Suggestions for improving the investigation of gesture in aphasia

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Conflicts of interest: None.

Abstract

Purpose: When we speak, we gesture, and indeed, persons with aphasia gesture more frequently. The reason(s) for this is still being investigated, spurring an increase in the number of studies of gesture in persons with aphasia. As the number of studies increases, so too does the need for a shared set of best practices for gesture research in aphasia. After briefly reviewing the importance and use of gesture in persons with aphasia, this viewpoint puts forth methodological and design considerations when evaluating gesture in persons with aphasia.

Methods & Results: We explore several different design and methodological considerations for gesture research specific to persons with aphasia, such as video angle specifications, data collection techniques, and analysis considerations. The goal of these suggestions is to develop transparent and reproducible methods for evaluating gesture in aphasia, to build a solid foundation for continued work in this area.

Conclusions: We have proposed that it is critical to evaluate multimodal communication in a methodologically robust way to facilitate increased knowledge about the relationship of gesture to spoken language, cognition, and to other aspects of living with aphasia and recovery from aphasia. We conclude by postulating future directions for gesture research in aphasia.

Keywords: gesture, aphasia, best practices, communication, multimodal

Introduction

Gesture has been the subject of psychological investigation for several decades. Here, when we use the term "gesture," we are referring to spontaneous hand movements that occur naturally in communication and are language-like (occurring with speech, or as a means of replacing speech). McNeill (1992) defines language-like gestures as comprising representative (i.e., iconic, deictic) and non-representative (i.e., beats) types. These gestures do not merely accompany speech, but rather, are an intrinsic component of language, found across all cultural and linguistic backgrounds (Kita, 2009). Gesture is integrally related to spoken language and uniquely reveals a speaker's knowledge, often communicating information beyond what is present in speech (Church & Goldin-Meadow, 1986; Goldin-Meadow & Alibali, 2013a). The benefits of gesture in neurotypical populations are numerous and well-documented for both speakers and listeners, facilitating communication and cognition (Kita, Alibali, & Chu, 2017). Some theoretical accounts of gesture production posit that speech and gesture share a common conceptual origin (McNeill, 1992) while others propose that speech and gesture form two separate, but parallel and highly integrated systems (de Ruiter, 2017). Aphasia researchers are uniquely positioned to test and elaborate on theories of the relationship between spoken language and gesture and explore whether the cognitive-linguistic functions of gesture that benefit neurotypical speakers might extend to aphasia to support language recovery.

In a recent review, Clough and Duff (2020) highlight the tremendous potential of examining gesture in neurogenic communication disorders but argue that such investigations have been limited and hampered by inconsistent methodological and design considerations, and reporting across disorders. Yet, when looking at studies focused on just persons with aphasia, a consistent finding is that persons with aphasia gesture more often and at a higher rate than neurotypical adults (de Beer, de Ruiter, Hielscher-Fastabend, & Hogrefe, 2019; Feyereisen, 1983; Sekine, Rose, Foster, Attard, & Lanyon, 2013). Therefore, gesture may be a particularly important communicative resource for individuals with aphasia: gestures have been shown to aid in clarification of a paraphasia or resolution of a word finding issue (Akhavan, Göksun, & Nozari, 2018; Kistner, Dipper, & Marshall, 2019; Lanyon & Rose, 2009) and to disambiguate, clarify, or add to speech (Dipper, Pritchard, Morgan, & Cocks, 2015; van Nispen, van de Sandt-Koenderman, Sekine, Krahmer, & Rose, 2017). A comprehensive review by Rose (2006) highlights the potential uses of gesture for facilitation of communication in persons with aphasia.

Given the critical role gesture plays in communication and cognition broadly, and the increased use of gesture by persons with aphasia to meet a range of communicative demands, continued research on gesture in persons with aphasia is needed. Furthermore, although many studies on gesture in persons with aphasia have been limited to characterizing gesture frequency and occasions of use, there are considerable opportunities to expand this line of work to advance basic and clinical science in aphasiology. Specifically, Clough and Duff (2020) propose that future work evaluating gesture in neurogenic communication disorders would benefit from (1) stronger theoretical grounding, and (2) use of more rigorous and quantitative empirical methods. The present article is a viewpoint -- that is, a scholarly based opinion on an issue of clinical relevance (gesture evaluation in aphasia). As such, we have chosen to focus this article on the methodological and design considerations that will improve future systematic research on (and clinical use of) gesture. For reading clarity, we have therefore divided the following viewpoint into an experimental methodology and an experimental design section, each of which briefly outlines relevant literature and knowledge gaps, and explores best practices that may alleviate these issues. We conclude by brainstorming future directions for gesture research in aphasia. Note that, due to the page limitations of this viewpoint, we have not exhaustively cited all gesture research in aphasia, but we have attempted to offer a diverse range of citations from various labs and study types.

Experimental Design

Experimental design refers to how participants are assigned to different groups, and how the variables of interest are conceptualized and collected. The bulk of gesture research in both neurotypical and aphasia populations has employed cross sectional designs. That is, data have been collected at a single time-point per individual. While cross sectional designs with large, representative sample sizes is useful in identifying group differences (e.g., difference in gesture frequency between neurotypical and aphasia populations), they cannot fully answer questions related to gesture's role in communication or relationship to language in aphasia across time. Although longitudinal studies of gesture, which follow a single participant over at least two time points, are more common in children (e.g., Capirci et al., 2005; Cattani et al., 2010; Mayberry & Nicoladis, 2000), longitudinal studies are few and far between in gesture-related aphasia research, and those that do exist typically comprise small sample sizes (Ahlsén, 1991; Béland & Ska, 1992; Braddock, 2007).

A best practice, and an area of future work, is to ensure that the chosen design matches the research question (e.g., a longitudinal design may fit better to understand gesture's role in recovery, whereas a cross sectional design may fit better to characterize a component of gesture). Dissertation work by Braddock (2007) suggests that the relationship between gesture and speech is dynamic in early recovery from stroke in N=6 persons with acute Broca's aphasia, highlighting large individual differences in gesture usage, and in the relationship of gesture with speech (e.g., facilitatory, supplementary, redundant), across recovery. This is not particularly surprising, given the vast heterogeneity of language severity and language impairment characteristics typically presented in persons with aphasia, and given heterogeneity in gesture usage in neurotypical populations (Chu, Meyer, Foulkes, & Kita, 2014). However, these data provide novel evidence regarding the recovery of both gesture and speech in aphasia, which could not be as sensitively detected using cross sectional designs. That is, longitudinal designs are a particularly compelling and sensitive means of evaluating the extent to which gesture preservation early in aphasia recovery (e.g., acute period) may predict recovery of language in later stages (e.g., chronic), which remains unexplored but is an important future direction for gesture work in aphasia. Further, longitudinal designs have promise for teasing apart individual differences in gesture usage and the relationship of gesture with speech and cognition (e.g., memory) in aphasia, as a function of spontaneous recovery, in response to intervention, or adaptive communication practices across partners and contexts. We propose that future gesture work employ a variety of designs (e.g., cross sectional, longitudinal) for a more complete view of gesture use and to address the range of open questions that exist regarding gesture in aphasia.

Experimental Methodology

Experimental methodology refers to the methods involved in variable manipulation and collection / observation. Gesture research has utilized a variety of methodologies based on the types of research questions (Holler, 2014). For example, research evaluating the role of gesture in neurotypical adults has focused, on the one hand, on experimentally controlled designs, such as the retelling of wordless cartoons (McNeill, 1992). On the other hand, much more has been gleaned about the social and pragmatic uses of gesture (in neurotypical adults) through less experimentally controlled conditions, such as conversation involving two parties (e.g., Holler & Wilkin, 2011; Jacobs & Garnham, 2007). In studies of gesture in aphasia, the methodology has been more limited and often observational (rather than experimental) in nature. Many studies evaluating gesture in aphasia have involved the observation of spontaneously co-occurring gestures during spoken discourse (e.g., Kong et al., 2017; Kong et al., 2015; Sekine & Rose, 2013) and during story retellings from wordless imagery (Pritchard, Dipper, Morgan, & Cocks, 2015). Gesture has also been evaluated, albeit usually as a secondary motivation, in some language and/or communication test batteries (Hogrefe, Goldenberg, & Ziegler, 2020), typically through the evaluation of gesture as it relates to praxis impairments that commonly are co-morbid with aphasia (Borod, Fitzpatrick, Helm-Estabrooks, & Goodglass, 1989; Kalenine, Buxbaum, & Coslett, 2010; Roby-Brami, Hermsdörfer, Roy, & Jacobs, 2012; Vanbellingen et al., 2010). Below, we put forth several key considerations for increasing experimental methodology rigor and transparency in gesture research in aphasia that we believe will enhance the reliability and replicability of the evidence base upon which future studies will be developed and clinical decisions will be made.

Data Collection

The Role of Task and Environment.

It is well known that gesture varies as a function of task (e.g., a retell of a wordless cartoon vs a story retelling that is autobiographical) and environment (e.g., with or without social structure), and the kinds of gestures used and the functions they fulfil are diverse (Holler, 2014). For example, a person may gesture often during spontaneous narratives that involve episodic details (Hilverman, Cook, & Duff, 2016: evidence from persons with amnesia), or during narratives with high use of spatial language (neurotypical evidence in Kita & Lausberg, 2008 and Rauscher, Krauss, & Chen, 1996;

evidence from aphasia shown in Pritchard et al., 2015). In comparing narrative discourse tasks, gesture production also varies as a function of the degree to which the task activates mental imagery: Feyereisen and Havard (1999) found that iconic gesture production was higher when describing motor imagery (e.g., explaining how to change a car tire) compared to visual imagery (e.g., describing a landscape or town) and lowest for abstract topics (e.g., giving political opinions) in neurotypical adults. Typically, however, studies in both neurotypical adults and in persons with aphasia employ a single task to evaluate gesture (e.g., procedural narrative), which makes more global comparisons about gesture usage or gesture's role difficult.

There are benefits to evaluating gesture across a variety of tasks for studying gesture in aphasia, in particular. Context is important for interpretation of gesture – that is, some gestures, like iconic gestures, are less easily interpretable when the speech signal is removed. Iconic gestures are also thought to be those that may facilitate lexical retrieval (Krauss et al., 2000). The idea that gesture facilitates lexical access in aphasia has been investigated experimentally (e.g., Rose et al., 2002). For example, in two case studies of persons with conduction aphasia (Cocks, Dipper, Middleton, & Morgan, 2011; Pritchard, Cocks, & Dipper, 2013), persons with conduction aphasia produced more iconic gestures than comparison participants during word-searching behaviors, and these gestures were most frequently shape outline gestures (produced relatively infrequently during fluent speech) that traced the outline of the intended target, suggesting that examining gesture alongside spoken discourse may facilitate identification of word searching and linguistic breakdown in the clinical assessment of aphasia. To study the extent to which gesture facilitates lexical access, researchers/clinicians need to know the target (intended message) of the person with aphasia. An autobiographical narrative, where the person with aphasia is describing something about their own life, may lack the common ground needed for researchers/clinicians to make viable judgments on the role of gesture on lexical access in the narrative, especially in the context of severe anomia or other language production impairments. On the other hand, if the person with aphasia is asked to describe an event with shared knowledge (e.g., Cinderella story), gesture's role on lexical access may be more easily ascertained, given that the verbal targets are most likely known by both (person with aphasia, researcher/clinician) in the conversation.

Alternatively, the researcher/clinician may be interested in comparing gesture's role across tasks for the person with aphasia. Gesture may play a greater role (e.g., is more heavily used), reflect a diversity of types (e.g., more iconic gestures in one, more deictic gestures in another), and have different functions (e.g., gesture used more often as redundant with speech during one task, and more supplementary to speech in another) depending on the task's cognitive and linguistic demands. For example, our group (Stark) has shown that persons with aphasia produce comparatively fewer iconic gestures during a picture sequence description task than a procedural task ("how to make a sandwich"), the latter of which is associated with more motor imagery (Stark & Cofoid, accepted). Contrasting gesture across task is a beneficial way to appreciate the individual differences in gesture as well as the changes in gesture due to task demand. Given that everyday communication task demands shift dynamically, assessing gesture across tasks in such a way allows one to appreciate gesture use in aphasia more fully. Therefore, we suggest there is a need for studies that consider evaluating gesture across tasks within a participant.

Methods of Data Collection.

Another important consideration for gesture study is the protocol being adhered to, which includes the way data is collected and how data is analyzed. That is, as gesture has received considerably less focus in aphasiology, there has not been a concerted effort in developing best practices for data collection or analysis, with gesture in mind. For example, data repositories have become a useful resource for researchers through which multicenter contributions of spoken discourse data make 'big data' analyses possible (e.g., AphasiaBank; MacWhinney et al., 2011). These large databases have been especially instrumental in studying aphasia, where small sample sizes in this heterogeneous population can limit generalizability and reduce statistical power. However, many of the videos collected during discourse elicitation in such repositories do not show the entire gesture space or do not provide an angle with which to clearly see gesture movement or handshape. The study of gesture in aphasia would benefit greatly from multi-center and multidisciplinary approaches, bridging expertise from fields such as speech language pathology, psychology, linguistics, and cognitive neuroscience. Therefore, as we pursue gesture analysis in aphasia, we urge consideration of best practices for gesture collection and analysis methods to facilitate such collaborations. We discuss these recommendations here.

First and foremost, the video space capturing the gesturing individual should encompass at least the entire gesturing space (i.e., from center-center to extreme periphery, ensuring that all gestures involving the upper limbs are able to be seen (McNeill, 1992) and be a straight-on shot. An ideal view would be a straight view of the entire body (Fig 1). Further, every effort should be made to remove anything in the gesturing space that may discourage gesturing, like a table, surface, or even a chair with arms (i.e., gives the ability to rest the hands on a surface; may make gesture onset and offset harder to identify), as well as props or items (e.g., pens, pieces of paper, reading glasses, coffee cups). Stimuli being used to elicit discourse should be carefully considered in the study design as they may prompt different types of gesture production (e.g., pictures tend to elicit pointing 'deictic' gestures). As we move toward virtual and remote study design, the camera in or on the computer must be able to capture the whole gesture space of the person, whilst the experimenter must also take steps to have the participant remove things (e.g., table) from the gesturing space. This may make for a slightly clumsy interaction, as the participant may be asked to shift back from the computer, which then may entail speaking louder (on the part of the participant and experimenter) and having to move back and forth toward the computer if something needs to be adjusted on screen.

From the perspective that all interactions are co-constructed, even in clinical and research settings, the verbal and non-verbal behaviors produced by the experimenter shape the productions of the participant and vice versa (Duff, Mutlu, Byom, & Turkstra, 2012; Hengst & Duff, 2007). Our recommendations take into account that, minimally, the desire of the researcher or clinician is to see the person with aphasia's gesture production. We would also argue that, dependent on the research question, it may be critical to include a view of the experimenter (e.g., for studies on gesture comprehension and multiparty interactional designs). This certainly increases the logistical and equipment demands to be able to capture both the participant and experimenter from a straight-on perspective that includes the entire gesture space. In our own work (Duff lab), we have often used three cameras, one centered on each individual and a third that captures the dyad together. In our remote studies, we record the session in gallery view so both the experimenter and participant are captured. While such setups create challenges and require creativity, research methods that allow us to capture gesture in conversational and group settings will increase the ecological validity of our protocols and facilitate generalization to the everyday settings of conversation and social interaction. When planning for gesture capture, researchers working with persons with aphasia should plan for multiparty interactions, sound magnification, mobility limitations (e.g., hemiplegia, wheelchair use), and motor speech caveats (e.g., reduced loudness) when designing their acquisition protocols.

FIGURE 1 here

Experimenter-Participant Dynamics.

Confederates (persons involved in research but not the participants of research) are often used in two-way gesture experiments, e.g., as the "listener" during the retelling of a story by a participant. These types of two-way gesturing experiments are important, given that they attempt to mirror more natural, conversational environments. But, as Holler (2014) emphasizes, the experimenter often takes on the role of the confederate in gesture studies. In studies where a person with aphasia is taking part as the participant, it is often necessary for the confederate, or study personnel, to have experience facilitating communication with persons with aphasia because the experimenter may need to utilize supported communication techniques (Kagan, 1998). This means that the confederate and the experimenter are not only familiar with the experimental manipulations and hypotheses, and thus may engage in microbehaviors given their expectations of the experiment, they may also produce behaviors to facilitate communication in the person with aphasia, both of which can in turn influence the gesturer (Hengst & Duff, 2007). For example, Kistner, Marshall and colleagues (2019) showed that both persons with aphasia and neurotypical comparison participants produced significantly more gestures during narrative and procedural discourse tasks when talking to an unfamiliar compared to familiar communication partner. The influence of one individual's behavior on the other in social interactions (even in the context of an experiment) is typical and interesting in its own right (i.e., research on gesture alignment or synchrony). Our goal in drawing attention to this bidirectional influence on behavior is not to encourage researchers to try and eliminate it but rather to encourage transparent methodology detailing the level of involvement of study personnel and training in the experiment, and review of fidelity to experimental protocol to allow for full consideration of the dynamics between participant and study personnel that may shape gesture in the context of the study.

Data Coding and Psychometric Properties

Just as there are numerous choices and decisions to make before transcribing verbal productions, there are many options for coding gesture. Tasks used to elicit gesture can also vary in their psychometric properties, or the validity and reliability of a measurement tool. In this section, we will discuss considerations for data coding and psychometric properties, which may influence the reliability, validity, reproducibility, and replicability of gesture studies in persons with aphasia.

Types of Gesture Coding.

Analysis of spoken language typically involves producing written transcripts of the speech, but these transcripts rarely record gesture or other nonverbal behaviors. One option for improving representation of gesture in aphasia research is to incorporate annotations of gesture occurrences alongside speech transcripts. This can be done using hand coding, that is, denoting gesture occurrences in the orthographic (or phonetic) speech transcript (for example, see McNeill, 1992). Another option is leveraging tools that facilitate multimodal language coding, such as ELAN (https://archive.mpi.nl/tla/elan; Wittenburg, Brugman, Russel, Klassmann, & Sloetjes, 2006). ELAN is a freely available annotation software that allows frame-by-frame analysis of audio and visual information via manual time-locked annotations arranged in multiple layers called ‘tiers.’ For example, one tier may be used to record speech transcriptions, another may be used to identify gesture productions, while additional synchronized tiers may record annotations for qualitative aspects such as gesture type, height, size, handedness, etc. McNeill (1992) describes gesture production as triphasic, consisting of a preparation (lifting of the hands), stroke (expressive part of the gesture), and retraction (return to resting position), all of which can be captured in ELAN. Further, annotations are time-locked with speech, providing a reproducible record of gestural data, and enabling the researcher to evaluate temporal and informational relationships of gesture with speech. Frame-by-frame analysis in ELAN can accurately record gesture duration by tracking gesture onset and offset at the moment where the hands start (or stop) to blur. However, in some cases, successive gestures may not have clear boundaries. In these cases, researchers can separate hand movements into unique gestures when there is a new preparation phase, a change in hand form, or a noticeable break in movement (Humphries, Holler, Crawford, & Poliakoff, 2020).

This type of coding system can be used to derive quantitative variables of gesture rate, such as gestures per 100 words, gestures per minute, or gesture frequency per other time or content unit. Once identified, gestures can be further characterized to examine the type and functions of the gestures produced. There are several types of gesture, including iconic gestures, which meaningfully relate to speech and visually depict the size, shape, position, or motoric properties and affordances of objects, as well as beat (rhythmic) gestures, referential gestures, deictic (pointing) gestures, and metaphoric (abstract) gestures (McNeill, 1992). Using a robust gesture type coding system (see NEUROGES-ELAN for an example; Lausberg & Sloetjes, 2009) is particularly important in aphasia, where persons with aphasia have been shown to produce a larger variety of gesture types than neurotypical participants (Sekine & Rose, 2013). Coding gestures for the function they serve (e.g., supplementing speech, replacing speech, facilitating lexical retrieval) also yields insights into the communicative role of gesture in aphasia. For example, persons with aphasia tend to communicate more information in gesture that is nonredundant with speech than neurotypical speakers (van Nispen et al., 2017). Gesture coding systems can also be used to detail less explored features of gesture in aphasia, for example, transcribing gestures using form-based sign language notation to characterize hand shape, direction, palm orientation, location to body, movement, and repetition (Hogrefe, Ziegler, Weidinger, & Goldenberg, 2012) or by gesture viewpoint (e.g., actor vs. observer perspective), gesture space, manner, path, and relationship of gesture with speech (Özer, Göksun, & Chatterjee, 2019). The type of coding system used will depend on the research questions and can provide insights into what type of gesture is used, how often, and for what purpose in aphasia.

Gesture coding has largely been categorical, meaning that gesture types (i.e., iconic, concrete deictic) and other gesture features have been coded in a frequentist fashion. However, one can also engage in continuous gesture coding (Hilliard & Cook, 2016; Pouw & Dixon, 2020), coding the speed and trajectory of a given gesture. Continuous coding such as this additionally answers research questions like how quickly gestures were made and transitioned between, which may then reflect on the efficiency and quickness of underlying cognitive processes. Categorical and continuous coding are both meaningful – indeed, they answer different research questions. To the best of our knowledge, only categorical coding has been used to evaluate gesture in aphasia. Pursuing both categorical and continuous coding in persons with aphasia will be important for understanding the efficiency and, indeed, learning of cognitive and linguistic concepts. For example, one group has suggested that quantifying gesture via continuous measures may be a reflection of 'cognitive fluency' (Congdon, Novack, & Goldin-Meadow, 2018). If gestures reflect some underlying conceptual knowledge (Goldin-Meadow & Alibali, 2013), then coding in a continuous style may be critical for understanding the efficiency of accessing this conceptual knowledge. Continuous coding, in addition to categorical coding, may therefore be a critical way to evaluate recovery processes in aphasia. Efficiency of access can be an important means of measuring cognitive and linguistic recovery in disorders like aphasia, which typically recover spontaneously at a rapid rate after injury (e.g., in the first three months of a stroke), after which the recovery progress slows considerably. Notably, though, recovery from aphasia has been demonstrated to occur for many years post-injury, and we posit that engaging in continuous coding of gesturing, alongside categorical coding, may be a sensitive means of evaluating not only what conceptual knowledge is being learned or is preserved, but also how quickly concepts are accessed. Caveats here are manual processes that may inhibit a change in gesture speed (e.g., hemiparesis, limb apraxia), but these can be taken into consideration as covariates.

Gesture coding is time consuming; to combat this, recent tools, like SPUDNIG (SPeeding Up the Detection of Non-iconic and Iconic Gestures), aim to automatize the detection and annotation of hand movements in video data (Ripperda, Drijvers, & Holler, 2020). Automatic tools such as this one do not entirely eliminate the human coder, but instead, may make the process more efficient (Beugher, Brône, & Goedemé, 2018; Ripperda et al., 2020). Regardless of the tool employed, identification of gesture type is difficult in aphasia because of the relationship of some gesture types with speech. For example, iconic gestures are often meaningless in the absence of speech (Hadar & Butterwork, 1997) and it may therefore be difficult to determine whether something is a gesture or not without the speech component. A non-gesture may be fidgeting or self-grooming. However, if in retelling the story of Cinderella, a person twists their hair to emphasize Cinderella's own hair, the identification of that as a gesture and not as a form of self-grooming comes down to gesture's relationship with speech. In aphasia, gestures may have an unclear relationship with speech because speech is empty, full of jargon, paragrammatic/agrammatic, and/or paraphasic. Thus, while there are certain challenges in gesture coding in aphasia, thoughtful attention to coding decisions and systematic and detailed gesture coding, as discussed here, will improve accuracy and decision making around these various challenges. We next discuss other issues that will improve the methodological rigor in this area.

Reliability and Training of Coding.

A particularly important consideration for methodology is the training of the coders. Typically, a single rater will code all gestures, with another rater coding a percentage of gestures. Evaluating the two raters by use of inter-rater reliability statistics can demonstrate the reliability of the two raters for the percentage of participants scored by both raters. However, rater agreement is not always provided in gesture studies. Ideally, as a single rater typically scores all gestures, both intra- and inter-rater reliability statistics should be provided (as Sekine & Rose, 2013, have done). In addition to rater reliability, enough detail must be provided about the coding parameters and the training of raters such that a study wishing to replicate the methodology can do so. That involves describing each type of gesture being coded, giving examples of coded gestures, and giving details regarding training of raters (e.g., was rater reliability first conducted on an outside sample, and then raters moved to the sample of interest?). Open sharing of coding protocol as an Appendix is highly encouraged.

Replicability.

To replicate a study, detail must be provided in the methodology section, which is discussed throughout this paper. In addition, facilitatory data sharing – open source data, public data availability – has led to an increase in attempts to replicate studies. However, sharing of gesture data is difficult, given that video (and typically, audio) is the basis for the data. This poses a threat to patient health information confidentiality. AphasiaBank (MacWhinney, Forbes, & Holland, 2011) has pioneered a means of sharing audiovisual data amongst researchers and clinicians interested in aphasia and other disorders under the TalkBank umbrella (e.g., TBIBank, DementiaBank), by including a clause in their institutional review board (IRB) that allows the sharing of data via a password-protected database. Future work focusing on gesture in aphasia would be apt to include such a clause in their IRB to facilitate replication in this otherwise understudied area. Indeed, we would encourage taking advantage of the TalkBank infrastructure, which allows for submission of audiovisual data and ELAN annotation files from personal studies (not necessarily following TalkBank discourse protocol; although note that we also recommend that new submissions modify camera angles to capture the full gesture space). Prior IRBs are freely available on their site (aphasia.talkbank.org). Users can simply submit their data to AphasiaBank for protected archiving, growing the publicly shared data relevant for understanding language and communication in persons with aphasia. Further, this type of archiving may promote transdisciplinary research (e.g., across lingustics, cognitive neuroscience, communication sciences and disorders) and collaborations.

Future Work in Aphasia

Neural Correlates of Gesture

An informative future direction related to experimental methodology of gesture is the investigation of the neural correlates of gesture through the lens of aphasia. The cognitive neuroscience of gesture, and its relationship with spoken language, has been examined in neurotypical adults (for a review, see Willems & Hagoort, 2007), but the research evaluating neural correlates of gesture production in left hemisphere brain damage has been dedicated to the production of isolated gestures to command (e.g., pantomiming), with a growing number exploring the neural correlates of gesture production during more naturalistic experiments, e.g., retelling of a videotaped story using gesture (Göksun, Lehet, Malykhina, & Chatterjee, 2013, 2015; Hogrefe, Ziegler, Weidinger, & Goldenberg, 2017) or conversation (Preisig et al., 2018). Evaluating the cognitive neuroscience of spontaneous gesture in persons with aphasia will be particularly meaningful. Given that persons with aphasia spontaneously produce gestures, on average, more frequently and with different function (e.g., supplementary) than persons without aphasia, evaluating preserved, alongside affected, brain areas can identify necessary and compensatory brain areas / networks supporting gesture. In this vein, lesion analyses have been critical for establishing our understanding of the language system (e.g., Fridriksson et al., 2016). Lesion analyses are one tool, but there are others, such as modelling how permanent (e.g., lesion) or temporary (e.g., transcranial magnetic current stimulation) disruption to structural networks (Gleichgerrcht et al., 2017) and functional networks (Siegel et al., 2018) associates with an impairment. A fruitful way forward for neuroscience of gesture in aphasia is evaluating neural data through the lens of theoretically-motivated research questions. For example, research has demonstrated specialized areas, and networks, for tool gesturing (pantomime), which broadly characterize a left hemisphere temporoparietal network (Buxbaum et al., 2014). Given that language also partially relies on this network (Hickok & Poeppel, 2004), it is worth evaluating the extent to which gesture and language share a common interface. For example, the Growth Point theory proposed by McNeill (1992) suggests that gesture and language share a common cognitive substrate (pre-linguistic concept access) prior to gesture and language diverging into parallel channels. Based on this theory, one could similarly ask if gesture and language share a common *neural* substrate that, when damaged, affects both gesture and language. Given aphasia's unique presentation of behavioral symptoms coupled with heterogeneous brain damage, the field can answer a plethora of interesting, and clinically relevant, research questions. Doing so will improve our ability to make informed hypotheses about the relationship of gesture and spoken language (e.g., shared neural substrates, shared time-courses) and, as an extension of this, improve our understanding of the role of gesture in language recovery.

Role of Gesture in Other Aspects of Cognition and Learning

Meta-analyses have concluded that both producing and observing gesture improves comprehension of and memory for communicated information in neurotypical populations (Dargue, Sweller, & Jones, 2019; Hostetter, 2011). While this viewpoint has focused largely on analyzing gesture *production* in persons with aphasia, it is also critical to consider how *observing* gesture might affect comprehension in this population. Using eye-tracking paradigms, Eggenberger and colleagues (2016) found that observing congruent gestures with short verbal phrases improved message comprehension in persons with aphasia compared to a baseline meaningless gesture condition, while observing incongruent gestures significantly decreased comprehension accuracy, and Preisig and colleagues (2018) found that persons with aphasia were more likely to fixate on gestures produced by their interlocutors than neurotypical participants. However, evidence for a benefit of observing gesture by persons with aphasia is mixed: Cocks and colleagues (2018) found that persons with aphasia were, on average, significantly worse at integrating information from gesture at the single word-level than neurotypical comparison participants, relying more on the verbal channel and suggesting that persons with aphasia may receive limited benefits from gesture observation due to a difficulty allocating attentional resources or reduced resource capacity. Indeed, even research in neurotypical populations has identified that individual differences in visual-spatial and verbal abilities moderate the benefit of gesture for language comprehension (Özer & Göksun, 2020). Further, individual differences in verbal working memory predict rate of gesture production, where neurotypical adults with lower working memory tend to gesture more often (Gillespie, James, Federmeier, & Watson, 2014). A body of work in neurotypical children and adults suggests that producing gesture reduces the cognitive load by freeing up verbal working memory space (Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001), and that neurotypical speakers gesture more when a task is cognitively or linguistically complex (Kita & Davies, 2009; Melinger & Kita, 2007). Thus, continued work is needed to identify whether spatial and verbal working memory capacity in persons with aphasia affects gesture comprehension or production and their ability to use gesture to improve cognitive processing and learning outcomes.

As successful (re)learning is a critical component in communication rehabilitation, whether gesture improves learning in aphasia is an important open question. The benefits of gesture on memory are well documented and extend even to people with severe hippocampal amnesia (Hilverman, Cook, & Duff, 2018). However, in a study of 14 people with chronic mild aphasia, gesture production facilitated novel word learning only for those with phonological and working memory impairments and actually reduced performance for those with semantic impairments (Kroenke, Kraft, Regenbrecht, & Obrig, 2013). Thus, the extent to which persons with aphasia benefit from gesture may depend both on careful selection of functional stimuli and task demands, as well as patterns of preserved cognitive and language abilities. Given the heterogeneous cognitive and linguistic profiles of persons with aphasia, providing detailed participant information is an important additional consideration for understanding for whom gesture production and observation is most beneficial and integrating results across studies.

Conclusions and Future Directions

Whilst it is always important to recognize that differences in results may be rooted in differences between experimental designs or methods, transparent and thorough reporting will aid in reliability, validity, reproducibility, and replicability of future gesture research in aphasia. Here, we give the reader suggestions to enhance reproducibility and quality of gesture research in aphasia, as well as postulate future research directions. Gesture is an important multimodal aspect of communication for persons with aphasia, and continued, and improved, research in this area will provide valuable information that promises to advance the assessment and treatment of persons with aphasia.

Acknowledgments

This work was supported by NIDCD grant R01 DC017926 awarded to MD.

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Tables & Figures

Figure 1: Capturing gesturing on video. Green (top row, center) is an ideal gesture capture, demonstrating a straight on view of the entire body, with no artificial place for hands to rest. Note that this gesture view may not always be the most appropriate. For example, if you want to capture something in front of the speaker (perhaps they are describing a picture in front of them), you may want to capture the picture to be able to ascertain gesture targets Yellow (top row) indicates good gesture capturing; whilst some data is lost (e.g., legs), most of the gesture area of the upper limbs is visible, there is no place to rest hands (e.g., chair arms, table), and the angle is straight on. Red (bottom row) indicates non-optimal gesture capturing, either because of poor angles (left, right) or incomplete gesture space, which may or may not also have a place to rest hands (e.g., table) (center). *Images are royalty-free stock from Microsoft 365.*