

Review Article

Inner Speech in Aphasia: Current Evidence, Clinical Implications, and Future Directions

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Purpose: Typical language users can engage in a lively internal monologue for introspection and task performance, but what is the nature of inner speech among individuals with aphasia? Studying the phenomenon of inner speech in this population has the potential to further our understanding of inner speech more generally, help clarify the subjective experience of those with aphasia, and inform clinical practice. In this scoping review, we describe and synthesize the existing literature on inner speech in aphasia.

Method: Studies examining inner speech in aphasia were located through electronic databases and citation searches. Across the various studies, methods include both subjective approaches (i.e., asking individuals with aphasia about the integrity of their inner speech) and objective approaches (i.e., administering objective language tests as proxy measures for inner speech ability). The findings of relevant studies are summarized.

Results: Although definitions of inner speech vary across research groups, studies using both subjective and objective

methods have established findings showing that inner speech can be preserved relative to spoken language in individuals with aphasia, particularly among those with relatively intact word retrieval and difficulty primarily at the level of speech output processing. Approaches that combine self-report with objective measures have demonstrated that individuals with aphasia are, on the whole, reliably able to report the integrity of their inner speech.

Conclusions: The examination of inner speech in individuals with aphasia has potential implications for clinical practice, in that differences in the preservation of inner speech across individuals may help guide clinical decision making around aphasia treatment. Although there are many questions that remain open to further investigation, studying inner speech in this specific population has also contributed to a broader understanding of the mechanisms of inner speech more generally.

At least one third of individuals who experience a stroke will develop *aphasia*, a language disorder that affects a person's ability to communicate and has long-term effects on quality of life (Berthier, 2005; Engelter et al., 2006; Hilari et al., 2010). There is considerable variability across individuals in terms of the specific language deficits associated with aphasia, but a common

thread among all individuals with the disorder is anomia or a difficulty with naming and word finding (Goodglass & Wingfield, 1997; Kohn & Goodglass, 1985; Laine & Martin, 2006; Maher & Raymer, 2004). While it is clear that individuals with aphasia can struggle with conveying their ideas through overt speech, much less is known about this population's ability to utilize *inner speech* (IS), a mental phenomenon that is well known to and has been widely studied in healthy language users.

Although there are multiple ways to define IS (see Definitions of IS section), the most basic definition refers to the mental imagery of having a little voice in one's head (Sokolov, 1972). Interestingly, individuals with aphasia commonly report that they are able to say words in their head that they cannot successfully say aloud; in one interview-based study, over 75% of participants with aphasia endorsed this experience in the context of daily communication (Fama, Hayward, Snider, Friedman, & Turkeltaub, 2017). These self-reports can be interpreted as a reflection

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Editor-in-Chief: Margaret Blake

Editor: Sarah Wallace

Received September 13, 2018

Revision received January 29, 2019

Accepted May 1, 2019

https://doi.org/10.1044/2019_AJSLP-CAC48-18-0212

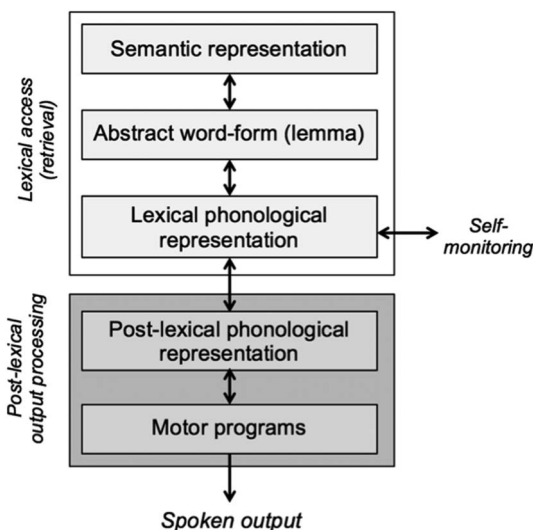
Publisher Note: This article is part of the Special Issue: Select Papers From the 48th Clinical Aphasiology Conference.

Disclosure: The authors have declared that no competing interests existed at the time of publication.

that the individual has perceived their IS to be successful, despite a failure of overt speech. To understand the mental processes underlying this phenomenon, in our own work, we have situated IS in the context of processing models of spoken naming that help to account for (a) how IS can be monitored prior to overt speech and (b) how overt speech could fail after successful IS. Processing models consistently describe *naming* as a multistep process, typically involving the following stages: retrieval of lexical semantics, retrieval of lexical phonology, and output processes for turning the phonological form into motor programs for articulation (Dell & O’Seaghdha, 1992; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Goldrick & Rapp, 2007; Levelt, Roelofs, & Meyer, 1999; Walker & Hickok, 2016). In the context of such processing models, we have hypothesized that the subjective experience of successful IS reflects successful processing through the level of phonological retrieval and that output processes (e.g., generating fully specified, postlexical phonological representations and translating phonology into articulatory motor plans) are not essential to an experience of IS (see Figure 1).

Several research groups have investigated the topic of IS in aphasia, but the disparate methodologies used make it difficult to compare and synthesize findings across studies. The purpose of this scoping review (Arksey & O’Malley, 2005) is to summarize the current state of knowledge with respect to IS in individuals with aphasia. We aim to provide researchers and clinicians with a better understanding of the phenomenon of IS in aphasia, which in turn has the potential to contribute to the field in several ways, including to help with clinical diagnosis and

Figure 1. A model of naming. This model includes the most consistent aspects of various processing models of naming that have been published over the past several decades. The arrow indicating “self-monitoring” is the level at which inner speech arises and becomes available to conscious monitoring by the speaker (figure from Fama, 2018).



selection of appropriate treatment approaches, to offer increased insight into the personal experience of having aphasia, and to provide information about the nature of IS more broadly. Although the formal methodology of the scoping review was limited to the topic of IS in aphasia, we provide a general context for these studies by beginning with a brief overview of the broader IS literature, including various definitions of IS, prior to turning to our specific population of interest. After describing findings from all previous studies of IS in aphasia, we discuss clinical implications, open questions, and future directions for this area of research.

IS in Healthy Language Users

The relationship between thought and language has been a topic of philosophical inquiry since the ancient Greek concept of *logos*, representing a unity of thought and word. The specific phenomenon of IS is familiar to most language users and has been studied scientifically since at least the late 19th century (see Sokolov, 1972, for a review). Early theorists suggested that IS serves as the basis of thinking and that IS requires the same articulatory movements required for overt speech, albeit to a lesser degree (Watson, 1913). This strong position regarding the role of articulation in IS was later dispelled by a case study in which temporary total paralysis, induced by curare in a healthy adult, did not affect the participant’s “consciousness, memory, or sensorium” (Smith, Brown, Toman, & Goodman, 1947, p. 11), but an ongoing debate remains as to the extent to which articulation may be activated during IS.

Over the past century, the phenomenon of IS has often been studied in the context of other mental processes. There is a significant literature on the role of IS in various aspects of cognition, including prominent work on the role of IS in working memory (Baddeley & Hitch, 1974) and language learning (Vygotsky, 1962). Since then, IS has been associated with a wide range of other mental tasks, including logical reasoning, reading, and executive functioning abilities such as planning, decision making, and task switching, among many others (for recent reviews, see Perrone-Bertolotti, Rapin, Lachaux, Baciú, & Løvenbrück, 2014; Alderson-Day & Fernyhough, 2015). In this section, we present several approaches to defining and studying IS and a summary of findings regarding the neural bases of the phenomenon.

Definitions of IS

Importantly, there are at least two ways to define IS. The first is characterized as the ability to generate language silently in one’s head or, in other words, to develop “an auditory–articulatory image of speech without uttering a sound” (Levine, Calvanio, & Popovics, 1982). This definition aligns with the subjective experience of generating internal language, that is, of talking to oneself in one’s head. It emphasizes the viewpoint of the person who is experiencing IS and possibly using IS in the service of a greater purpose, such as verbal rehearsal, self-reflection, or executive functions such as planning or decision making.

The second approach to defining IS focuses on the more observable aspects of IS: “the objectively measurable ability to appreciate the auditory–articulatory structure of speech irrespective of its meaning. The subject may be asked, for example, to divide a word into syllables, to synthesize a word from a sequence of syllables, or to detect homonyms or rhymes” (Levine et al., 1982). This definition refers not only to the ability to produce language silently in one’s head but also to the ability to perform some computation or manipulation of that mental imagery. As described in the quote above, investigators focused on this more objective approach are often interested in demonstrable behaviors (e.g., syllable counting, rhyme judgment) that can be performed based on internal language. These tasks are not necessarily “language specific” in that they may rely on other cognitive processes such as working memory and decision making.

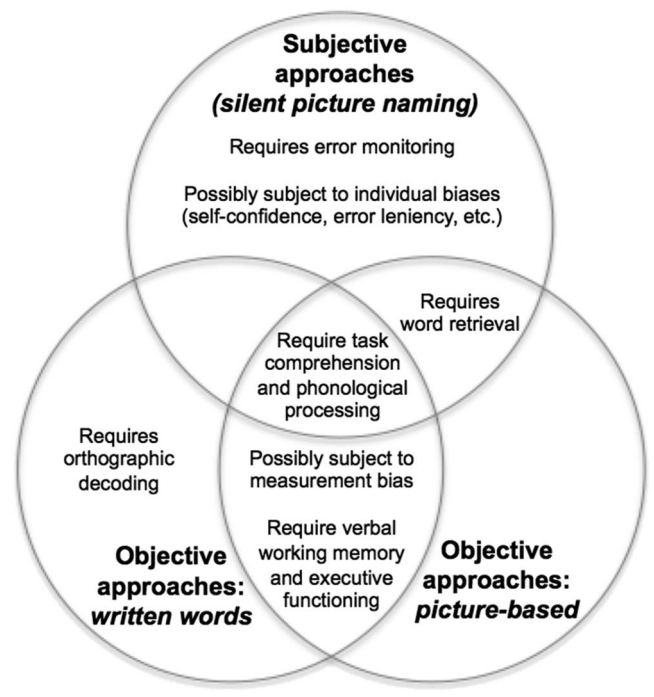
Approaches to the Study of IS

In healthy language users, IS has been scientifically examined in the context of both definitions. First, to facilitate understanding of the experience of IS as verbal thinking or self-directed internal language, researchers have designed questionnaires to elicit self-reports about IS in healthy adults (Hurlburt, Alderson-Day, Kühn, & Fernyhough, 2016; Morin, Uttl, & Hamper, 2011). These studies have contributed subjective evidence to our knowledge of the wide variety of purposes for which IS is used, with one study finding the most commonly reported purpose of IS to be self-referential thought, that is, thinking silently about any aspect of the self (Morin et al., 2011). Another subjective approach to the study of IS is to examine errors in silent recitation of tongue twisters. Early comparisons of self-reported errors in inner and overt speech illustrated that errors in IS often parallel overt slips of the tongue (Dell & Repka, 1992; Postma & Noordanus, 1996).

In studies taking a more objective approach, the properties of IS are investigated through performance on measurable tests. In studies of healthy language users and a variety of disordered populations, rhyme and homophone judgments have been frequently utilized as a proxy measure for IS (Geva & Warburton, 2018; Gustafson, Bess, & Lancaster, 2017; Perrone-Bertolotti et al., 2014). One caveat to note is that the objective tests used to measure IS in these studies are proxy measures that provide only an approximation of IS (when IS is defined as generating accurate silent, internal language). For instance, one may need to use IS to perform a rhyme judgment, but successful performance relies on other processes, such as working memory and executive functioning. In addition, accurate performance on a proxy task such as rhyme judgment can be attained without fully intact IS (e.g., one need not know the initial sounds of two target words in order to judge whether they rhyme or not; see the Objective Versus Subjective Approaches to the Study of IS in Aphasia section and Figure 2 for more discussion of these issues).

More recently, Oppenheim and Dell (2008) combined subjective and objective approaches in an investigation of two specific effects seen in overt speech errors: lexical bias,

Figure 2. Methods of studying inner speech in aphasia. This figure is a conceptual representation of the mental processes required for the various approaches and the potential biases inherent to each approach. Objective approaches involve asking participants to make phonological judgments (e.g., rhymes, homophones) on either written words (left) or pictures (right). Subjective approaches involve asking participants to provide self-reports of success during a silent picture-naming task. Interview-based methods are not directly represented in the diagram but are subject to the same potential biases as other subjective approaches.



where the error is likely to be a real word, and phonemic similarity effect, where closely related phonemes (e.g., /d/ and /t/) are more likely to be substituted for one another than phonemically distant sounds (e.g., /d/ and /m/; Oppenheim & Dell, 2008). Healthy young adults performed silent repetition of four-word tongue twister phrases and provided self-report of imagined errors. Results showed that IS exhibits lexical bias but not a phonemic similarity effect, indicating that IS is not fully specified (Oppenheim & Dell, 2008). Such a finding is at odds with early models claiming fully specified articulatory plans within IS (Levelt, 1983; Postma & Noordanus, 1996) and instead suggests IS is based on a pre-articulatory representation, such as lexical phonology, which newer models suggest is impoverished relative to postlexical phonology (Goldrick & Rapp, 2007; Indefrey & Levelt, 2004). Later, the same authors showed that IS can evoke articulatory processing under certain circumstances, asserting that the level of specificity within IS is flexible (Oppenheim & Dell, 2010).

Neural Correlates of IS

There is some evidence regarding the brain structures and networks that underlie IS in healthy individuals. An

early positron emission tomography (PET) study ($N = 6$) showed activation in the left inferior frontal gyrus (IFG) when healthy participants were asked to recite sentences silently in their minds, “without speaking or making subvocal articulatory movements” (McGuire et al., 1996). Other neuroimaging findings in healthy speakers use tasks such as covert rhyme judgments as a proxy for IS, in order to focus on the more objective definition of IS as the ability to perform a computation on internal language. Such studies that use functional MRI show activation of language regions, including supramarginal gyrus, in addition to the left IFG during silent rhyme judgment (Hoefl et al., 2007; Lurito, Kareken, Lowe, Chen, & Mathews, 2000). These suggest that IS utilizes neural substrates that overlap with those underlying overt speech. In studies that directly compare covert to overt speech to test this question, however, results typically indicate a greater response in sensorimotor and premotor regions during overt speech (Owen, Borowsky, & Sarty, 2004; Shuster & Lemieux, 2005).

Method

We conducted a scoping review of prior literature on the topic of IS in individuals with aphasia. Scoping reviews are relatively new and can take many forms, but their primary purpose is to map the existing literature, clarify working definitions, identify gaps, and recommend future directions (Peters et al., 2015; Pham et al., 2014). A scoping review is appropriate for the topic of IS in aphasia because the existing literature is limited and various researchers use heterogeneous methods to study IS in this population. Our primary research questions were as follows:

- Is there evidence of preserved IS among individuals with aphasia?
- What is the nature of IS among individuals with aphasia?

Although there is no singular, agreed-upon methodology for a scoping review, our approach aligns with existing guidelines (Arksey & O'Malley, 2005; Peters et al., 2015). After establishing our research questions, we identified studies for review by searching the database PubMed (most recent search in January 2018) using the search terms *inner speech* and *aphasia*. We also reviewed reference lists of recent articles by research groups other than our own (e.g., Geva, Jones, et al., 2011; Langland-Hassan, Faries, Richardson, & Dietz, 2015; Stark, Geva, & Warburton, 2017) to identify any appropriate studies that may have been missed in our database search. In order to be included in this review, studies were required to be full-text, peer-reviewed English language manuscripts (not conference proceedings). We only included articles that were relevant to our research questions, that is, that investigated the phenomenon of IS in individuals with aphasia. There was complete author agreement in all cases of excluded articles. The articles described in this review thus represent, to the best of our knowledge, the entire set of studies

that have been published to date on the topic of IS in aphasia.

Results

As mentioned in the introduction, we know very little about IS ability in individuals with aphasia. After excluding duplicates and articles that did not meet our inclusion criteria, our search identified 12 studies relevant to the topic of IS in aphasia (see Table 1). In this section, we will summarize evidence from both objective and subjective approaches, showing that IS can be preserved in individuals with spoken language impairments.

Objective Evidence for the Preservation of IS in Aphasia

Several prior studies have shown that IS can be preserved in individuals with acquired language impairments. An early study examined IS specifically in the context of conduction aphasia to test a theory that conduction aphasia represents a disturbance of IS (Feinberg, Rothi, & Heilman, 1986). They used picture-based rhyme and homophone judgments as objective measures of IS ability, and results indicated that four of five individuals with conduction aphasia performed well on these tasks despite displaying a general impairment of spoken output (Feinberg et al., 1986). Another study focused on a different aphasia subtype, Broca's aphasia, to examine the use of pre-articulatory monitoring for error detection and correction (Oomen, Postma, & Kolk, 2001). While this study was not framed as an investigation of IS per se, findings indicated that individuals with Broca's aphasia are able to monitor speech errors successfully using only pre-articulatory information (due to masking of spoken output), suggesting some access to internal phonology in this population (Oomen et al., 2001).

More recently, a few studies have used behavioral proxies for IS (e.g., silent homophone judgments based on written words) to test the preservation of IS in aphasia, without focusing on a particular aphasia subtype. Results show that individuals with conduction aphasia and individuals with motor planning impairments have preserved IS relative to spoken naming or oral reading (Geva, Bennett, Warburton, & Patterson, 2011; Stark et al., 2017). This research group defines IS as “the ability to create an internal representation of the auditory word form and to apply computations or manipulations to this representation,” which maps onto the objective approach to defining IS (see Definitions of IS section). Using this definition, impairments in IS were localized via voxel-based lesion-symptom mapping to damage in the left IFG (pars opercularis) and the white matter adjacent to the supramarginal gyrus (Geva, Jones, et al., 2011). These voxel-based lesion-symptom mapping findings are consistent with the functional neuroimaging studies in healthy speakers (see Neural Correlates of IS section), which localize activation primarily to the left IFG during tasks relying on IS.

Table 1. Studies on inner speech (IS) in aphasia.

Paper	Participants (N; aphasia subtypes)	Approach to studying IS	Methods	Results and outcomes
Goodglass et al. (1976)*	N = 42 Various	Mixed (subjective reports of tip-of-the-tongue, ToT)	<ul style="list-style-type: none"> Participants completed a picture-naming task. For incorrect trials, participants were asked (a) whether they had an idea of the word (ToT), (b) to identify the number of syllables and the first letter, and (c) to select the word from multiple choices. 	<ul style="list-style-type: none"> Individuals with Broca's and conduction aphasia reported ToT > 50% of the time and were able to demonstrate some knowledge of words they were unable to say aloud (via syllable counting and first letter identification). Individuals with Wernicke's aphasia reported high levels of ToT but low levels of phonological knowledge. Individuals with anomia rarely reported ToT. 4/5 patients were able to perform well on all three IS-based tasks, despite poor overt picture naming. Conclusion: "Four patients had access to the phonological representation of words at a higher level than their verbal production indicated" (Feinberg et al., 1986).
Feinberg et al. (1986)	N = 5 Conduction	Objective	<ul style="list-style-type: none"> IS tasks = rhyme and homophone judgments (2AFC) and word length comparisons, all based on pictures (requiring word retrieval). 	<ul style="list-style-type: none"> Results show that individuals with Broca's aphasia have more preserved error monitoring in the presence of white noise, when compared to age-matched controls (N = 11). Authors conclude that individuals with Broca's aphasia primarily use pre-articulatory monitoring to detect errors. Patients as a group performed worse than age-matched controls (N = 27) on all three IS tasks. Some patients showed dissociation between inner and overt speech (IS tasks vs. oral reading), in both directions (i.e., inner > overt and inner < overt). Preserved inner speech relative to overt speech is attributed either to apraxia or to impairments in translating the phonological code into articulatory code. VLSM showed that performance on the IS tasks was associated with lesions to areas in the left inferior frontal gyrus, pre- and postcentral gyrus, anterior supramarginal gyrus, and adjacent white matter.
Oomen et al. (2001)*	N = 11 Broca's	N/A (self-monitoring)	<ul style="list-style-type: none"> Participants completed speech production tasks under normal conditions and with auditory masking present, in order to compare monitoring ability. 	
Geva, Bennett, et al. (2011)	N = 29 Various	Objective	<ul style="list-style-type: none"> IS tasks = Y/N rhyme judgment (real words) and homophone judgment (real words and pseudowords), all performed on written words (adapted from the PALPA). IS task performance was compared to oral reading, spoken sentence comprehension, and repetition. 	<ul style="list-style-type: none"> Behavioral = same as above, except for the pseudoword homophone judgment task. Patients underwent structural MRI scanning for the purposes of voxel-based lesion-symptom mapping (VLSM). IS task = silent rhyme judgment task based on pictures (requiring word retrieval). Patients also completed the WAB-R and portions of the CLQT.
Geva, Jones, et al. (2011)	N = 17 Various	Objective		<ul style="list-style-type: none"> Patients performed worse than age-matched controls (N = 12) on the silent rhyme judgment task, despite relatively intact ability to perform an auditory rhyme judgment task. No correlation between IS task performance and confrontation or generative naming tasks. At the item level, self-reported successful IS predicted success of spoken naming as well as the likelihood of phonological errors in cases where naming failed. During naming treatment, participants successfully learned more words that had been reported as successful vs. unsuccessful IS on the IS task.
Langland-Hassan et al. (2015)	N = 11 Various	Objective		
Hayward et al. (2016)	N = 2 Both fluent	Mixed	<ul style="list-style-type: none"> IS task = self-report during silent picture naming. Participants also completed overt naming and later participated in a paired-associate naming treatment on a subset of unsuccessful items from the naming task. 	

(table continues)

Table 1. (Continued).

Paper	Participants (N; aphasia subtypes)	Approach to studying IS	Methods	Results and outcomes
Hayward (2016)	N = 6 Various	Mixed	<ul style="list-style-type: none"> • IS task = same as above. • Self-reported success of IS was analyzed with respect to psycholinguistic variables of the word stimuli. 	<ul style="list-style-type: none"> • Successful vs. unsuccessful IS items differed on frequency and age of acquisition, but not articulatory complexity, triphone probability, phonological neighbors, or length in phonemes or syllables. • Author concluded that IS relates to phonological retrieval and not to output processing.
Stark et al. (2017)	N = 38 Various	Objective	<ul style="list-style-type: none"> • IS tasks = Y/N homophone and rhyme judgment, both performed on written words (stimuli taken in part from the PALPA). • Overt speech measured via oral reading. • Participants with preserved IS were divided into groups based on overt speech ability and IS scores were compared to CAT tasks. 	<ul style="list-style-type: none"> • Eight participants showed preserved IS/poor overt speech, i.e., dissociation of inner/overt speech. • IS rhyme scores related to spoken naming; IS homophone scores related to MLU (picture description). • 21 participants showed preserved IS/good overt speech. • No significant correlations with CAT tasks, when correcting for multiple comparisons.
Fama et al. (2017)	N = 37 Various	Subjective	<ul style="list-style-type: none"> • Self-report of the experience of successful IS during anomia (i.e., successful IS but failure to name) based on a structured interview. • Participants also completed an objective language battery and underwent structural MRI scanning for the purposes of multivariate lesion–symptom mapping. 	<ul style="list-style-type: none"> • Successful IS during anomia was subjectively dissociable from other experiences of anomia, e.g., having an idea but not being able to think of the word. • Self-reported experience of IS during anomia in the context of daily life was related to measures of output processing (as predicted), but also to overall severity of language impairments (not predicted). • Multivariate lesion–symptom mapping analysis demonstrated that the experience of successful IS followed by anomia is associated with damage to brain regions supporting speech output.
Fama, Snider, et al. (2019)	N = 53; N = 27 included in all analyses Various	Mixed	<ul style="list-style-type: none"> • IS task = self-report during silent picture naming (divided across 2 days). • Participants also completed three picture-based tasks requiring word retrieval (spoken naming, first letter identification, syllable counting), as well as three matched auditory tasks (repetition instead of naming), all using the same stimuli. 	<ul style="list-style-type: none"> • Overall levels of self-reported successful IS were stable across days in most participants. • Participants performed better on the picture-based tasks for words that were reported as successful vs. unsuccessful IS (analysis performed at the item level). • Authors concluded that self-reported IS is a meaningful reflection of lexical retrieval.
Fama, Henderson, et al. (2019)	N = 53 Various	Mixed	<ul style="list-style-type: none"> • IS task = self-report during silent picture naming. • Participants also completed tasks relying heavily on word retrieval (e.g., picture-based rhyme judgment, controlling for performance on a matched auditory version) and tasks relying heavily on output processing (e.g., oral reading and repetition). 	<ul style="list-style-type: none"> • Overall self-reported IS related to performance on retrieval-based tasks, but not to tasks relying on output processing (analysis performed at the task level). • In a hierarchical regression analysis, self-reported IS was a better predictor of spoken naming than the objective, retrieval-based tasks. • Successful IS related to overall levels of phonological errors on a spoken naming task (not semantic errors).

Note. The table shows the number of participants with aphasia (if controls were included, they are not listed here) and aphasia subtypes, general approach to studying inner speech (subjective, objective, or mixed subjective/objective), methods, and relevant outcomes. Studies marked with an asterisk (*) are not framed by the researchers as investigations of inner speech, per se; Goodglass et al. (1976) studied “tip-of-the-tongue,” and Oomen et al. (2001) studied pre- and postarticulatory monitoring. 2AFC = Two-alternative forced choice; PALPA = Psycholinguistic Assessments of Language Processing in Aphasia; WAB-R = Western Aphasia Battery–Revised; CLQT = Cognitive Linguistic Quick Test; MLU = mean length of utterance; CAT = Comprehensive Aphasia Test.

Another recent study used a silent, picture-based rhyme judgment task as a proxy for IS ability (Langland-Hassan et al., 2015). When participants with aphasia performed the silent task, as a group, they performed near floor; in contrast, performance was relatively preserved on a 10-item auditory version of the task. There were no correlations between performance on the silent rhyme judgment task and measures of confrontation naming or generative naming, so the authors concluded that impairments of IS are consistent across individuals with aphasia, regardless of spoken production ability (Langland-Hassan et al., 2015). It is possible that this study may have been underpowered given the small sample size ($N = 11$), so replication in a larger group would increase confidence in the interpretation of these findings.

Taken as a group, these studies using objective approaches to study IS in aphasia demonstrate that IS, defined as the ability to perform sound-based judgments on written words or pictures, can be preserved relative to overt production in individuals with aphasia. Compared to subjective approaches to measuring IS, using objective language scores as proxies for IS has the benefit of maintaining a level of objectivity that reduces the impacts of individual variability in self-monitoring and also helps to avoid the effects of potential biases in subjective IS reporting (see Potential Biases in IS Reporting section for a detailed discussion of this). Although the aforementioned caveats about these proxy tasks (Approaches to the Study of IS section) should be kept in mind when interpreting the results of the studies just described, these studies provide clear evidence that IS processing can be preserved relative to spoken language in some individuals with aphasia.

The Subjective Experience of IS in Individuals With Aphasia

While the majority of work on IS in aphasia has relied on objective proxy measures of IS, alternative approaches assess the subjective experience of IS and compare self-reports to objective language scores for the purpose of better understanding the nature of IS. Goodglass and colleagues were the first to examine the more subjective aspects of IS by studying tip-of-the-tongue (ToT), a closely related phenomenon in which individuals feel *close* to retrieving a target word in their heads. During a confrontation naming task, they asked patients with a variety of aphasia subtypes whether they had an “idea of the word” for items that they were unable to name aloud and then compared these self-reports to general performance on measures of lexical knowledge (see Table 1; Goodglass, Kaplan, Weintraub, & Ackerman, 1976). Results showed that all participants reported ToT experiences at a frequency greater than their average performance on the lexical knowledge tasks, but individuals with Broca’s and conduction aphasia showed the lowest discrepancy between these two measures, suggesting that their reports of ToT were meaningful (Goodglass et al., 1976). Individuals with anomic aphasia reported relatively low levels of ToT and exhibited poor performance on the

objective tasks, both consistent with the relatively poor lexical access that is characteristic of this aphasia subtype. In patients with Wernicke’s aphasia, there was a mismatch: They exhibited poor performance on lexical knowledge tasks despite frequent reports of ToT, which was ascribed to poor self-monitoring (Goodglass et al., 1976).

While the Goodglass et al. study was an examination of ToT rather than IS specifically, it is an important example of how the subjective experience of word retrieval can be meaningfully studied in individuals with aphasia, providing preliminary evidence for an important connection between self-reports and objective measures (Goodglass et al., 1976). In work from our own lab, we have similarly aimed to tie subjective reports of IS in the context of silent picture naming to objective measures of word retrieval and production, thus merging these two distinct ways in which IS is typically characterized. We define IS as a sense of being able to say a word in one’s head, with all the right sounds in the right order, a definition that falls under the category of subjective approaches to defining IS (see Definitions of IS section). Because we define IS in the context of naming tasks, it is essential to appreciate the most essential aspects of processing models of naming, word finding, and speech production (see Figure 1). As discussed above, we hypothesize that the subjective experience of successful IS reflects successful lexical retrieval; a failure of naming after successful IS could reflect the inability to generate postlexical phonological representations (e.g., in an individual with conduction aphasia) or an inability to formulate and sequence articulatory motor plans (e.g., in an individual with apraxia of speech).

We have primarily examined self-reported IS by asking individuals to report the success of IS during a silent picture-naming test, in which a picture is presented and each participant reports whether he or she is able to say the word inside his or her head, with all the right sounds in the right order, without moving the mouth, lips, or tongue. Importantly, our work builds on the prior study by Goodglass et al. (1976) by examining IS specifically (rather than ToT) and by comparing subjective reports of IS to objective task performance at the level of individual items in addition to comparing overall task-level accuracy. In two individuals with aphasia, item-level IS reports predicted the subsequent success of spoken naming and the likelihood that, if naming failed, the error would be phonologically related to the target (Hayward, Snider, Luta, Friedman, & Turkeltaub, 2016). During subsequent anomia therapy, participants also successfully relearned more words for which they had previously reported successful IS than words for which they had reported unsuccessful IS (Hayward et al., 2016). In a larger group of six participants, words reported as successful versus unsuccessful IS were compared in terms of word characteristics related to lexical retrieval (e.g., frequency) or to speech output processing (e.g., articulatory complexity; Hayward, 2016). These findings were confirmed in a later study using a larger participant group, supporting a theory of IS in which output processing is not required for a subjective experience of successful IS,

although it is necessary for spoken naming (Fama, 2018; Fama, Henderson, et al., 2019; Fama, Snider, et al., 2019; Hayward, 2016). These findings are consistent with previous literature elucidating the mechanisms of IS in healthy individuals (Oppenheim & Dell, 2008) and demonstrating preserved ability of individuals with aphasia to generate phonological representations via silent picture naming (Feinberg et al., 1986).

A similar approach to studying self-reported IS at the item level has since been replicated in a larger group of participants (Fama, Henderson, et al., 2019; Fama, Snider, et al., 2019). In this more recent study, the IS report and spoken naming tasks were divided into two matched item lists and administered on two separate days, approximately 2 weeks apart, allowing for examination of day-to-day stability. Results indicated that scores from both IS report and spoken naming were relatively consistent across the two testing days in most participants, with striking similarity in the pattern of variability across the two tasks (Fama, Snider, et al., 2019). In this study, participants also completed silent first letter identification and syllable counting tasks on the same picture stimuli for which they provided reports of their IS (Fama, Snider, et al., 2019). Because these tasks rely on word retrieval, we predicted that participants would perform better on these tasks for items that they reported being able to name correctly internally on the IS report task (successful IS), compared to words they reported not being able to name correctly internally (unsuccessful IS). Results confirmed our prediction, providing explicit support for the hypothesis that self-reported successful IS relates to lexical phonological retrieval (see Table 1; Fama, Snider, et al., 2019).

We also assessed the individual reliability of IS judgments in a sample of 23 participants and found that 17 of them provided evidence of meaningful IS judgments, but three participants showed substantial day-to-day variability (they were outliers in the comparison described above), and three additional participants were not able to demonstrate more phonological knowledge of words they reported being able to name internally compared to those they did not (Fama, Snider, et al., 2019). In task-level analyses of the same data set, IS reports were so successful in capturing phonological retrieval ability that, in a regression model predicting spoken naming accuracy, they supplanted the objective measures of phonological retrieval and improved the overall model fit; in this sense, IS reports could be said to be a better measure of phonological retrieval than the objective measures used (Fama, Henderson, et al., 2019). In our prior work, we have also made use of an interview-based approach for studying the subjective experience of IS in individuals with aphasia (Fama et al., 2017). We asked each participant to rate how frequently they experienced a feeling of being able to say a word in his or her head, despite being unable to say the word out loud (labeled *successful IS*). This was contrasted with an earlier failure of word finding, the feeling of having a sense of what one wants to say but not being able to retrieve the word. Results showed that the experience of successful IS during anomia is meaningful and dissociable from other experiences of anomia in

which the process fails prior to successful word retrieval (Fama et al., 2017). Behavioral analyses revealed a tentative relationship between successful IS during anomia and an objective measure of phonological output processing. Correspondingly, a multivariate lesion–symptom mapping analysis demonstrated that the experience of successful IS followed by anomia is associated with damage to brain regions supporting speech output (Fama et al., 2017). These findings are consistent with our other studies (Fama, 2018; Fama, Snider, et al., 2019; Hayward et al., 2016), showing that successful IS reflects successful retrieval and that overt anomia following successful IS reflects output processing impairments.

Overall, our own studies have found robust support for the conclusion that the subjective experience of IS is meaningful and is related to lexical retrieval, although we cannot yet draw conclusions about the exact degree of successful retrieval that is required for a judgment of successful IS. Some of the objective, retrieval-based language tasks that were shown to relate to IS could be performed via partial phonological access only, and a relationship that was established between self-reported IS and phonological errors during spoken naming is also consistent with either partial or complete phonological retrieval (Fama, Henderson, et al., 2019). Importantly, a feeling of IS may arise based on different degrees of success at the level of phonological retrieval across participants or even within participants in different task contexts. In the Discussion section (Practical Considerations Regarding the Use of Subjective Reports in Individuals With Aphasia section), we will acknowledge the practical considerations related to the interpretation of subjective reports of IS in individuals with aphasia.

Discussion

Objective Versus Subjective Approaches to the Study of IS in Aphasia

This review summarized the literature on IS in aphasia, including valuable findings from studies using objective and subjective methodologies to study the phenomenon. As described in other sections, objective approaches use tasks such as rhyme or homophone judgments as a proxy for IS. In contrast, subjective approaches rely on self-report from individuals with aphasia during silent naming tasks or in structured interview settings. It is important that we acknowledge the conceptual differences between the two approaches, as there are different mental processes and potential biases involved in each (see Figure 2). Given these differences, it is not feasible to unite the various methodologies into a single operational definition of IS; instead, future research should continue to pursue both approaches, with relevant clinical implications being drawn from each.

Practical Considerations Regarding the Use of Subjective Reports in Individuals With Aphasia

Validating and understanding the experience of IS in a subjective context necessitates that some of the data be

based on self-report by the individuals participating in the studies. Although there is a precedent for asking healthy language users about their experience of IS (Hurlburt et al., 2016; Morin et al., 2011), here, we have presented research focused on IS in individuals with an acquired language disorder, who, by definition, have some difficulty with comprehension, expression, and/or self-monitoring and awareness of deficits. Interpreting the results from studies utilizing subjective approaches in this population requires consideration of the limitations of relying on self-report by individuals with aphasia.

General Comprehension Issues in Aphasia

Although communicating with individuals with aphasia about metalinguistic ideas can be challenging, there is a considerable precedent in the aphasia literature for using self-report and other subjective measures in this population, particularly for exploring issues related to social participation and quality of life, using both qualitative and quantitative approaches (Brown, Worrall, Davidson, & Howe, 2012; Cocchini, Gregg, Beschin, Dean, & Della Sala, 2010; Hilari, Byng, Lamping, & Smith, 2003; Howe, Worrall, & Hickson, 2008; Lomas et al., 1989; Worrall et al., 2011). In our own previous study using interviews to examine the subjective experience of IS in aphasia, we followed general recommendations for supported conversation and specific guidelines for successfully interviewing people with aphasia (Kagan, 1998; Luck & Rose, 2007). We obtained self-reports from individuals with aphasia in person, using communication strategies to maximize comprehension and verbal output (Fama et al., 2017), for example, repeating questions, using written key words and pictures, probing with yes/no questions in addition to open-ended questions, and allowing extended time for responses. In other studies, we utilized a self-report measure of IS that was provided item-by-item during a silent naming task; for this, we gave clear instructions and offered examples and practice items prior to the task (Fama, 2018; Fama, Snider, et al., 2019; Hayward, 2016; Hayward et al., 2016). In addition to these measures, we also required a predetermined, minimum degree of sentence-level comprehension ability for inclusion in the final analyses of each study. Together, precautionary measures such as these may minimize negative impact of poor comprehension on ability to perform the self-report tasks, making subjective approaches feasible for the study of IS in most individuals with aphasia.

Potential Biases in IS Reporting

Although previous findings on IS in aphasia clearly demonstrate that the subjective reports of participants are, on the whole, reliable and meaningful, there are also subjective biases that are pertinent to interpretation of self-reported IS. As previously described, when participants are asked to report the success of IS during a silent picture-naming task, it is possible that some participants have a level of tolerance for slight errors in word retrieval. A certain amount of leniency in error judgment has been previously observed in healthy language users, whose

perception systems may not accurately identify errors in IS when similar phonemes are involved (Oppenheim & Dell, 2008). Future studies using subjective approaches to study IS in aphasia could include a measure asking participants to make explicit judgments of the accuracy of their spoken naming; this would provide information about individuals' willingness to allow minor production errors in the context of accuracy judgments. Any tolerance exhibited during spoken naming may extend to judgments made on IS as well, as was shown in previous work from our lab in a small number of participants (Hayward, 2016).

More generally, there may be an effect of self-confidence or overall insight in reporting the accuracy of IS. Although reduced insight into deficits is more typical in right-hemisphere stroke as opposed to left-hemisphere stroke, it is widely acknowledged that some individuals with aphasia demonstrate poor error awareness (Helm-Estabrooks & Albert, 2004; R. C. Marshall, Neuburger, & Phillips, 1994). There is also evidence for general variability in confidence around communication ability among individuals with aphasia. A rating scale was recently developed to help clinicians and researchers gain quantitative information about communicative confidence (the Communication Confidence Rating Scale for Aphasia; Babbitt, Heinemann, Semik, & Cherney, 2011). In future studies, it would be useful to include the Communication Confidence Rating Scale for Aphasia and/or a measure of general awareness of language difficulties such as the Visual Analogue Test for Anosognosia for Language Impairment (Cocchini et al., 2010) alongside subjective IS measures. Another future direction would be to construct a self-efficacy scale in order to achieve a more accurate, context-specific assessment of confidence beliefs that may be influencing self-reported IS (Bandura, 2006). The results of such assessments could contribute to our understanding of potential impacts of overall communicative confidence, error awareness, and insight on the subjective experience of IS.

Potential Impacts of Impaired Error Detection

Beyond task comprehension and bias, one might raise concerns about whether individuals with aphasia have adequate error detection ability in order to describe the success of their internal word retrieval. There are several competing theories of self-monitoring/error detection that fall into two main categories: comprehension-based and production-based monitoring systems (Laver, 1980; Levelt, 1983, 1989; MacKay, 1987; Schlenck, Huber, & Willmes, 1987). In the latter category, a recent theory proposes that self-monitoring of speech production is subserved by a domain-general conflict monitoring system (Nozari, Dell, & Schwartz, 2011). Given significant, reasonable criticisms of both groups of theories (Maher, Gonzalez Rothi, & Heilman, 1994; J. Marshall, Robson, Pring, & Chiat, 1998; Nickels & Howard, 1995; Nozari et al., 2011; Postma, 2000), it is likely that the most accurate account of error detection may be one that allows a role for error signals to arise from both comprehension and production processes and includes a domain-general monitor to detect these error signals.

Although there is no agreed-upon theory of error detection in speech, nearly all of the proposed models include a mechanism by which word retrieval can be monitored prior to spoken output, suggesting that IS judgments are possible; however, if monitoring were impaired, participants with aphasia might inaccurately report their experience of IS. Importantly, there is an extensive prior literature demonstrating that many individuals with aphasia can detect errors in their spoken output (R. C. Marshall et al., 1994; Nickels & Howard, 1995; Oomen et al., 2001; Schwartz, Middleton, Brecher, Gagliardi, & Garvey, 2016). Furthermore, individuals with Broca's aphasia have been shown to rely more heavily on internal, pre-articulatory monitoring as opposed to postarticulatory monitoring (Oomen et al., 2001), which provides evidence that at least some individuals with aphasia should be able to monitor their IS. The strong relationships that have been identified between the subjective and objective measures in our own studies further support that, in general, people with aphasia can provide meaningful judgments of their own language ability (Fama, Henderson, et al., 2019; Fama, Snider, et al., 2019; Hayward, 2016; Hayward et al., 2016).

Although our previous studies support the reliability of IS self-reports in aphasia generally, we have found that a small number of participants do show some evidence of unreliable reporting (Fama, 2018; Fama, Snider, et al., 2019). For those individuals, it is possible that they were judging their IS based on expectation of performance on other tasks, based on retrieval of very limited information about the target word, or completely erroneously (as described in the previous section). Compared to other study participants, those participants showed lower accuracy on an auditory word-to-picture matching task and lower accuracy and less frequent spontaneous error detection/correction on the spoken naming task; the last of these differences may be particularly indicative of general impairments of error detection (Fama, Henderson, et al., 2019; Fama, Snider, et al., 2019). In future studies or clinical practices that consider self-reported IS as a useful source of information about word retrieval, these possibilities should be taken into account; further work is needed to understand more about what types of individuals with aphasia are most likely to be unreliable in this way.

Broader Implications for Self-Monitoring of IS

Studies of IS in aphasia that utilize subjective measures have the potential to contribute to ongoing debate about the nature of self-monitoring of speech more generally. As described above, there are a few competing theories of self-monitoring, including comprehension-, production-, and conflict-based monitoring systems, most of which include an account of how speech can be monitored internally, prior to spoken output (Levelt et al., 1999; Nozari et al., 2011). Our prior studies have demonstrated that people with aphasia are generally able to report the success of their IS despite difficulties with various language processes and that this report can be performed based on lexical

phonology, independent of the ability to produce a word aloud (Fama, Henderson, et al., 2019; Fama, Snider, et al., 2019; Hayward, 2016; Hayward et al., 2016). These findings are consistent with both production-based and comprehension-based theories of self-monitoring, with the exception of a theory in which motor-sensory modeling pathways are the primary substrate for internal self-monitoring (Tian & Poeppel, 2012, 2015). Existing findings do not yet reveal the nature of the representations on which individuals with aphasia judge the accuracy of their IS, that is, what mental processes are involved, nor do they indicate whether the basis of IS judgments can differ across task contexts.

Additionally, there is an open question as to the relationship between self-monitoring and domain-general cognitive processing. A recent model proposes that self-monitoring of speech relies on domain-general executive functioning ability (Nozari et al., 2011). Prior studies suggest that general executive function skills can affect language processing in aphasia (Zinn, Bosworth, Hoenig, & Swartzwelder, 2007), so future studies comparing these domain-cognitive skills to the reliability of IS monitoring would clarify whether this model of self-monitoring is viable with respect to IS. Such studies would also generally align with a current trend in aphasia research, which is to consider the role of domain-general cognitive processing in the understanding of deficits and spared abilities of individuals with aphasia.

Potential Clinical Applications of IS in Aphasia

The possibility of clinical benefit from this line of research leads naturally to a set of potential treatment studies. In the context of objective approaches to studying IS, understanding an individual's internal phonological processing abilities may reveal their potential to benefit from various therapeutic approaches. In the context of subjective approaches, knowing how often an individual experiences successful IS during anomia might be informative as to the main cause of his or her anomia, which could in turn help with the selection of a treatment approach. For instance, someone who reports high levels of successful IS during anomia is likely to have relatively preserved word retrieval and is likely to benefit from a different therapeutic approach than someone who has difficulty at earlier levels of abstract word forms or even semantic representations, or in the connections between these levels. Future research could compare overall levels of IS to response to various treatment approaches designed to primarily target either word finding or word production.

Beyond the general diagnostic information that could be gained from knowledge of self-reported IS, we have previously shown in two people with aphasia that individual words reported as successful versus unsuccessful IS respond differently to naming treatment (Hayward et al., 2016); a future study replicating these findings in a large participant group would be beneficial. Furthermore, a prospectively designed treatment study could compare treatment approaches to determine what types of anomia treatments are best

sued for treating words that are reported as successful versus unsuccessful IS. One might predict that successful IS words would be best learned through treatments focused on speech output (e.g., treatments that are typically utilized to treat acquired apraxia of speech; Farias, Davis, & Wilson, 2014; Wambaugh, West, & Doyle, 1998), whereas words that are unsuccessful in IS may require treatment approaches focused on earlier stages of word finding (e.g., semantic feature analysis; Boyle & Coelho, 1995).

Studies such as the ones described above may help clinicians make decisions about which words to treat during therapy and/or which treatment approaches to use to improve the production of those words; however, an important consideration in any treatment study is the likelihood for generalization. If future studies are able to show that self-reported IS can effectively inform clinical treatment planning, an essential next step would be to understand whether there is any level of generalization that can be achieved. One possible approach to producing treatment effects beyond the individual items utilized during therapy would be to investigate whether IS can serve as a mechanism for self-cueing in individuals with output deficits. At least one prior case study has shown that it is possible to train someone with aphasia to self-generate phonological cues, with improvements seen on trained words alongside some suggestion of a generalization effect (DeDe, Parris, & Waters, 2003). While that study focused on written and tactile cues, a future study utilizing IS as a mechanism for self-cueing could involve instructions about mental imagery related to IS, focused on either auditory imagery (imagine “hearing” the word in your head), motor imagery (imagine “saying” the word in your head), or both.

A Broader Set of Open Questions Regarding the Nature of IS

Applicability of These Findings Beyond the Context of Naming Concrete Nouns

All studies on IS in aphasia, both objective and subjective approaches, have focused on the phenomenon primarily in the context of single words, so there is an important open question about the relevance of previous findings beyond this limited context. First, we might consider whether these findings would extend beyond concrete nouns to single-word processing of other word categories, such as abstract nouns, verbs, or adjectives. The mental process of word finding (as it relates to silent naming) or phonological processing (as it relates to rhyme or homophone judgments) should be similar across these grammatical categories, so one might expect similar findings; however, this has not been empirically tested.

In our own previous studies using a subjective approach to the study of IS in aphasia, we have focused our theory of IS in the context of single-word picture naming; accordingly, many of the processing models on which we base our interpretations (see The Subjective Experience of IS in Individuals With Aphasia section and Figure 1)

focus on naming and word finding at the level of single words. It is not obvious, therefore, how the subjective criteria for reporting successful IS of single words relate to the mechanisms by which someone would report successful IS for words embedded within sentences or for evaluating the success of IS at the level of whole phrases or sentences. The addition of a syntactic level of processing may affect the way in which IS is internally generated and monitored, and to date, there are no studies examining IS at this level in aphasia. Many individuals with aphasia who are able to produce speech beyond the single-word level are likely to experience IS that is more fluent as well, so studies in this area are needed to more fully understand the phenomenon of IS in aphasia beyond the single-word level.

Prior literature suggests that the nature of IS in healthy language users depends on the task context (Oppenheim & Dell, 2010; Sokolov, 1972), so it would be interesting to determine whether this flexibility in IS applies to individuals with aphasia as well. In our own prior studies, we have found that articulatory processing is not essential to a judgment of successful IS in the context of naming, but it is unclear whether these findings would differ in other task contexts. Future studies using alternative tasks such as silent reading, for example, would help reveal whether IS is flexible across task contexts in individuals with aphasia.

The Ability of People With Aphasia to Use IS to Accomplish a Broader Set of Mental Tasks

An additional topic of interest related to the experience of IS beyond those with aphasia is the notion that IS is often used in the service of other cognitive functions. In the context of relatively abstract definitions of IS, where it represents verbal thinking or general self-directed inner language, IS has a role in many cognitive tasks, including, but not limited to, working memory, language learning, reading, and executive functioning abilities such as planning, decision making, and task switching (Alderson-Day & Fernyhough, 2015; Baddeley & Hitch, 1974; Hurlburt et al., 2016; Morin et al., 2011; Perrone-Bertolotti et al., 2014; Vygotsky, 1962). A new direction for research on IS in aphasia, therefore, would be to examine the more abstract forms of IS in this specific population. Such approaches would require an operational definition of IS that would allow individuals with aphasia to report about the experience more generally; recent questionnaires about IS developed for healthy language users may serve as an appropriate starting point (Morin et al., 2011). If these methods could be adapted for use in individuals with aphasia, two areas of research questions could be addressed: (a) whether individuals with aphasia are able to use IS to perform everyday, cognitive tasks that benefit from the ability to think verbally and more generally and (b) to what extent individuals with aphasia retain the experience of having “a little voice in one’s head,” a phenomenon that is well known to all language users and seemingly integral to the conscious, human experience.

Conclusion

In this review, we have described evidence that some individuals with aphasia are able to make use of IS despite deficits in spoken language. In many cases, they are able to perform objective tasks relying on internal word forms (e.g., rhyme or homophone judgments) and to reliably report, at the level of individual items, the success with which they are able to say a word internally. Studies using objective definitions of IS reveal predictable differences among aphasia subtypes with respect to the preservation of IS ability, and studies using a subjective definition of IS reveal that the majority of individuals in this population are reliable reporters with respect to the experience of IS. Both approaches have led to data showing that IS relates in predictable ways to lesion location in patients with left-hemisphere stroke. On the whole, the relatively small number of studies that have been performed on IS in individuals with aphasia has contributed to our general understanding of the mental processing underlying IS. This literature suggests that IS could be considered as an additional source of information with respect to anomia diagnosis and treatment planning in the context of processing models of naming. Future investigations, as described above, will further clarify the mechanisms underlying the experience, which will help to further inform clinical decision making around naming treatment and may also contribute to a greater understanding of the experience of IS in all language users.

Acknowledgments

This work was supported by National Institute on Deafness and Other Communication Disorders Grants F31DC014875 (to M. E. F.) and R03DC014310 (to P. E. T.). M. E. F. received additional training support through the ASHFoundation New Century Scholars Doctoral Scholarship. Thank you to William Hayward, Sarah Snider, and Rhonda Friedman for their contributions to our many discussions on the topic of inner speech in aphasia.

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