person with conduction aphasia, it was found that, when recounting a cartoon, the individual with conduction aphasia produced more iconic gestures than a comparison sample of controls during word searching behavior (Pritchard et al., 2013). Interestingly, this individual produced a similar frequency of iconic gestures compared with control participants alongside normal language. In a larger sample of persons with aphasia and matched controls, iconic gestures were produced in similar frequencies and forms by both groups, but the aphasia group utilized iconic gestures alongside their otherwise semantically impoverished language (Pritchard et al., 2015). A study in N=95 persons with aphasia demonstrated the use of at least one type of iconic gesture during a fictional story retell (Cinderella), further emphasizing reliance on this type of gesture to convey, disambiguate, or add meaning during discourse by persons with otherwise impoverished spoken language (Sekine & Rose, 2013b). Further, iconic gestures produced during narratives by persons with aphasia do not always mirror their lexical affiliates' complexity (i.e., if lexical affiliates are simple, iconic gestures are not necessarily simple)—indeed, authors identify a particular gesture–language mismatch in the aphasia group, where they found semantically 'light' verbs (which have little semantic content alone) to be paired with a semantically richer iconic gesture (Dipper et al., 2015). This evidence diverges from the hand-in-hand hypotheses (So et al., 2009), more so supporting iconic gestures as compensatory in aphasia.

While the literature has made clear that iconic gestures are heavily used in aphasia, largely more often than are used by persons without aphasia, there exist critical gaps in the literature.

The primary gap targeted by our project is on task-specificity of iconic gesture use in aphasia. Most studies evaluating iconic gesture in aphasia have focused on gesturing during a single discourse task (e.g. fictional story retell) (Kistner et al., 2019; Pritchard et al., 2015; Sekine & Rose, 2013a) or a naming task (Rose & Douglas, 2001). However, restricting evaluation of iconic gestures to a single task likely lends us an impoverished understanding of how, when and why iconic gestures are employed in naturalistic contexts. It is well acknowledged that language is task-specific, i.e., that the structure (microlinguistic) and functional (macrostructural) aspects of spoken language shift according to task demands (Dalton & Richardson, 2019; Li et al., 1996; Shadden et al., 1990; Stark, 2019; Ulatowska et al., 1981). For that reason, it is important to employ a variety of tasks to most comprehensively evaluate spoken language ability (Brookshire & Nicholas, 1994; Stark, 2019). It follows that employing a variety of tasks to assess a person's innate reliance on gesture is clinically important. Further, evaluating the extent to which task influences gesture type and frequency can lend valuable information toward planning treatment, e.g., provide information to the clinician regarding typical gesture use, as well as atypical or inaccurate gesture use at a task-specific level. Presently, gesture-based therapies have largely not resulted in significant improvement in spoken language in aphasia (Rose et al., 2013), and one such reason may be our lack of understanding about task-specific gesturing. Therefore, directly comparing gesture use between tasks in the same person will allow us to understand gesture use more sensitively and comprehensively, as well as the relationship between task and gesture. Doing so in naturalistic tasks, like spoken discourse, can also give us critical insight about how gesture is used in a spontaneously communicative sense. Finally, if we can understand the types and frequency of gestures produced across a range of naturalistic tasks in aphasia, and how these gestures relate to spoken language competency, we can more accurately formulate predictive hypotheses regarding language recovery. For example, we can answer clinically critical questions like: to what extent does iconic gesturing during narrative in the acute phase of aphasia predict communicative success in the chronic stage of aphasia (or indeed, predict in which individuals aphasia will resolve)?

Evaluating task-specific gesturing has critical importance for growing theories related to gesture use in typical populations, as well as those with language impairments. There are two core theories that have been used to describe gesture use in aphasia, including the trade-off hypothesis (de Ruiter et al., 2012; de Ruiter, 2006) and the lexical (or word) retrieval hypothesis (Krauss, 1998; Krauss & Hadar, 2001). The trade-off hypothesis claims that, when gesturing gets harder, speakers will rely relatively more on speech, and, alternatively, that when speaking gets harder, speakers will rely relatively more on gestures (de Ruiter et al., 2012). Broadly, this theory fits with evidence comparing overall gesture usage in aphasia to gesture usage in matched samples of persons without aphasia, finding almost always that persons with aphasia gesture more often whilst also producing less speech (Sekine & Rose, 2013b). Identifying task-specific effects on iconic gesturing has ramifications for elucidating this theory. Some discourse tasks employ pictures, which in turn may facilitate different patterns of gesturing—for example, a trend toward more concrete/deictic gestures, rather than iconic gestures. In tandem, picture-oriented tasks may elicit more nouns and simpler language structure than other tasks (Stark, 2019). For speakers with more severe aphasia, these tasks can elicit more spoken output than less structured tasks, and tasks without pictures. It is therefore of interest to compare gesture usage across tasks with varying cognitive and linguistic complexity – some with pictures, some relying more on autobiographical memory, some on semantic memory – to establish the extent to which the tradeoff hypothesis adequately describes, or predicts, gesture usage in aphasia.

The lexical retrieval hypothesis is of importance to language-like gesturing, which, by definition, are meant to coincide with language and may help to disambiguate, emphasize, add information to, or be redundant with speech. In the lexical retrieval hypothesis, gestures are thought to directly facilitate lexical retrieval processes (Krauss, 1998; Krauss & Hadar, 2001), a theory based on Levelt's model of lexical retrieval, such that early, pre-linguistic conceptualization stages feed forward into later, lexical and phonological stages (Levelt, 1989). That is, iconic gestures, in particular, are thought to originate in the processes that precede conceptualization / formulation of the preverbal message, and as such can precede even in cases of blockages or damage to later stages. Importantly, this theory hypothesizes that the imagistic information from iconic gesture may facilitate lexical retrieval by "defining the conceptual input to the semantic lexicon; by maintaining a set of core features while reselecting a lexical entry; and by means of directly activating phonological word-forms" (Hadar & Butterworth, 1997). Indeed, iconic gesturing has been shown to improve object naming (Rose & Douglas, 2001) and occur alongside word finding problems (Kong et al., 2015; Pritchard et al., 2013). Identifying task-specific effects on iconic gesturing is important for refining the lexical retrieval hypothesis of gesturing in aphasia. For example, iconic gesturing may be used more often, and with a greater success rate, when tasks do not involve other visual stimuli (e.g., picture descriptions), as they stand in for the concrete imagery that may otherwise facilitate lexical access.

Here, we compare iconic gestures made by persons with aphasia (PWA) and a matched, non-brain-damaged control group (NBD) during two discourse tasks: a procedural narrative and an expository, picture sequence description. The main purpose of this study was to evaluate the main effect of task on iconic gesture frequency and rate, and the relationship of iconic gesture use with relevant biographical information (e.g., aphasia severity, aphasia type) and with speech.

Methodology and Design

Participants

Participant data was collected through AphasiaBank, a password protected database for researchers interested in spoken discourse use in aphasia (MacWhinney et al., 2011). We collected data for two groups: a non-brain-damaged (NBD) control group, who did not have brain damage or aphasia, and an aphasia group, who had acquired brain damage and aphasia (or latent aphasia) as per clinical assessment and standardized testing scores. Included participants in both groups spoke English as their primary language.

Exclusion criteria: PWA group: First, we excluded participants for whom their video did not show the entirety of both upper limbs. This was necessary to ensure accurate gesture coding. We then excluded persons with aphasia who did not gesture during at least one task of interest (described in ***Stimuli***). Finally, participants were excluded if they were given a picture aid for the "Sandwich" procedural discourse (described in more detail in section ***Stimuli***). This decision was made because not every individual was given this additional support (roughly ~20% of the database received a picture during the Sandwich task). As we wanted to evaluate the difference in gesture usage between discourse genres (expositional vs. procedural), and only expositional was meant to include a visual aid, inclusion of those individuals with a visual aid during the procedural task would be inconsistent. NBD group: To derive a control group, we first reviewed all video data from AphasiaBank control dataset, once again we excluding participants for whom their video did not show the entirety of both upper limbs. From non-excluded participants, we then matched the control group to the aphasia group on age (using case control matching in SPSS 27 with a fuzzy interval of one standard deviation of age, derived from the aphasia group). This was our final control ("NBD") group. Dissimilar to the aphasia group, we did not require that members of the

NBD group gesture during at least one of the tasks, because we found that, on average, most members of the NBD group did not gesture during most spoken discourse tasks.

Following the parameters described above, this study included a total of N=75 (PWA group), described in Table 2, and N=35 (NBD group), described in Table 3. The two groups were not significantly different in age (Z=-1.72, p=.09), education (Z=1.01, p=.31), or sex (Fisher's exact test, p=.31).

TABLE 2 HERE

TABLE 3 HERE

Stimuli

Gestures were analyzed during two spontaneous speech discourse tasks, drawn from the AphasiaBank protocol (MacWhinney et al., 2011), called the "Sandwich" and the "Window" tasks.

The "Sandwich" task was a procedural narrative, in which participants described how to make a peanut butter and jelly sandwich. As noted earlier, this task did not include any visual aids. The instructions for the Sandwich task 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 no response in 10 seconds was given, the examiner gave a second prompt: "If you were feeling hungry for a peanut butter and jelly sandwich, how would you make it?" If no response was given, the examiner utilized a set of Troubleshooting questions (available on aphasiabank.talkbank.org).

The "Broken Window" task (shortened, here, to 'Window') was an expository task (specifically, a picture sequence description), in which participants described a sequence of four pictures: a boy kicking a soccer ball through a picture window, knocking over a lamp and surprising a sitting man (Menn et al., 1998). The instructions for the Window task were as follows: "Now I'm going to show you these pictures." *Examiner presents picture series*. "Take a little time to look at these pictures. They tell a story. Take a look at all of them, and then I'll ask you to tell me the story with a beginning, a middle, and an end. You can look at the pictures as you tell the story." If no response was given in 10 seconds, the examiner gave a second prompt: "Take a look at this picture (point to first picture) and tell me what you think is happening." If needed, the examiner pointed to each picture sequentially, giving the prompt: "And what happens here?" For each panel, if no response, the examiner provided the prompt: "Can you tell me anything about this picture?" If no response was given to any of these prompts, the examiner utilized a set of Troubleshooting questions (available on aphasiabank.talkbank.org).

Gesture Scoring

Types of gestures

Iconic gestures represent meaning that is closely related to the semantic content of the speech that they accompany (McNeil, 1992). Within the iconic category, two further subcategories were specified: referential and viewpoint. Referential gestures are those used to assign the entity of referents to a place in front of the speaker, without referring to a concrete entity in the room. Viewpoint gestures are those used to depict an action, event or object through an observer's eyes (observer viewpoint) or through the character's eyes (character viewpoint). All gesture categories (and subcategories) are described in Table 1.

The primary outcomes of this study were gesture *frequency* (defined as [1] raw frequency of gesture by category (and subcategory) and [2] as a proportion of total gestures) and *rate* (defined as gestures produced [1] per minute and [2] per spoken utterance).

TABLE 1 HERE

Raters and Reliability

The primary rater (author CC) trained two undergraduate raters in gesture scoring. Raters practiced scoring on a random sample of ten subjects (a combination of samples from each participant group). Author CC then cross-checked scoring to establish inter-rater reliability of at least 80% agreement on these practice samples. Any disagreements were discussed between all raters and a consensus was arrived at. Following resolution of any outstanding issues, raters were then assigned approximately 25 total individuals (22% of total sample) to rate.

Analysis

All analyses were conducted in SPSS 27. The data was, overall, not normal in distribution, and we therefore employed non-parametric statistics. The goal was not to directly compare the PWA and the NBD group, because the selection process for these two groups was slightly different. Instead, our main analyses were within-group: comparing demographics, language variables, and main effects of task on iconic gestures. As such, we will not directly compare the iconic gesture frequency or rate between the PWA and NBD groups.

Results

Iconic gesture usage in non-brain-damaged (NBD) group (N=35)

Biographical

The NBD group did not show a significant relationship between gesture frequency and education (r_s=-.09, p=.60), but did show a small correlation between age and gesture frequency (r_s=-.38, p=.02), suggesting that older adults tended to gesture less frequently. We also evaluated gender, finding that there was no significant difference in total gesturing frequency by gender (df=5, $\chi 2$=5.96, p=.31).

Spoken Language

As we did for the aphasia group, we also evaluated the relationship between iconic gestures and language variables, extracted from the two speaking tasks. Members of the NBD group did not show a significant relationship between gesture frequency and total speaking time (r_s=.10, p=.57), total utterances (r_s=.19, p=.28), total tokens (r_s=.27, p=.12) nor average words per minute (r_s=.09, p=.63). We did not evaluate the relationship between percentage of total word errors and percentage of total utterance errors because this group tended to make very few of these (total word errors, M=0±0; total utterance errors, M=.09±.27) or these were not coded in the transcripts. We did not evaluate hesitations or errors for the NBD group, as either very few were made, or these were not coded in the transcripts.

Task Effects

The NBD group showed a similar pattern to the aphasia group (data in Table 4). For total iconic gestures used, there was a significant difference between tasks (Z=-3.45, p=.001), with significantly more iconic gestures produced during Sandwich (M=1.03, SD=1.56) than Window (M=.03, SD=.17). Not surprisingly, this significant difference between tasks extended to gesturing rate, measured both by gesture per minute ($Z=-3.53$, $p<.001$) and gesture per utterance ($Z=-3.48$, $p<.001$), with Sandwich task demonstrating greater gesturing rate (**Per min**, Sandwich: $M=10.71\pm2.87$; Window: $M=.03\pm.18$. **Per utterance**, Sandwich: $M=.11\pm.18$; Window, $M=.002\pm.01$).

We did not complete ANOVAs to evaluate the main effect of task on referential and viewpoint gestures, largely because the NBD group did not produce many of either gesture during the Window task. Indeed, only 22.9% ($N=8$) produced a referential gesture during the Sandwich task, and only 42.9% produced a viewpoint gesture during the Sandwich task. The trend was similar for the Window task, with 0% producing a referential gesture, and 2.9% producing a viewpoint gesture. It is clear that, when members of the NBD chose to use iconic gestures, it was during the Sandwich task, and of those iconic gestures, there were more viewpoint than referential gestures used.

TABLE 4 HERE

Iconic gesture usage in persons with aphasia (PWA) group (N=75)

Examples of iconic gestures seen in this group are shown in Tables S1 (referential gestures) and S2 (viewpoint gestures).

Biographical

We collapsed iconic gestures across tasks to evaluate relationships with demographic variables, i.e., summed all iconic gestures. After multiple comparison correction using Bonferroni correction ($p<.008$), none of the following significantly associated with overall gesture usage: aphasia severity (r_s=.10, p=.38), years of speech-language therapy (r_s=.21, p=.07), education (r_s=.21, p=.08), or age (r_s=-.26, p=.02). Aphasia duration – that is, the amount of time one has lived with aphasia – did significantly correlate with overall gesture usage (r_s=.36, p=.002), indicating that persons with more chronic aphasia tended to produce iconic gestures more frequently. Using a Chi-square test, we evaluated the impact of physical status (no motor impairment; unilateral hemiparesis; unilateral hemiplegia) on total gesturing frequency pooled across tasks, finding no significant relationship between gesture frequency and presence of either hemiparesis or hemiplegia (df=38, χ^2=29.82, p=.83) [note that N=1 did not have data on motor impairment, so this analysis included N=74 persons with aphasia]. We also did this for gender, finding that there was no significant difference in total gesturing frequency by gender (df=19, χ^2=19.78, p=.41).

Spoken Language

We subsequently evaluated the relationship between iconic gestures and language variables, extracted from the two speaking tasks. To holistically evaluate the relationship of spoken language with total iconic gestures produced, we collapsed language variables across the tasks, creating a sum for each: total speaking time, total utterances produced, total tokens produced, total percentage of utterance errors produced (which includes utterances tagged as empty speech, jargon, circumlocutive, or grammatically incorrect [paragrammatic or agrammatic]) and average words per minute (Table 5). Total iconic gesture frequency (i.e., sum across both tasks), after Bonferroni correction ($p<.01$), significantly correlated with total speaking time ($r_s=.42$, $p<.001$), total utterances ($r_s=.62$, $p<.001$), total tokens ($r_s=.49$, $p<.001$), and total utterance errors ($r_s=.38$, $p=.001$). We did not find a significant relationship between gesture frequency and average words per minute ($r_s=.10$, $p=.41$).

Next, we examined the relationship between language fluency variables and iconic gesture frequency. To do so, we extracted the following variables from the spoken discourse: filled hesitations (i.e., false starts, fragments), unfilled hesitations (i.e., pauses of at least 3 sec or greater), number of lexical errors (i.e., phonological and semantically related errors with known targets), and number of non-lexical errors (i.e., phonologically related non-words and semantically unrelated errors with known targets) (Table 5). For the Sandwich story, there was a significant relationship (Bonferroni corrected, $p<.0125$) between total iconic gestures produced and filled hesitations ($r_s=.41$, $p<.001$) as well as unfilled hesitations ($r_s=.27$, $p=.02$), but not lexical errors ($r_s=.08$, $p=.48$) or non-lexical errors ($r_s=.15$, $p=.20$). Because aphasia duration significantly correlated with filled hesitations ($r_s=.39$, $p=.001$) (but not unfilled hesitations, $r_s=.05$, $p=.67$), we subsequently performed a partial correlation to identify the extent to which those two biographic variables modulated the relationship between total iconic gestures produced during Sandwich. Partial correlation indicated that there was still a significant relationship between filled hesitations and total iconic gestures produced during Sandwich ($r=.26$, $p=.025$) when controlling for aphasia duration. We evaluated the same language fluency metrics for the Window story, finding that filled hesitations ($r_s=-.01$, $p=.97$), unfilled hesitations ($r_s=-.07$, $p=.54$), lexical errors ($r_s=-.14$, $p=.23$) nor non-lexical errors ($r_s=.02$, $p=.86$) correlated with total iconic gestures produced. This is interesting, given that the number of filled (p=.91) and unfilled (p=.11) hesitations was not significantly different between the two tasks, but filled hesitations were clearly correlated with total number of iconic gestures produced during only the Sandwich task.

Task Effects

Within the aphasia group, 57.3% made an iconic gesture during the Window task, whilst 100% made an iconic gesture during the Sandwich task (data in Table X). Not surprisingly, when evaluating total iconic gestures used (i.e., sum of gesture per task), there was a significant difference in gesture frequency between tasks ($Z=3.45$, $p=.001$) and in gesturing rate, measured both by gesture per minute ($Z=3.53$, $p<.001$) and gesture per utterance ($Z=3.48$, $p<.001$). In all cases, this demonstrated greater iconic gesture frequency and gesturing rate during the Sandwich task (Table 5).

We next investigated the extent to which the patterns noted above extended to specific types of iconic gestures, specifically, referential and viewpoint gestures. To do so, we calculated referential and viewpoint gestures produced as a proportion of all iconic gestures. Of the 57.3% (N=43) who made iconic gestures during the Window task, these tended to be viewpoint gestures (45.3%) compared with referential gestures (37.3%). Of the 100% (N=75) who made iconic gestures during the Sandwich task, these likewise tended to be viewpoint gestures (96%) rather than referential gestures (84%). Fisher's exact tests noted that there was not a significant difference in whether someone did or did not make a referential gesture ($p=.52$) or a viewpoint gesture ($p>.99$) by task.

To statistically analyze differences in gesture frequency within the two categories of iconic gestures (referential, viewpoint), we conducted a 2 (task) x 2 (gesture type) repeated measures ANOVA. Expectedly, there was a main effect of task, where the Sandwich task produced significantly more referential gestures than Window task, $F(1)=94.06$, $p<.001$, $\eta^2=.56$. There was also a main effect of gesture type, $F(1) = 15.66$, $p<.001$, $\eta^2=.18$, where more viewpoint than referential gestures were produced. There was not a significant interaction ($F[1]=2.74$, $p=.10$, $\eta^2=.04$), such that one task did not produce a statistically different distribution of referential and viewpoint tasks compared with the other task.

We completed two similar 2 (task) x 2 (type) repeated measures ANOVAs for gesture rate, once for rate as modeled by gesture per utterance and once for rate as modeled by gesture per minute. There was a main effect of task, with the Sandwich task producing a significantly higher rate of iconic gestures (per minute: $F(1)=159.24$, $p<.001$, $\eta^2=.68$; per utterance: $F(1)=147.96$, $p<.001$, $\eta^2=.67$). There was again a significant main effect of type (per minute: $F(1)=9.35$, $p=.003$, $\eta^2=.11$; per utterance: $F(1)=12.56$, $p=.001$, $\eta^2=.15$), where viewpoint gesturing rate was higher than referential gesturing rate. There was not a significant interaction (per minute: $F[1]=1.44$, $p=.23$, $\eta^2=.02$; per utterance: $F(1)=3.07$, $p=.08$, $\eta^2=.04$), such that one task did not produce a statistically different distribution of gesturing rate compared with the other task.

Finally, we answered the question: if a person used more viewpoint gestures on the Sandwich task, did they also do so on the Window task? To evaluate this, we binarized each variable (1=used gesture, 0=did not use gesture) and computed the Phi correlation on the transformed data. There was not a significant relationship between tasks for referential gestures ($\varphi=.11$, $p=.34$) or viewpoint gestures ($\varphi=.05$, $p=.67$), further emphasizing task-specific gesturing, such that a person who may have used more viewpoint gestures during one task did not necessarily do so on the other task.

TABLE 5 HERE

Aphasia Classification

Finally, we wanted to evaluate the interaction of aphasia classification (nonfluent, fluent types) and iconic gesture usage. We therefore divided our group into the classic dichotomous classification of aphasia: nonfluent (N=22; Broca's, Transcortical Motor) and fluent (N=48; Anomic, Conduction, Transcortical Sensory, Wernicke's) (Table 6). We did not include the N=5 individuals without aphasia (not aphasic by WAB) in this analysis. The two aphasia groups were not significantly different on age (Z=.34, p=.73) or education (Z=1.26, p=.21). The non-fluent group received more years of speech-language therapy (Z=2.72, p=.007) and also had longer aphasia duration (Z=2.63, p=.009). Not surprisingly – because of the large number of persons with anomic aphasia in the fluent group – the fluent group demonstrated less severe aphasia (p<.001).

TABLE 6 HERE

Within the nonfluent group, 100% made an iconic gesture during the Sandwich task, and 54.5% made an iconic gesture during the Window task (Table 7). Within the fluent group, 100% made an iconic gesture during the Sandwich task, and 62.5% made an iconic gesture during the Window task. There was not a significant difference in whether or not a subject made an iconic gesture by aphasia type during the Window task (Fisher's exact test, p=.60). As all members of both aphasia type groups gestured during the Sandwich task, there was no significant difference.

We then conducted crosstabulations to identify an interaction of aphasia type with referential and viewpoint gesture usage. To evaluate group (aphasia type) differences in whether or not a referential gesture was made during the Sandwich task, we employed a Fisher exact test, which demonstrated no significant difference (p>.99). We found a significant difference for whether or not a viewpoint gesture was made during the Sandwich task (p=.03), with all members of the fluent group (100%) making a viewpoint gesture, as compared to the nonfluent group

(86.4%). For the Window task, Fisher exact tests indicated no difference in whether or not a referential gesture ($p=.60$) or viewpoint gesture ($p>.99$) was made.

We then compared gesture rates for aphasia type groups using Mann-Whitney U Tests. When gestures were modeled as a proportion of speaking duration (per minute), we did not find a significant difference in total iconic gestures produced per minute for either Sandwich ($Z=1.04$, $p=.30$) or Window ($Z=.38$, $p=.71$) by aphasia type. We did find a significant difference in total iconic gestures produced per utterance for Sandwich ($Z=2.03$, $p=.04$; mean ranks, nonfluent $M=28.25$, fluent=38.82) but not for Window ($Z=.49$, $p=.62$). That is, on only the Sandwich task, gesture rate (as modeled by either per minute or per utterance) differed significantly between the aphasia type groups, where persons with fluent aphasia produced a greater iconic gesture rate.

We subsequently explored group (aphasia type) differences in specific iconic gesture types, referential and viewpoint. We first evaluated differences in gesture frequency by group, evaluating total referential gestures and total viewpoint gestures used during each task. We did not find a significant difference in total gestures used by group, for either Sandwich (referential, $Z=1.51$, $p=.13$; viewpoint, $Z=.57$, $p=.57$) or Window (referential, $Z=.23$, $p=.82$; viewpoint, $Z=.35$, $p=.73$).

TABLE 7 HERE

Discussion

We evaluated iconic gestures in a large group of persons with post-stroke, chronic aphasia (PWA), as compared with a group of age-, education- and sex-similar non-brain-damaged adults (NBD). Below, we will discuss how these results fit in within overarching, theoretical hypotheses of gesture, as well as prior findings of iconic gesture usage in aphasia. We will end with discussing clinical implications of this work.

Regarding biographical correlates of iconic gesture use, only aphasia chronicity was correlated with iconic gesture usage. That is, those individuals who were living with aphasia for a longer period were those who tended to use a higher frequency of iconic gestures. This may speak to gestures serving as a compensatory, or supportive, addition to their spontaneous speech (Dipper et al., 2015). This idea of gestures as compensatory has theoretical foundations (Jan Peter de Ruiter, 2006; Krauss & Hadar, 2001), suggesting that increased gesture usage has a tendency to coincide with increased task difficulty and/or specific difficulty in word finding. Indeed, gesture – iconic gesture in particular – has been shown to occur much more often in aphasia than in age-matched counterparts without aphasia (Kistner et al., 2019; Pritchard et al., 2013; Sekine & Rose, 2013b). Aphasia severity, age, years of speech-language therapy, gender, nor physical status was correlated with total iconic gesture use. Increasing aphasia severity has previously been shown to coincide with gesture production (Kong et al., 2015), but as we only evaluated iconic gestures, it may be the case that we did not pick up on this relationship. We also did not find a significant relationship between hemiplegia or hemiparesis and gesture usage, which has also been shown previously (Kong et al., 2015). Of note, regarding limitations of the present study, is also a lack of data about limb-related apraxia in our PWA group, which may also explain some variance in gesture usage. In the NBD group, we did not identify any significant relationships between biographical information and iconic gesture use.

Much of the research in iconic gesture use has focused on the differing frequency of iconic gestures in nonfluent as compared to fluent aphasia. In general, this research has been mixed, with some studies finding significantly more iconic gesture use in nonfluent populations, primarily Broca's aphasia (Goldblum, 1978; Hadar, 1991; but see, Cicone et al., 1979) but some have observed a high incidence of iconic gestures across PWA (Feyereisen, 1983; Sekine & Rose, 2013a). In this study, we found no significant difference in total iconic gestures produced or gesture rate between fluent and nonfluent aphasia across the two tasks of interest. We did find a significant difference for whether or not a viewpoint gesture was made during the Sandwich task, with all members of the fluent group (100%) making a viewpoint gesture, as compared to the nonfluent group (86.4%). However, when evaluating overall iconic gesture use and gesture rate, we did not identify a significant difference between the groups for either task. This is not dissimilar from findings evaluating gesture usage (including iconic) across aphasia subtypes. Sekine & Rose, 2013a found that PWA showed specific gesture production patterns according to their aphasia type, when evaluating a large cohort of subjects from AphasiaBank during the Cinderella story retell narrative. Specifically, more than half of the participants with Broca's and Conduction aphasias produced a viewpoint iconic gesture, whilst at least half of all participants regardless of aphasia subtype produced a referential iconic gesture. Notably, more than half of their NBD population produced a referential and a viewpoint gesture, as compared to our NBD population, which showed a much smaller proportion of subjects producing at least one iconic gesture during either task. This highlights task-related differences in iconic gesture production in persons with aphasia and without aphasia, which we will discuss in the following paragraphs.

Whilst some have noted that there is a tendency for persons with specific aphasia types to rely on specific types of gestures (e.g., concrete deictic, iconic, beats, pointing to self) (Sekine & Rose, 2013b), it is difficult to draw conclusions based on gesture usage and rate by aphasia type because of the vast intra-group differences in underlying language ability within each aphasia type. For example, iconic gestures likely rely on some intact pre-linguistic components, such as access to semantics (Hadar & Butterworth, 1997), and yet persons with Broca's aphasia (for example) can present with relatively intact or relatively impaired semantics. This makes drawing overarching conclusions about gesture usage stratified by aphasia type inherently difficult and, perhaps, not meaningful. What might be more meaningful, and which our further work will address, is the extent to which residual pre-linguistic and linguistic skills predict gesture usage. Rose & Douglas (2001) explored this in reference to gesture's facilitatory effects in object naming, finding that individuals with phonological access, storage, or encoding difficulties showed improved naming abilities when iconic gestures were present, versus those with a semantic impairment or a motor speech disorder (e.g., apraxia). But, it is likely not just a conceptual impairment driving the increased use of iconic gestures in PWA, but specifically the pre-linguistic conceptual impairment; it follows that persons with conceptual impairments (e.g., non-verbal design copying, spatial rotation mentalization) have been shown to produce gestures less frequently than PWA with relatively intact conceptual abilities (Hadar et al., 1998), further suggesting that it is the pre-linguistic conceptualization that is critical for gesturing (especially iconic). We could not stratify iconic gesture use by pre-linguistic conceptual ability in the current dataset, as the AphasiaBank corpus does not provide this data.

We also evaluated the relationship between metrics of spoken language and iconic gesture usage. There are a variety of theories exploring the relationship between spoken language and iconic gesture usage. These theories hypothesize, respectively, that gestures are used more frequently when spoken language production is made more difficult, or otherwise impaired (Jan Peter de Ruiter, 2006); that using gestures may help with lexical retrieval (Krauss, 1998); and that gestures run parallel to speech (So et al., 2009). Iconic gestures, in particular, tend to occur prior to the lexical item(s) that they complement and, because of their complexity, tend to occur across an utterance rather than at the word-level (Hadar & Butterworth, 1997). We found, in the PWA group, that iconic gesture usage was significantly correlated with total spoken output (i.e., tokens, utterances, duration) as well as utterance-level language dysfluencies (i.e., utterance-level errors) and hesitations, but not lexical or non-lexical word errors nor words per minute. Presumably due to the impoverished frequency of iconic gesture use in the NBD group, we did not identify significant relationships between spoken language variables and iconic gesture frequency or rate. The patterns that we identified in the PWA group offer credence to the hypotheses mentioned earlier: that more iconic gestures tend to be produced when there is an utterance-level error, likely because the iconic gesture was pre-linguistically formulated to coincide with several lexical item(s); and that more iconic gestures were produced with increasing output, suggesting that these types of gestures run, at least in part, parallel to speech. Interestingly, though, we did not find a straightforward relationship between aphasia severity or between word-level lexical or nonlexical errors. There is some support for the lexical retrieval hypothesis, which suggests that more iconic gestures would be produced with increased word finding difficulty (Dipper et al., 2015; Kistner et al., 2019; Krauss, 1998). While we did not find a significant relationship between word-level errors and iconic gesture frequency, there was a significant relationship of iconic gesture frequency with utterance-level errors. As they are coded in AphasiaBank, an utterance-level error could be one or a combination of the following: empty speech, circumlocution, grammatical issue (paragrammatic,

agrammatic), or jargon. In any of these cases, there may have been issues with word retrieval, and as such, our results provide some support for iconic gestures occurring in instances of impaired language.

Innovatively, we evaluated the role of the discourse task in iconic gesture production. Task has been shown to influence spoken language in persons with and without aphasia (Dalton & Richardson, 2019; Fergadiotis et al., 2011; Fergadiotis & Wright, 2011; Li et al., 1996; Shadden et al., 1990; Stark, 2019; Ulatowska et al., 1981; Wright & Capilouto, 2009) and it is not surprising that we identified a main effect of task on iconic gesture frequency and rate in both subject groups. Specifically, subjects produced statistically more iconic gestures, and gestured at a greater rate, during the procedural narrative task (Sandwich) than during the picture sequence, expositional task (Window). We further teased apart iconic gestures into two common types of iconic gestures: referential and viewpoint gestures. We did not find a significant interaction between task and iconic gesture type, suggesting that one task did not produce significantly more of one type of iconic gesture than the other. Therefore, a variety of iconic gestures are likely employed during both tasks evaluated here. We did not evaluate the informational relationship of each of these iconic gesture types to their respective speech (i.e., to disambiguate, to add information, to be redundant), but further evaluation of the informational relationship between speech and iconic gesture type is necessary to better understand the possible task-specific facilitatory effects of each iconic gesture type.

One explanation for the difference in iconic gesture production by task is shared knowledge (or common ground). That is – one task, the picture sequence task – provided a visual cue that was available to both the primary speaker and the other interlocutor (i.e., experimenter). Because the picture sequence was available to both persons in the experiment room, it may have been the case that fewer iconic gestures were produced because of shared knowledge (Bottenberg & Lemme, 1991; but see, Brenneise-Sarshad et al., 1991). In the case of a shared visual cue, iconic gestures may not have been favored by either subject group because of a reliance on other types of gestures – specifically, concrete deictic gestures (Sekine & Rose, 2013b). Whilst we did not report on other gestures produced during these tasks here, as we wanted to focus on iconic gesture usage, we did collect data on concrete deictic (e.g., pointing) gestures, finding that many gestures produced by the aphasia group included pointing to specific parts of the picture. We also hypothesized earlier, in the introduction, that iconic gesturing may be used more often, and with a greater success rate, when tasks do not involve other visual stimuli (e.g., picture descriptions), as they stand in for the concrete imagery that may otherwise facilitate lexical access. This lines up with our findings. Further, there is a precedent for iconic gesture use during procedural narratives by PWA: Pritchard et al., (2015) identified a similar frequency of iconic gesture between PWA and an NBD group, noting that PWA used gestures conveying rich semantic information (likely due to semantically impoverished speech), as compared with their NBD group. Task-specific gesturing has also been identified in childhood discourse (Reig Alamillo, 2012). Therefore, there is mounting evidence that discourse task affects spontaneous gesture usage in persons with and without aphasia. Here, we provide one of the few studies directly contrasting gesture usage across two tasks in the same group of subjects, with hope that more work follows our own in exploring these task-specific gesture relationships.

Taken together, not unlike the large amount of evidence demonstrating task-specific language in the spoken modality, there is task-specific gesturing. Understanding this has clinical ramifications. Indeed, while gesture is often employed in speech-language therapy for PWA, especially those with more severe production impairments, a systematic review indicated that gesture training alone had nonsignificant effects on verbal production in post-stroke aphasia and few studies examined generalization of gesture training to discourse (Rose et al., 2013). This systematic review emphasizes that gestures should be included in clinical assessments in aphasia. Therefore, for gesture training to be helpful for language recovery in aphasia, we need to better understand how and when gestures are used, language system characteristics that associate with specific types of gestures (i.e., intact pre-linguistic semantic ability and iconic gesture usage), how gestures differ across tasks and communication scenarios, and the informational and temporal relationship between gesture and speech. A lot of work has been done to clarify this in aphasia (Jan Peter de Ruiter, 2006; Dipper et al., 2011, 2015; Hogrefe et al., 2016; Kistner et al., 2019; Krauss & Hadar, 2001; Pritchard et al., 2013; M. L. Rose et al., 2017; Scharp et al., 2007; Sekine & Rose, 2013b), but an enhanced investigation of the role of gesture in spontaneous speech – especially across different elicitation methods – is both under-researched and necessary to comprehensively understand the role of gesture in a variety of naturalistic situations. We hope that our study has emphasized the need to further explore task-specific gesturing in aphasia.

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Supplementary

Table S1. Referential gesture examples

Gesture anatomy	Reference
Window Task	
Hands cupped	Ball
Draws circle on table/in air	Ball
Sandwich Task	
Hand flat/palm up or tracing square on table	Slices of bread
Hand cupped	Jar

Table S2. Viewpoint gesture examples

Gesture anatomy	Reference
Window Task	
Uses two fingers to perform 'kicking' action	Kicking ball through window
Arcs hand/arm through the air from one side	Trajectory of ball
Sandwich Task	
Hands come together	Putting together sandwich / folding bread
One open hand with outside edge down,	slicing/cutting sandwich

Tables and Figures

Table 1: Gesture descriptions and examples.

Iconic Gesture Type	Definition
Referential (Gullberg, 2006; McNeil, 1992)	Gesture used to assign the entity of referents, such as objects, places, or characters in the story, into the space in front of a speaker where any concrete object is absent. For the purposes of this gesture, we include manual / air drawing to be referential, as doing so is common in persons with aphasia (e.g., Kistner et al., 2019) *E.g., the participant uses two hands to form a circle in the air, meaning a 'ball.'*
Viewpoint (VPT) (McNeil, 1992)	Viewpoint can take two points of view: observer and character. In observer viewpoint, the gesture depicts a concrete action, event, or object as though the speaker is observing it from afar. *E.g., to depict someone running, the speaker traces her index finger from left to right as if she is seeing the scene as an observer.* In character viewpoint, the gesture uses the speaker's own body in depicting a concrete action, event, or object, as though the gesturer is the character/object itself. *E.g., to depict someone running, he swings his arms back and forth, as if he is running.*

Table 2: Aphasia group demographics (N=75).

Demographics	**M(SD) or Frequency**
Age	60.70 (11.22)
Education	15.43 (2.58)
Aphasia Severity (WAB AQ)*	73.73 (14.37)
Aphasia chronicity (years)	5.01 (4.31)
Years of SLP therapy	3.26 (2.44)
Race	8 African American 1 Asian 1 Native Hawaiian or other Pacific Island 62 White
Ethnicity	3 Hispanic or Latinx
Sex	34 females
Handedness (pre-morbid)	3 ambidextrous 7 left-handed 64 right-handed 1 unknown
Language Status	6 childhood bilinguals (English plus 2nd language by 6 years old) 6 late bilinguals (English plus 2nd language after 6 years old) 62 monolinguals 1 multilingual (speaks 3 or more languages fluently)
Presence of dysarthria and/or apraxia of speech	43 with apraxia of speech 8 with dysarthria (3 unknown)
Presence of hemiparesis or hemiplegia	23 no motor impairment 21 right-sided hemiplegia (i.e., paralysis) 28 right-sided hemiparesis (i.e., weakness) 2 left-hemisphere hemiparesis (i.e., weakness) 1 unknown
Aphasia etiology	73 stroke, 2 other or unknown
Types of aphasia	27 Anomic 19 Broca's 18 Conduction 0 Global 0 Mixed Transcortical 3 Transcortical Motor 1 Transcortical Sensory 2 Wernicke's 5 Not Aphasic by WAB (i.e., scoring >93.8 on WAB)

WAB AQ = Western Aphasia Battery Aphasia Quotient
SLP = speech-language pathology
*=as measured by Western Aphasia Battery Revised Aphasia Quotient, where 100 = no aphasia

Table 3: NBD group demographics (N=35).

Demographics	M(SD) or Frequency
Age	64.15 (7.21)
Education	14.97 (1.67)
Race	35 White
Ethnicity	0 Hispanic or Latino
Sex	20 females
Handedness (pre-morbid)	33 right-handed 1 left-handed 1 ambidextrous
Language Status	4 unknown 1 multilingual 1 late bilingual (English plus 2^{nd} language after 6 years old) 29 monolingual

WAB AQ = Western Aphasia Battery Aphasia Quotient
SLP = speech-language pathology

Table 4: Descriptive statistics of iconic gesture usage in NBD group only (N=35), divided by task.

Gesture	Window Task	Sandwich Task
N using at least 1 gesture	2.9%	45.7%
Task duration (secs)	34.80 (13.72, range 14-84)	36.34 (23.10, range 8-137)
Total tokens	81.83 (27.95, range 36-167)	98.17 (63.09, range 25-359)
Total utterances	8.66 (2.65, range 3-18)	10.60 (5.73, range 3-34)
Gesture frequency, all iconics	.03 (.17, range 0-1)	1.03 (1.56, range 0-5)
Referential	0 (no gestures)	.26 (.51, range 0-2)
Viewpoint	.03 (.17, range 0-1)	.77 (1.22, range 0-4)
Gesture rate per min, all iconics	.03 (.18, range 0-1.09)	1.84 (2.87, range 0-10.71)
Referential	0 (no gestures)	.44 (.87, range 0-3.16)
Viewpoint	.03 (.18, range 0-1.09)	1.40 (2.23, range 0-8.57)
Gesture rate per utterance, all iconics	.002 (.01, range 0-.07)	.11 (.18, range 0-.83)
Referential	0 (no gestures)	.03 (.05, range 0-.17)
Viewpoint	.002 (.01 range 0-.07)	.08 (.14, range 0-.67)

Table 5: Descriptive statistics of iconic gesture usage in aphasia group only, divided by task.

Gesture	Window Task	Sandwich Task
N using at least 1 gesture	43 (57.3%)	76 (100%)
Task duration (secs)	54.51 (37.33, range 10-228)	44.96 (29.00, range 5-140)
Total tokens	49.20 (33.14, range 5-147)	40.23 (26.82, range 4-131)
Total utterances	8.81 (4.71, range 2-27)	7.56 (4.25, range 2-19)
Filled hesitations	9.39 (10.74, range 0-61)	9.59 (10.42, range 0-77)
Unfilled hesitations	2.35 (3.59, range 0-18)	1.57 (2.18, range 0-11)
Lexical errors	.56 (1.11, range 0-6)	.20 (.49, range 0-2)
Non-lexical errors	.52 (1.00, range 0-5)	1.01 (1.56, range 0-8)
Gesture frequency, all iconics	1.84 (2.59, range 0-11)	7.11 (4.39, range 1-34)
Referential	.68 (1.19, range 0-6)	3.01 (2.53, range 0-15)
Viewpoint	1.16 (1.76, range 0-7)	4.09 (2.74, range 0-19)
Gesture rate per min, all iconics	2.14 (2.83, range 0-11.25)	11.49 (6.25, range 2.73-35)
Referential	.69 (1.20, range 0-6.67)	4.96 (4.56, range 0-25)
Viewpoint	1.45 (2.27, range 0-11.25)	6.53 (3.98, range 0-24)
Gesture rate per utterance, all iconics	.20 (.27, range 0-1.20)	1.04 (.51, range .29-3.33)
Referential	.07 (.11, range 0-.55)	.44 (.36, range 0-1.67)
Viewpoint	.13 (.21, range 0-1.20)	.60 (.35, range 0-1.73)

Table 6: Descriptive statistics of iconic gesture usage in aphasia group by aphasia classification, divided by task.

	Nonfluent (N=22)	Fluent (N=48)
Aphasia severity (WAB AQ)*	60.58 (9.12)	77.39 (11.75)
Education	14.73 (2.60)	15.59 (2.45)
Gender	6 females	25 females
Age	60.56 (9.09)	60.80 (12.08)
Aphasia duration	7.39 (6.19)	4.03 (2.81)
Years of speech-language therapy	4.55 (2.59)	2.79 (2.27)
Aphasia types	19 Broca's 3 Transcortical motor	27 Anomic 18 Conduction 1 Transcortical sensory 2 Wernicke's

*=as measured by Western Aphasia Battery Revised Aphasia Quotient, where 100 = no aphasia.

Table 7: Descriptive statistics of iconic gesture usage in aphasia group by aphasia classification (nonfluent, N=22; fluent, N=45), divided by task.

Gesture	Window Task		Sandwich Task	
	Nonfluent	Fluent	Nonfluent	Fluent
N using at least 1 gesture	54.5%	62.5%	100%	100%
Task duration (secs)	54.00 (48.18)	57.15 (32.81)	48.68 (38.85)	44.85 (24.67)
Total tokens	25.32 (13.74)	59.00 (35.01)	26.91 (18.35)	44.29 (27.67)
Total utterances	7.96 (4.48)	9.35 (4.94)	7.68 (4.63)	7.48 (4.11)
Filled hesitations	12.32 (16.15)	8.25 (7.33)	8.45 (7.03)	10.33 (11.91)
Unfilled hesitations	2.64 (3.42)	2.38 (3.82)	1.55 (1.92)	1.73 (2.37)
Lexical errors	.41 (.80)	.58 (1.09)	0 (0)	.31 (.59)
Non-lexical errors	.77 (1.38)	.42 (.79)	1.18 (1.89)	1.04 (1.46)
Gesture frequency, all iconics	2.36 (3.22)	1.75 (2.36)	7.05 (6.99)	7.04 (2.82)
Referential	.91 (1.66)	.60 (.94)	2.82 (3.49)	3.00 (2.02)
Viewpoint	1.46 (2.13)	1.15 (1.62)	4.23 (4.09)	4.04 (2.00)
Gesture rate per min, all iconics	2.95 (3.69)	1.95 (2.41)	10.13 (5.76)	11.57 (6.44)
Referential	.94 (1.73)	.61 (.90)	3.56 (2.52)	5.20 (4.98)
Viewpoint	2.01 (3.02)	1.35 (1.91)	6.57 (5.59)	6.37 (3.21)
Gesture rate per utterance, all iconics	.28 (.37)	.18 (.22)	.91 (.57)	1.08 (.49)
Referential	.10 (.17)	.06 (.08)	.35 (.30)	.46 (.36)
Viewpoint	.18 (.30)	.12 (.17)	.57 (.43)	.62 (.33)

Learning Outcomes

1. The reader will synthesize major hypotheses related to gesture usage in aphasia and how they relate to performance on specific discourse tasks.
2. The reader will understand the difference between iconic gesturing and other language-like gestures, and the relationship between iconic gestures and spoken language.
3. The reader will identify that task-specific gesturing (in particular, iconic gesturing) occurs in both persons with and without aphasia.