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Anomia and Anomic Aphasia: Implications for Lexical Processing

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Abstract and Keywords

Anomia is a term that describes the inability to retrieve a desired word, and is the most common deficit present across different aphasia syndromes. Anomic aphasia is a specific aphasia syndrome characterized by a primary deficit of word retrieval with relatively spared performance in other language domains, such as auditory comprehension and sentence production. Damage to a number of cognitive and motor systems can produce errors in word retrieval tasks, only subsets of which are language deficits. In the cognitive and neuropsychological underpinnings section, we discuss the major processing steps that occur in lexical retrieval and outline how deficits at each of the stages may produce anomia. The neuroanatomical correlates section will include a review of lesion and neuroimaging studies of language processing to examine anomia and anomia recovery in the acute and chronic stages. The assessment section will highlight how discrepancies in performance between tasks contrasting output modes and input modalities may provide insight into the locus of impairment in anomia. Finally, the treatment section will outline some of the rehabilitation techniques for forms of anomia, and take a closer look at the evidence base for different aspects of treatment.

Keywords: Anomia, Anomic aphasia, Word retrieval, Lexical processing

Syndrome Description and Unique Characteristics

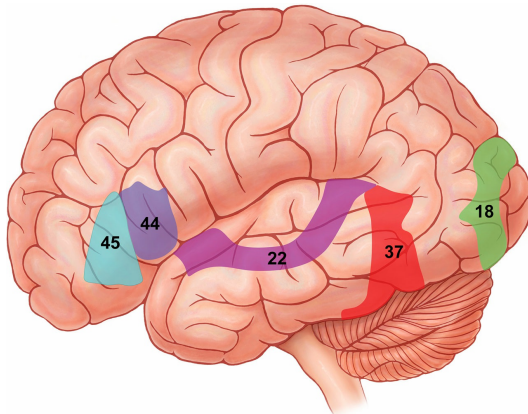
The term *anomia* refers to the inability to retrieve a desired word, typically in the course of conversational sentence production. Anomia is a very common symptom present across different aphasia syndromes. In contrast, *anomic aphasia* refers to a specific aphasia syndrome characterized by a primary deficit of word retrieval with relatively spared performance in other language domains, namely auditory comprehension and sentence production. Anomia across aphasia syndromes varies by the source of failure in a lexical system that is distributed across cortical regions, leading to varied types of errors when word retrieval processes fail. *Semantic anomia* is a syndrome thought to reflect damage to the semantic system. These individuals tend to experience difficulties in word retrieval that span lexical tasks that use different input modalities (e.g., picture naming, naming to definition or to tactile information) and/or different output modes (e.g., oral, written, and gestural communication) (Rothi, Raymer, Maher, Greenwald, & Morris, 1991). They often demonstrate disturbances in auditory comprehension and reading comprehension, which both rely on the integrity of the semantic system. Moreover, the same items tend to be in error across different tasks (Shallice, 1988), and errors are often semantic in nature (Raymer et al., 1997) (e.g., “birthday” for present). If the semantic impairment is a result of a degenerative disease process, the word-finding difficulties may also progress in severity with time.

Classical *anomia* or *pure anomia* is a form of anomic aphasia thought to reflect a deficit to the lexical system without semantic or phonological impairment. To be characterized as classical anomia, a person must demonstrate intact auditory comprehension, relatively few if any phonological errors in picture naming, and the ability to read

and repeat words as well as nonwords (Geschwind, 1967; Lambon Ralph, Sage, & Roberts, 2000). Importantly, conceptual information appears intact in these individuals, so the person can often choose the correct word among spoken choices and gesture the use of the word, provided there is no comorbid limb apraxia or paresis. Classical anomia can be thought of as a disconnection between intact semantic knowledge and phonological word forms, or a postsemantic, prephonological impairment (Lambon Ralph et al., 2000).

The time course of the onset of anomia depends on the underlying pathology. Anomia as a result of stroke or traumatic brain injury is more likely to occur suddenly, as opposed to the progressive decline that occurs with neurodegenerative diseases such as Alzheimer's disease (AD). The prognosis for progressive (e.g., semantic dementia, primary progressive aphasia [PPA]) versus static (e.g., stroke) etiologies of anomia inherently will be different due to the difference in the time course of the underlying neuropathologies, but treatment strategies have been shown to be helpful in anomia as a result of both stroke (Crosson, Fabrizio, et al., 2007; Edmonds, Nadeau, & Kiran, 2009; Fridriksson, Holland, Beeson, & Morrow, 2005; Fridriksson et al., 2007; Kendall et al., 2008; Raymer et al., 2012) and dementia (Cotelli, Manenti, Cappa, Zanetti, & Miniussi, 2008; Jokel, Rochon, & Anderson, 2010; Jokel, Rochon, & Leonard, 2002; Marcotte & Ansaldo, 2010; Ousset et al., 2002).

Neuroanatomical Correlates of Anomia in Acute and Chronic Stages



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Figure 1 . Brodmann areas 18, 22, 37, 44, and 45.

Damage to a variety of brain regions in the language network that assist with the lexical retrieval process can produce word retrieval deficits, including regions in the frontal, temporal, and parietal cortex, particularly in the left hemisphere (Mesulam, 2008). Brain scans taken during the acute stages following stroke have provided insight into which cortical regions play a major role in early aphasia onset and recovery. By contrasting a measure of structural damage (i.e., diffusion-weighted imaging, DWI) with a measure of decreased blood flow to specific brain regions (i.e., perfusion-weighted imaging, PWI) it is possible to investigate diffusion-perfusion mismatch (Hillis et al., 2006, 2008). This measurement indicates the amount of salvageable tissue or penumbra of the lesion after stroke, which can predict recovery from anomia in the acute stages. Hillis and colleagues (2008) found that for individuals with a greater than 20% difference between DWI and PWI in the left Brodmann Area (BA) 37 (i.e., the occipitotemporal area that encompasses caudal portions of the fusiform gyrus and inferior temporal gyrus) on the first day after stroke, the degree of diffusion-perfusion mismatch significantly predicted the degree of recovery in word retrieval abilities, as tested in a picture-naming task. The implication is that reperfusion of BA 37 is important for recovery of naming function (see Figure 1). Those individuals who do not show reperfusion in that area show poorer prognosis for anomia recovery than those who do show reperfusion.

Additional support for BA 37 as an important region in the network for word retrieval is found in studies that document anomia after damage to this region (Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Foundas, Daniels, & Vasterling, 1998; Raymer et al., 1997) and functional magnetic resonance imaging (fMRI) studies (Antonucci, Beeson, Labiner, & Rapcsak, 2008; Antonucci, Beeson, & Rapcsak, 2004). One such study presents an individual, H.H., with an acute focal lesion of BA 37 (Raymer et al., 1997). He presented with a collection of behavioral deficits consistent with damage when accessing the phonological output lexicon and in accessing

orthographic representations by way of semantics, that is, disconnection between semantics and the phonological lexicon. This resulted in severely impaired confrontation naming and word-finding difficulties in conversation.

Brodmann Areas 44 (pars opercularis), 45 (pars triangularis), and 22 (superior temporal gyrus) are additional cortical regions that seem to be important for recovery of word retrieval function. Reperfusion of blood flow for each of these regions during the first few days after stroke was associated with the degree of picture-naming improvement (Hillis et al., 2006).

Subcortical structures in the basal ganglia also appear to play a role in the word retrieval process by assisting with the selection of a word among competitors (Crosson, McGregor, et al., 2007; Mink, 1996). Damage to basal ganglia themselves is unlikely to produce anomia if language regions receive adequate blood perfusion (Hillis et al., 2006), but basal ganglia lesions can exacerbate the deficit seen with hypoperfused primary language regions after injury, and possibly impact the reorganization of neural networks in individuals in the chronic stages of aphasia as well (Parkinson, Raymer, Chang, Fitzgerald, & Crosson, 2009).

It has been suggested that right basal ganglia assist with inhibiting right frontal activity that serves as noise in the system during language production (Crosson et al., 2003). Thus, after a right basal ganglia lesion, right hemisphere frontal activity during a picture-naming task may indicate a disinhibitory response rather than compensatory "recruitment." In other words, right hemisphere frontal activation may be a maladaptive response instead of an indication of recovery. Similarly, it is thought that the left basal ganglia inhibit left frontal activity (Parkinson et al., 2009). After a stroke, this inhibition may be degraded or inefficient, resulting in interference with word retrieval. In sum, intact basal ganglia may help the brain with productive reorganization of language networks after stroke.

Right versus Left Hemisphere Language Processing in Aphasia

Lesion size and location appear to influence the neural recovery patterns for individuals with chronic anomia. Individuals with smaller lesions in the left hemisphere tend to show reengagement of the perilesional cortex associated with language recovery, whereas individuals with larger left hemisphere lesions tend to show recruitment of right hemisphere homologues of language areas to complete language tasks (Crosson, McGregor, et al., 2007; Vitali et al., 2007, 2010). Although this is still an area of debate in the literature, individuals who are able to utilize left hemisphere areas are apt to show better overall recovery than individuals who rely on recruitment of right hemisphere structures (Breier et al., 2009; Fridriksson, 2010; Fridriksson, Bonilha, Baker, Moser, & Rorden, 2010).

There are several possible explanations for why persons with aphasia who utilize the left hemisphere show better recovery than those who use the right hemisphere. First, perilesional areas may serve better to support language functions because they may actually represent an expansion of the original cortical map. Fridriksson et al. (2010) found that in individuals with aphasia, BA 18 (lateral occipital lobe) modulated naming performance. This area is adjacent to BA 37, an important region for word retrieval in healthy people, and may have become part of the expanded cortical map for naming in individuals with BA 37 damage. Healthy participants also showed BA 18 activity, albeit much less than individuals with aphasia, which indicates that it is probably part of the network to support naming function in healthy persons, but does not become a primary region until injury to other regions requires that it take on a heavier processing load. Hence, the left hemisphere regions may be better equipped and more specialized for language functions if they played a supportive role prior to injury.

Another possible reason why left hemisphere activity tends to be associated with better anomia recovery is that the mere presence of perilesional activity means that the perilesional cortex is somewhat available. Individuals with smaller lesions in the language cortex may have sufficient available cortex in those regions to support language functions, whereas those with larger cortical lesions may have insufficient cortex available and therefore recruit the right hemisphere. Hence, the shift to the right hemisphere may be a result of a larger lesion producing more severe deficits, as well as less available language cortex in the left hemisphere to restore function.

These are likely not the only explanations for right hemisphere involvement in language after stroke. There also seem to be laterality effects in aging, in that older individuals tend to show positive fMRI activation in the right hemisphere for language (Meinzer et al., 2012) and motor tasks (McGregor et al., 2011), whereas younger people show negative fMRI activation in the right hemisphere. It has been hypothesized that older people have increased

difficulty inhibiting the right hemisphere (Cabeza, 2002). Because many of the stroke participants in research studies are older, the interpretation of right hemisphere activity may not be as straightforward as a compensatory mechanism after stroke, but may also be due to age-related changes in laterality (Eyler, Sherzai, Kaup, & Jeste, 2011; Guidotti Breting, Tuminello, & Duke Han, 2012; Obler et al., 2010). Additional research is necessary to gain a more complete picture of these age-related changes and how they may influence recovery from stroke.

Left versus right hemisphere activation may also be related to accuracy of word retrieval. People making errors in picture-naming tasks appear to recruit a different network than people making successful attempts (Fridriksson, Baker, & Moser, 2009; Vitali et al., 2010). Among a group of 11 individuals with various profiles of aphasia, semantic paraphasias in naming produced fMRI activity in right hemisphere regions (e.g., middle occipital gyrus, cuneus, posterior inferior temporal gyrus) and phonemic paraphasias in naming produced fMRI activity in left hemisphere regions (e.g., left cuneus, precuneus, and posterior and inferior temporal lobe), both of which were different from successful attempts at naming that tended to engage the right hemisphere (e.g., right hemisphere homologues of Broca's area, right precentral gyrus, and Wernicke's areas, right supplementary motor area, right supramarginal gyrus, right middle and superior temporal lobe, and right temporal pole) (Fridriksson et al., 2009). These results indicate that across different profiles of aphasia, semantic and phonemic errors in naming attempts produced common activity in particular cortical regions. In addition, the right hemisphere language network that was used for correct attempts at picture naming for individuals with aphasia includes the same regions that were reported for control participants, indicating that these right hemisphere areas are a part of the "normal" language network.

After a left hemisphere lesion, the residual right hemisphere regions that belong to the normal language network may be relied upon to a much greater degree in individuals with anomia. Instead of serving a supporting role to the left hemisphere, the bulk of the language processing may now occur in these right hemisphere regions. One hypothesis posits that paraphasias in picture-naming attempts after stroke are a result of the less proficient right hemisphere completing the language task instead of the disrupted left hemisphere causing the error; however, there is no clear evidence to support this claim (Code, 1996). Given the results by Fridriksson et al. (2009) indicating that semantic and phonemic errors correspond to activity in different hemispheres, it seems more likely that both hemispheres are adjusting to a disrupted and noisy system.

There is some evidence that left hemisphere frontal activity interferes with the word retrieval process in individuals with aphasia. Suppression of left hemisphere frontal activity due to cathodal transcranial direct current stimulation (Monti et al., 2008), cathodal repetitive transcranial magnetic stimulation (Naeser et al., 2005), or large frontal lesions (Parkinson et al., 2009) improves picture naming in some individuals. One plausible explanation for this finding is that in individuals with aphasia, the left frontal cortex produces noise in the system because of the damaged network. Lesions or cathodal stimulation to this area suppress hyperactive inhibitory interneurons (Classen et al., 1997), which removes competing neural activity in the left frontal lobe and releases or disinhibits other regions that can then assist with taking over language function, including word retrieval (Monti et al., 2008).

Crosson and colleagues (Crosson, McGregor, et al., 2007; Crosson et al., 2009) demonstrated that therapeutic strategies can be used in treatment to target specific neural mechanisms to enhance aphasia recovery. As reviewed above, although left hemisphere perilesional activity has been associated with better gains in individuals with aphasia, there is evidence that in chronic moderate-severe aphasia, left frontal activity may hamper treatment response by creating "noise" in the system (Parkinson et al., 2009). Crosson and colleagues (Benjamin et al., 2014; Crosson et al., 2009) set out to target the right frontal lobe as a potential neural mechanism to support word retrieval recovery. Participants with left frontal lesions underwent a naming treatment that incorporated a left hand movement intended to activate intention mechanisms and shift activity to the right frontal lobe. Participants who improved with the treatment showed relateralization to the right frontal lobe. When compared to control participants undergoing the same naming treatment minus the left hand movement, a rightward shift in activity occurred only for the naming treatment with the hand movement. The control treatment did not produce this relateralization. As neuroimaging techniques continue to advance, so will the capacity to develop and test theoretically grounded anomia treatments that target specific neural mechanisms to enhance recovery.

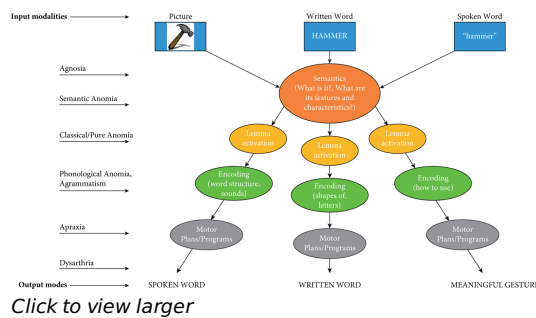
Other cognitive and linguistic strategies, driven by therapeutic techniques, will also impact how the brain completes a linguistic task. Inferior frontal and inferior parietal regions have been shown to support recovery from anomia after phonological treatment (Cornelissen et al., 2003; Fridriksson, Morrow-Odom, Moser, Fridriksson, & Baylis,

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2006; Leger et al., 2002; Vitali et al., 2007). Using structural equation modeling, a connectivity analysis of fMRI data, Vitali et al. (2010) found that for a single case study (S.A.), phonological training of picture naming resulted in bilateral activation of the inferior frontal gyrus, whereas naming of untrained items resulted in connectivity of a large number of regions mainly in the right hemisphere. One interpretation of these results is that the training instantiated a phonological cognitive strategy to successfully retrieve trained items using the bilateral inferior frontal gyrus. However, for untrained items this strategy was unsuccessful, and inefficient widespread right hemisphere activation may have represented a struggling system.

In sum, a wide network of brain regions appears to play active or supportive roles in word retrieval abilities. After stroke, acute reperfusion of BA 44, 45, and 22 assists with recovery of naming function (Hillis et al., 2006). Activity in BA 18 may be evidence of an expanded cortical map, as it lies adjacent to BA 37, a region that is a key part of the naming network in healthy individuals (Fridriksson et al., 2010). Lesion size and location, as well as severity of aphasia, appear to influence whether an individual utilizes primarily left or right hemisphere structures for word retrieval (Crosson, McGregor, et al., 2007; Vitali et al., 2007, 2010), but in general, people who are able to use left hemisphere structures tend to fare better (Breier et al., 2009; Fridriksson et al., 2010). The study of age-related changes in brain functioning, including lateralization for language (Meinzer et al., 2012), should be a consideration for aphasia treatment research, because many study participants are older. Finally, therapeutic techniques that target optimal brain activation patterns during naming for individuals with particular lesion characteristics (Benjamin et al., 2014) may provide a crucial link between technological advances in neuroimaging and growth in clinical service delivery for individuals with anomia.

Cognitive Neuropsychological Underpinnings of Anomia



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Figure 2 . Relationship between input modalities (picture, written word, and spoken word) and output modes (spoken word, written word, and meaningful gesture).

Regardless of the theoretical model of “naming” to which we subscribe, there is general agreement that a collection of processes has to occur to produce the phonetic code that represents a name corresponding to a given concept: selecting the concept/meaning (i.e., semantic representation), mapping that representation onto a lexical entry or phonological code, and producing the articulatory movements that correspond to the desired lexical entry (i.e., phonetics) (see Figure 2). The relationship among these processes and how they interact directly or indirectly with one another are precisely what constitute the differences between these theoretical models of lexical retrieval. It is beyond the scope of this chapter to compare and contrast these models, but these processes will be discussed to describe the possible cognitive neuropsychological basis of word retrieval deficits in aphasia.

Semantic Anomia

After stroke, and commonly in some forms of dementia, word retrieval deficits can be due to the loss of core semantic knowledge or access to semantic knowledge, which is known as *semantic anomia*. There has been a longstanding debate in the literature about the nature of semantic impairment and whether the semantic representations themselves are degraded in the semantic memory store (Hodges, Patterson, Oxbury, & Funnell, 1992) or if access to intact representations is impaired (Warrington & McCarthy, 1983; Warrington & Shallice, 1979). Thompson and Jefferies (2013) outlined three ways in which semantic impairment may present. Following is an overview of these profiles of semantic impairment and a discussion of the implications for word retrieval with the caveat that these profiles are still under debate in the literature.

The first profile of semantic impairment is little or no damage to representations within the semantic storage, but impaired attentional control mechanisms that allow the individual to focus on relevant aspects of the concept (Jefferies & Lambon Ralph, 2006; Thompson & Jefferies, 2013). This pattern is seen in poststroke *semantic anomia*, whereby access to semantic knowledge is impaired causing difficulties with word retrieval despite intact or mostly intact semantic representations (as demonstrated by good performance on auditory comprehension tasks). It has been suggested that the integrity of semantic access is necessary for individuals with aphasia to learn new words (Gupta, Martin, Abbs, Schwartz, & Lipinski, 2006) and combine known words into new utterances (Martin & Saffran, 1999). Many studies investigating treatments for anomia target deficits in linking intact semantic representations to lexical word form (i.e., encoding of sounds and word structure) (Boyle & Coelho, 1995; Freed & Marshall, 1995).

Breakdown in the word retrieval process either in the connections between the semantic and lemma activation levels or at the semantic level itself may result in semantic paraphasias. *Semantic paraphasias* occur when the incorrect production is semantically related to the target. It is thought that either the individual is unsure of the semantic characteristics that distinguish the target from the inaccurate production of a semantically related item or he or she is unable to activate the target lemma to a greater extent than competing lemmas and therefore accesses a semantically related, but inaccurate lemma (Rapp & Goldrick, 2006). Semantic paraphasias may be classified according to the inaccurate word's relationship to the target, for example, coordinate errors (e.g., truck for car), subordinate errors (e.g., sedan for car) or superordinate errors (e.g., vehicle for car). Some paraphasic errors are semantically related associates of the target word (e.g., garage for car). Individuals with semantic impairment may demonstrate semantic paraphasias, but the presence of semantic paraphasias does not necessarily imply semantic system damage (Maher & Raymer, 2004). Individuals may activate an incorrect lemma despite intact semantic representations (Hillis & Caramazza, 1995; Rothi et al., 1991).

Category-specific anomia is a specific type of semantic anomia characterized by the inability to name items in a particular category (e.g., colors, proper names) despite normal performance on other categories of words (Geschwind & Fusillo, 1966; Lucchelli & De Renzi, 1992; Oxbury, Oxbury, & Humphrey, 1969). There have also been examples of double dissociation between the ability to name living items versus nonliving items (Hillis & Caramazza, 1991; Warrington & McCarthy, 1994; Warrington & Shallice, 1984), which suggests that the neural processes required to identify these categories are organized differently in the brain (Chouinard & Goodale, 2010).

One theory of category-specific anomia states that as cortical regions that process and store semantic concepts are lost or degenerate, the ability to name items that depend on these regions will also deteriorate (Brambati et al., 2006). An alternate hypothesis is that because some neurodegenerative diseases such as AD show patchy neuropathology associated with anomia, the selective disruption of naming items in a particular semantic category is not due to specific cortical regions that store these concepts. Rather impaired performance is dependent on the semantic features of the items to be named. Items with semantic features that tend to cooccur (such as "has fur" and "has four legs") are more resilient to degradation than items with few correlated features (Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997). Thus, the selective disruption of a category is merely a result of the vulnerability of items in that semantic category because of a few correlating feature pairs. According to this theory, living things have more intercorrelated features (Tyler & Moss, 2001) and therefore tend to be more resilient to damage. Despite reported cases in the literature, a meta-analysis (Capitani, Laiacona, Mahon, & Caramazza, 2003) concluded that evidence for the existence of cases of reliable category-specific anomia is weak.

The second profile of semantic impairment is degeneration of the representations in the semantic store resulting in a permanent loss of semantic knowledge (Hodges et al., 1992; Thompson & Jefferies, 2013; Warrington, 1975). This profile causes deficient processing across modalities and affects words, pictures, and object use, and is consistent with what occurs in *semantic dementia*. The person becomes unaware of the differences between items in a category (e.g., all round fruits become an apple) because semantic knowledge is lost or degraded. Similarly, when seeing a pair of scissors, for example, there may only be partial knowledge about what the object is, how it is used, where it is found, and what we call it.

The study of progressive forms of anomia, such as in PPA, allows us to investigate a progressive decline in naming abilities associated with cortical atrophy in specific brain regions over time in the same individual in order to better establish brain-behavior relationships. Neurodegenerative diseases are mostly confined to gray matter (Mesulam et al., 2009), as opposed to stroke, which often affects white matter as well. Investigations of the types of errors

that individuals with semantic anomia produce, in combination with neuroimaging methods to identify areas of cortical dysfunction, lend insight into possible brain-behavior relationships in the lexical retrieval process. Along these lines, Budd et al. (2010) investigated the naming abilities of 50 individuals with poststroke aphasia and 55 individuals with PPA. Stroke participants were grouped according to one of five left hemisphere lesion locations [i.e., anterior middle cerebral artery (MCA), posterior MCA, mixed anterior and posterior MCA, posterior cerebral artery (PCA), or purely subcortical regions] and PPA participants were grouped according to the three variants (i.e., semantic, logopenic, and agrammatic PPA), which also corresponded to specific areas of cortical atrophy. They found that coordinate semantic errors (i.e., within category errors, such as “world map” for “globe”) were present across all five locations of stroke and three subtypes of PPA, despite different locations of dysfunctional cortex. This is consistent with other research that has shown that coordinate errors can occur as a result of disruption in several processes involved in lexical retrieval (Cloutman et al., 2009; Hillis & Caramazza, 1995). The group of individuals with the semantic variant of PPA (i.e., semantic dementia), whose neuropathology shows atrophy, hypoperfusion, or hypometabolism in the anterior temporal lobes, had a distinct profile of naming errors in that they made more visual errors (e.g., snake for rope) and superordinate errors (e.g., animal for dog) than the other groups. These error types are consistent with the idea that core semantic knowledge is degraded in the semantic variant of PPA (Budd et al., 2010).

Individuals with all three variants of PPA may present with anomia; however, persons with the logopenic and agrammatic subtypes will often be able to identify a picture from among semantically related foils when the word is spoken, whereas those with the semantic subtype will have difficulty with this as the disease progresses (Mesulam et al., 2009). As individuals with the semantic variant of PPA decline, the semantic maps become nonspecific in that distinctions between members of a semantic category are no longer clear. In essence, the label is neither independently retrieved nor comprehended when spoken because the core understanding of the concept is degraded or lost.

The third profile of semantic impairment occurs when an individual is able to identify semantic information about an object in one modality (e.g., auditory), but is unable to identify semantic information about the object in another modality (e.g., visual). This is known as *modality-specific impairment*, and indicates that there are damaged connections between a sensory input (e.g., visual, auditory, or tactile) and the semantic storage system (Catani & ffytche, 2005).

As previously discussed, it has been suggested that semantic anomia may be due to difficulties *accessing* semantic representations, as opposed to actual *loss* of information (Warrington & McCarthy, 1983; Warrington & Shallice, 1979). The often inconsistent nature of word retrieval abilities seems to support this semantic access account. The idea is not black and white, but for the sake of simplicity, the position states that if a concept is completely lost, then a person should not be able to inconsistently bring it up during word retrieval tasks, as is often seen with aphasia. If someone can identify semantic information from one modality (e.g., visual), but not from another (e.g., auditory), then there is evidence that the entire concept is not lost, but that access to the concept from one modality is impaired (Bartels & Wallesch, 1996; Marangolo, Rinaldi, & Sabatini, 2004). For example, poor performance on picture or object naming and other semantic tasks that use visual objects or pictures (e.g., matching pictures that are related), but good performance on semantic tasks for words that are read or heard, may indicate an intact semantic representation, but degraded access to it in via objects or pictures (Ellis & Young, 1996).

An example of modality-specific naming impairment comes from the classic neuropsychological case of Johann Voit, the German beer brewer who fell from a staircase and sustained a head injury in 1883 (Bartels & Wallesch, 1996). Voit demonstrated significant anomia, but was able to gradually write the names of objects, letter by letter. Once he was close to completing a written word, he was able to speak the name of the object. The graphomotor action of writing the word or making the motion of writing the word with his hand, foot, or tongue allowed him to speak the word. When his limbs were constrained and he was asked to stick out his tongue to avoid the cueing movements, he was unable to name objects or give information about the number of syllables or initial letter. It is thought that Voit demonstrated deficits in modality-specific semantic access, as he was unable to describe nonvisual sensory attributes of objects when the names were spoken to him. It has also been suggested that his deficits may have been due to degraded associations between different sensory aspects of objects as well as a rapid decay of perceptions. He may have learned that he was able to access semantic information from graphomotor actions and then started using these motions as a compensatory strategy. This case highlights how

brain injury can selectively affect input modalities to the semantic system and emphasizes the importance of including naming tasks across different modalities in identifying the source of word retrieval impairment.

Another example of modality-specific naming impairment comes from a case study by Marangolo et al. (2004) that described an individual with anomia who had greater difficulty naming to definition than picture naming. When asked to focus on the perceptual features of an item that was described by drawing it, he retrieved the name based on visual attributes of his drawing. The authors hypothesized that this individual could access semantic knowledge by way of a visual structural description system. He could activate pictorial input in the visual structural description system directly from a spoken word, but it bypassed verbal semantics. The visual stimulus then allowed him to use his less impaired visual naming pathway to name the item.

In sum, semantic impairment may impact word retrieval in three ways. First, an individual with semantic anomia may have good knowledge of an item (i.e., the semantic representation is intact), but may be unable to retrieve the label for it because access to that representation is degraded. Second, a person with degraded representations within the semantic store will have difficulty with word retrieval because specific knowledge about the item is lost, such that it becomes generic and nonspecific. An individual with semantic dementia may not be able to retrieve the word “stapler,” for example, because he or she does not have the core knowledge of what the item is, how it is used, etc. Finally, semantic impairment may present itself in one modality while leaving another alone, indicating difficulty in accessing an intact semantic representation. An individual with modality-specific impairment may be able to identify an item visually, but not from auditory information, such as a definition.

Classical Anomia

Another locus of impairment in anomia is disruption in determining the label or grammatical features for an activated concept. This is sometimes referred to as lemma activation (Bock & Levelt, 1994; Caramazza, 1997; Dell, 1986; Levelt, 1992; Roelofs, 1992). A person with a selective deficit in this process may be able to provide conceptual information about an object, show how it is used, indicate where it can be found, and repeat the name, but will be unable to speak or write the name independently. Anomia that is a result of a deficit to the lexical system without semantic or phonological impairment is referred to as *classical* or *pure anomia*. Recall that classical anomia can be thought of as a disconnection between intact semantic knowledge and intact phonological word form knowledge (Damasio et al., 1996; Foundas et al., 1998; Raymer et al., 1997). Phonemic cueing can often assist with word retrieval in a person with classical anomia because it helps with the selection of a lemma or lexical word form among competitors.¹

Phonological Anomia

Impaired phonological processing can also impact lexical retrieval. An individual who cannot select the phonemes for a given concept, insert phonemes into the correct position in a syllable, or maintain the phonemes in working memory before they are used will experience difficulty expressing that concept (Nickels, 2002) because downstream verbal execution processes rely on accurate information at the phonological level. If the semantic representation has been accessed, but difficulty activating the correct phonological entry during the phonological encoding stage occurs, then this may demonstrate phonemic paraphasias, or sound-based errors. Phonemic paraphasias include sound additions, subtractions, and distortions, as well as produced words that sound similar, rhyme, or share some of the same letters as the target word. Nickels (2002) defined phonological impairment primarily by its symptoms: “the individual makes phonological errors in all tasks requiring speech output and these are more common on words with more phonemes” (p. 948). Moreover, there is some evidence that phonological neighborhood density, or the degree to which other words sound like a target word, plays a role in phonological error rates (Middleton & Schwartz, 2011).

Assessment of Anomia

We have established that the expression of a word or utterance depends on the integrity of a series of lexical processing steps. The ability to accurately retrieve and express a desired word may be disrupted by deficits in any one or more of these processes. It is not uncommon to read in clinical reports and research articles that a diagnosis of anomia was determined based on performance on one standardized language assessment, such as a

picture-naming test. However, it is important to consider what the tasks in these assessments measure, and more specifically, which cognitive processes are vital to complete the tasks. First, I will briefly review published assessments for anomia. Then I will discuss some alternate ways to assess word retrieval that provide additional knowledge about potential disrupted and preserved stages in the naming process.

Published Assessments for Anomia

The Western Aphasia Battery-Revised (WAB-R) (Kertesz, 2007) assesses auditory comprehension, verbal fluency, and repetition to provide a measure of severity of overall language impairment and to classify aphasia type on the basis of performance in each of the areas. Based on this assessment, anomic aphasia is the least severe classification of aphasia subtype, characterized by minor to severe deficits in naming and word retrieval (0–9) in the context of normal (or minor impairments in) fluency, comprehension, and repetition. The naming portion of this assessment elicits responses for confrontation naming of objects and responses to questions. In addition, it assesses sentence completion and category member generation (animals). The WAB-R provides information about deficits in confrontation naming, as 60% of the naming score is based on confrontation naming, but it may not be sensitive enough to detect minor word retrieval deficits in conversation. Moreover, it does not indicate which stage in the naming process may be experiencing breakdown.

The Boston Naming Test (BNT) (Kaplan, Goodglass, & Weintraub, 2001) also serves as a measure of confrontation-naming abilities. It consists of 60 black and white line drawings of objects to name. If the person exhibits gross visual confusions (e.g., snake for pretzel), then the examiner may provide a semantic cue to redirect the person to the correct item that is to be named. Phonemic cues may also be provided in the event the person is unable to retrieve the object name in the allotted time, but a correct answer after a phonemic cue does not increase the total score for this test. It does, however, indicate to the examiner whether the person is stimulable based on phonemic cues, which may assist with diagnosis and treatment planning. An additional useful portion of the revised version of the BNT for distinguishing semantic as opposed to phonological-based anomia is the inclusion of a multiple choice picture/written word matching task that can be used after completing the naming task.

The Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) (Kay, Lesser, & Coltheart, 1992) is an assessment tool that allows the clinician to choose from 60 subtests based on an individual's needs. The assessments are divided into four sections: Auditory Processing, Reading and Spelling, Picture and Word Semantics, and Sentence Comprehension. There are eight subtests of word and picture semantics that examine spoken and written word-to-picture matching, spoken and written synonym judgments, word semantic associations, spoken-to-written word matching, spoken and written picture naming, repetition, oral reading, and written spelling. Overall, the PALPA is designed to allow the clinician to develop hypotheses about the nature of the impairments in a given individual and choose subtests that assess those impairments. Strengths of the PALPA relevant to word retrieval assessment are that it systematically manipulates and controls for psycholinguistic variables, such as word frequency, number of syllables, imageability, and morphemic complexity.

The Northwestern Assessment of Verbs and Sentences (NAVS) (Thompson, 2011) is a relatively new assessment designed to examine the production and comprehension of action verbs as well as the production of verb argument structure in sentences and the comprehension and production of canonical and noncanonical sentences. The NAVS has five subtests: the Verb Naming Test, the Verb Comprehension Test, the Argument Structure Production Test, the Sentence Production Priming Test, and the Sentence Comprehension Test.

Interpretation of Anomia Assessments

Accurate picture naming requires intact visual processing, from the integrity of the eye (e.g., cones and rods reacting to light) to basic visual and spatial abilities (e.g., perceiving shapes on a page). Impairment in these early visual processes could lead to the inability to produce the name of a picture, but these errors are not disruptions in word retrieval abilities. Similarly, some individuals perceive visual information correctly as demonstrated by the ability to copy a picture, and demonstrate intact knowledge about the meaning of objects by correctly identifying an object when provided with the definition, but are unable to name an item from visual information alone, due to the inability to link intact visual perception to an intact semantic representation. This is a visual perceptual impairment termed *associative agnosia*. Although visual agnosias are not language based, they result in poor performance on picture-naming assessments.

Similar examples of modality-specific impairments prior to semantic access can be found in the auditory modality. The inability to identify an item when given the definition due to hearing impairment or due to the inability to link speech to intact semantic representations, such as with word meaning deafness,² is not considered an anomic error. Language assessments that require a response to information presented in the auditory modality rely on the integrity of the hearing system and of linking auditory information to meaningful concepts in the semantic system. Hence, disruptions in auditory perception may impact performance on these assessments.

The most direct way to determine if someone has a modality-specific impairment in naming is to present stimuli in different modalities and look for discrepancies in performance. For example, to assess the naming of 10 items, the stimuli can be presented as pictures, written words, spoken words, and spoken definitions. Better performance on naming to definition than picture naming might indicate impairment in visual perception or accessing semantic information in the visual modality. Conversely, better performance on picture naming than naming to definition may indicate impairment in auditory perception or accessing semantic information in the auditory modality. If a person shows similar naming impairment across presentation modalities, then the clinician can rule out the likelihood of a primary perceptual impairment causing the naming deficit, or disrupting the access to semantic representations from a particular modality.

Plausible explanations for *similarly* impaired performance across input modalities are that the person has an impairment in (1) the semantic system, (2) the phonological encoding system, or (3) the motor speech system. To determine the most likely candidates for language disruption, the clinician can assess different output modes by asking the participant to speak the word, write the word, point to a picture of the word, or gesture the use of the word (Rothi et al., 1991). A person who is equally impaired in all input modalities and output modes may demonstrate core semantic impairment, whereby the concepts themselves are degraded.

In sum, the modality in which we present stimuli has the potential to impact performance on language assessments because of (1) perceptual impairments in a particular modality (e.g., vision, hearing), or (2) impairment in organizing perceptual information and linking the percept to meaningful concepts in the semantic system (e.g., visual or auditory agnosias). Presenting stimuli in multiple input modalities and eliciting responses in multiple output modes will result in a better understanding of the locus of impairment in the word retrieval process.

Treatment

For more than 100 years, treatments for aphasia have focused on relearning lost functions via repeated practice. In 1898, Henry Charlton Bastian proposed that individuals with aphasia may be able to regain language functions by beginning to relearn individual sounds and eventually working up to words, phrases, and sentences (Finger, 1994). A few years later, Charles Mills published techniques to “re-educate” individuals with aphasia, which included repetition of real and meaningless syllables, reading aloud, copying and writing from dictation, phonetic methods, observation of articulatory movements using a mirror, and retraining in grammar (Finger, 1994). Despite the advances in neuroscience and technology over the past century, many of the same therapeutic strategies are used today in various treatments for communication disorders, including anomia.

One plausible strategy to developing theoretically based treatments for anomia is to determine at which level in cognitive processing breakdown occurs, and then to investigate how particular treatments affect activation of that process (e.g., semantics, word form lexicon, and/or phonology) (Martin, Fink, Renvall, & Laine, 2006). In fact, many treatment studies in the literature can be categorized according to the nature of the treatment task or the stage in the lexical retrieval process they target.³ Even so, there is evidence that individuals with different profiles of anomia (e.g., distinct deficits and preserved abilities) are able to respond to similar treatments by taking from the therapy whichever strategies they need to address deficient areas (Hillis, 1998). In such a case, a combination treatment approach incorporating semantic and phonological cueing may provide sufficient stimulation at a number of stages in cognitive processing to improve naming in individuals with various deficits that ultimately lead to anomia (Nickels, 2002).

With information obtained by assessing word retrieval across modalities, it is possible to obtain a general idea of the deficient process(es) (e.g., semantic knowledge, lexical access, phonology), input modalities (e.g., visual, auditory), and output modes (e.g., oral, graphemic) that may be affected most in a given individual leading to word retrieval difficulties. This knowledge will help to determine which areas may benefit most from task-specific training.

To capitalize on task-specific training and translate the skill to functional communication, the recommendation is to concurrently provide real-world experiences to link the training to a meaningful social context. These meaningful experiences in which the skill is practiced provide personal value in learning and an opportunity for social engagement. This is consistent with the World Health Organization (WHO, 2001) International Classification of Functioning, Disability and Health guidelines for treatment of an individual with a disability at the (1) impairment, (2) activity limitation, and (3) participation restriction levels. Treatment at the impairment level occurs by targeting the process, input, and output modality that most affects a person's word-finding deficits. Activity limitations posed by deficits in word retrieval can be targeted by concurrently using the skill in various communication activities (e.g., use of the word in conversation). To make the treatment meaningful, and take it from the speech treatment session to life experiences, the skill should be used in real social contexts to target participation restriction. Ideally the training at the impairment and the activity level continues throughout this social training to boost the process that needs enhancement. Concurrent use of the skill in meaningful situations is important to facilitate long-term maintenance.

Treatments for anomia attempt to promote (1) the use of the remaining neural systems to complete language processing via a restorative approach, or (2) compensation for the loss by use of technology, gesture (pantomimes), or another alternative modality (drawing, communication device). In the former approach to treatment, we attempt to reengage what is left of the neural system in order to create functional networks to produce language. Spontaneous and therapy-induced recovery occurs via "experience" or "use of the system." Repeated exposure to specific demands on the system, such as producing the names of objects or actions, is the impetus for changing the neural system. In other words, experience is the most potent modulator of neural adaptation. Multiple repetitions or exposures of an experience are needed to make lasting changes in the nervous system (Kleim & Jones, 2008; Nudo, 2011). If the deficit is so severe or the loss of neural tissue is so great that sufficient activation cannot be achieved to enhance restorative connections with experience, then there will be a decreased likelihood of *restoring* function, even with treatment. For these individuals, the use of compensatory strategies to communicate, such as alternative and augmentative communication (AAC) devices, may be the most beneficial clinically.

Semantic Treatments for Anomia

There is a large literature on theories of how the semantic system is organized in the brain and how it responds to illness or injury. In general, it is believed that when the semantic system is damaged, it becomes difficult for a concept or semantic representation to be distinguished from other competing representations. As described in the cognitive and neurological underpinnings section of this chapter, the semantic representations themselves become degraded or access to the representations is disturbed. In essence, categories of items become large and nonspecific (e.g., all four-legged animals are a dog). Therefore, treatments for anomia as a result of semantic impairment often use tasks and cueing strategies that focus on the meaning of the target and features that make up the target to assist with providing the details about the item that the system is either neglecting to process or does not know exists, such as distinguishing features or knowledge of how an object is used (Boyle, 2004; Boyle & Coelho, 1995; Coelho, McHugh, & Boyle, 2000; Hillis, 1998).

Semantically based treatment tasks include sorting pictures according to semantic categories (e.g., animals versus fruits), choosing the picture that does not belong in the category (e.g., cat, dog, horse, *bee*), answering yes/no questions about semantic features of a word (e.g., Does a dog meow?), and word-picture matching with semantically related distracters (e.g., target word: dog; choices: dog, cat, horse, cow). Some semantic treatments also include a verbal production component, such as describing features of an item or how the item is used (Boyle, 2004; Boyle & Coelho, 1995; Lowell, Beeson, & Holland, 1995). Studies have shown that in some individuals, word retrieval improves following semantic-based treatments (Boyle, 2010; Davis & Pring, 1991; Fink, Schwartz, Sobel, & Myers, 1997; Marshall, Pound, White-Thompson, & Pring, 1990; Marshall, Pring, & Chiat, 1998; Nickels & Best, 1996; Wambaugh, Mauszycki, Cameron, Wright, & Nessler, 2013). There is also evidence that semantic tasks can improve naming in individuals without semantic impairment (Nickels & Best, 1996). Therefore, Nickels (2002) suggests that in some cases, semantic treatments focusing on semantic properties of items may be thought of as teaching a semantic strategy rather than actually remediating the semantic system.

Semantic feature analysis is one treatment technique used to target semantic knowledge by asking a person with

aphasia to name a picture and then describe the semantic attributes of the picture with prompts (e.g., category, location, function, associated object, use, visual characteristics) (Boyle, 2004, 2010; Boyle & Coelho, 1995; Coelho et al., 2000; Rider, Wright, Marshall, & Page, 2008; Wambaugh et al., 2013). According to the Hebbian learning principle (Hebb, 1949), repeated production of the labels and semantic features of the items results in strengthening of connections among features and labels, and consequently a higher likelihood of retrieving the label during subsequent attempts. Another possibility is that semantic feature analysis instantiates a mediating/compensatory strategy for the individual with aphasia (Boyle, 2004; Wambaugh et al., 2013). Regardless of the mechanism, improvements in naming have been reported using Semantic Feature Analysis training (Boyle, 2004, 2010; Coelho et al., 2000; Wambaugh et al., 2013), and generalization to untreated items within the same semantic categories as treated items has been demonstrated in some individuals (Boyle, 2004).

The semantic system is engaged during language tasks, including word retrieval. Phonological and orthographic tasks probably always engage the semantic system because it is difficult to bypass conceptual understanding when we read or hear something, except potentially in instances of dementia, whereby representations in the semantic store are so degraded that reading and repetition occur via a grapheme-to-phoneme or phoneme-to-phoneme route (e.g., reading without understanding or repeating without understanding) (Ellis & Young, 1996). Hence whatever we do in treatment will likely engage the semantic system to some extent whether or not it is our intention to do so.

Phonological Treatments for Anomia

Therapies that are phonologically based attempt to strengthen connections between the semantic system and phonological representations (Maher & Raymer, 2004). Phonological treatments operate under the assumptions that better phonological sequence knowledge may (1) enhance an individual's lexical semantic knowledge, similar to what occurs in typical child language development (Kendall et al., 2008), or (2) improve phonological self-cueing (Vitali et al., 2010). They include tasks such as repetition, phonemic cueing hierarchies, syllable judgments, initial phoneme discrimination, phoneme counting, and rhyme judgment (van Hees, Angwin, McMahon, & Copland, 2013).

For phonological self-cueing to be successful, Bruce and Howard (1988) proposed that individuals must have access to the first letter of words they are unable to retrieve, be able to convert letters to sounds, and benefit from phonemic cueing. However, studies that show improvements with phonological self-cueing often indicate that participants demonstrate two of the three principles above: they are able to retrieve the first letter of words they are unable to name and they are stimulative to phonemic cues, but they are often unable to convert letters to sounds (Nickels, 2002). Nevertheless, long lasting effects of phonological treatments have been reported (Davis & Pring, 1991; Raymer, Thompson, Jacobs, & LeGrand, 1993; Rose, Douglas, & Matyas, 2002).

It is thought that there are sensory feedback mechanisms in place from the articulators that may enhance phonological processing (Tremblay, Shiller, & Ostry, 2003). Just as a child learns to produce words in part by learning how sounds feel when they are produced, enhancing awareness of sensory feedback may assist with phonological processing in individuals with aphasia who may have lost some of the information about how phonemes are produced (Kendall, Nadeau, et al., 2006; Kendall et al., 2008). In a healthy system, these sensory feedback mechanisms allow us to make small real time adjustments in articulation, and may over time assist with rewriting the programs and plans of how the phonemes are produced (i.e., motor speech processes) (Kendall, Rodriguez, Rosenbek, Conway, & Gonzalez Rothi, 2006) as well as the attributes of how the phonemes sound and in which lexical items they are used (i.e., phonological awareness) (Kendall et al., 2008).

Individuals with anomia often respond to various cues to retrieve the name of an object or action. The most common cueing techniques are semantic cueing (e.g., providing conceptual attributes associated with a word) and phonemic cueing (e.g., providing sound-based information, often the first phoneme of a word). Semantic and phonemic cueing may enhance activation of a semantic representation among competing representations by providing direct conceptual information in the case of the former and via feedback from the phonological system to the semantic system in the latter. Phonemic cueing may also assist in choosing a phonological code among competitors for a particular concept or may provide a model for motor planning for the execution of the speech sounds. The reasons the cues enhance performance depend on specific abilities, which can be different from person to person. Nevertheless, the cues seem to be able to target different stages in lexical retrieval, which makes them useful for a variety of anomia profiles.

Kendall and colleagues (2008) trained individuals with aphasia using a multimodal approach to discovery of phonemes. The treatment utilized auditory, visual, and tactile–kinesthetic cues to learn about how phonemes are produced at a basic level before progressing to words. They hypothesized that by acquiring sequences of phonemes during training, individuals with aphasia would be better able to generalize these sequences to other untrained words that contained the same sequences of phonemes. They also suggest that participants may enhance residual lexical semantic knowledge by strengthening connections between concepts and phonology. Indeed, after treatment, 8 out of 10 individuals showed evidence of improved naming abilities.

Locus of Impairment and Target for Therapy

Should treatment for anomia target the stage in naming at which breakdown occurs or processes that are relatively intact? Phonological treatments have been shown to improve naming in some individuals with semantic impairments (Drew & Thompson, 1999; Nickels & Best, 1996; Raymer et al., 1993; van Hees et al., 2013), potentially by strengthening representations at the phonological word form (Maher & Raymer, 2004) or the connections between the semantic system and the phonological word form (Martin et al., 2006), particularly if pictured stimuli that likely activate semantic processing are used (van Hees et al., 2013).

Van Hees et al. (2013) investigated the response to semantic feature analysis and phonological components analysis for improving naming abilities in eight people with aphasia to further elucidate the relationship between the locus of breakdown in word retrieval and their responses to treatment targeting different lexical stages, namely the semantic system and phonological encoding. They found that seven of eight participants showed improvements in naming after phonological components analysis, whereas four of eight participants showed improvements after semantic feature analysis. Moreover, they found that the semantic treatment was not beneficial for people with semantic deficits, but the phonological treatment was beneficial for most participants, regardless of the locus of breakdown. Possible explanations for this finding are that phonological components analysis better facilitated a strategy for self-cueing during naming or that phonological components analysis may have bypassed the impaired semantic system, whereby naming occurred via a direct nonsemantic route, although the existence of this route is controversial (van Hees et al., 2013).

Nickels (2002) suggests that semantic and phonological treatments do not actually isolate the semantic or phonological system because semantic treatments tend to also rely on phonology (i.e., speaking the name of the word), and phonological treatments tend to activate the semantic system automatically by virtue of treating a target word. Thus, they often activate both systems, albeit potentially to different degrees. Nevertheless, better understanding of the relationship between the stage of breakdown in word retrieval and treatment tasks that target different stages in the naming process may facilitate better customization of treatments in the future. To ensure that a treatment task is beneficial for a person with anomia, Nickels (2002) suggested that short trials of a treatment be conducted to see if the person responds prior to beginning a course of treatment using that technique (Best, Herbert, Hickin, Osborne, & Howard, 2002; Rose et al., 2002).

In sum, clinicians often need to make an educated guess about which treatment approach will work best for a given client, sometimes based on that person's probable locus of impairment in the word retrieval process. In a clinical setting, it is unrealistic to expect that an exhaustive assessment will point to a specific treatment approach that will inevitably work for the individual with anomia. More likely, the clinician will use an approach that tends to yield treatment gains with a wide variety of profiles of anomia. At present, the best bets seem to be cueing hierarchies and multimodal treatments (Nickels, 2002) that allow multiple attempts at remediating the language system at different stages of processing so that each person can take away from the treatment what is most beneficial to his or her language.

Errorless versus Errorful Learning

In thinking about the application of errorless versus errorful learning to anomia rehabilitation, it is necessary to consider the utility of producing errors and whether these errors mean something to the cognitive system. Does perceptual feedback that an error was produced assist with changing performance? This seems to hold true with the healthy language system, as errors are often perceived by the speaker and corrected, but it may or may not be true with a disordered language system. When a person with a lexical retrieval deficit makes a lexical error, is the person able to use the knowledge about this error to improve performance or is the error reinforced? According

to Hebbian learning principles (Hebb, 1949), connections are reinforced when neurons fire together. When a person with aphasia produces language errors, it is plausible that the connections between inaccurate associations are strengthened, thereby reinforcing the errors. Hence, via repeated exposure, the coupling between a semantic representation and either an inaccurate lexical entry or multiple inaccurate attempts may become strengthened such that inaccuracies and “noise” in the system prevent successful lexical retrieval. In an errorless learning treatment paradigm, opportunities for making errors are reduced in order to decrease the likelihood of reinforcing them via repeated unsuccessful attempts. A review of anomia treatment studies (Fillingham, Hodgson, Sage, & Lambon Ralph, 2003) that investigated (1) error-eliminating therapies, (2) error-reducing therapies (because true error elimination is difficult to implement in aphasia treatment), and (3) errorful learning therapies found no differences between immediate treatment effects, follow-up effects, and generalization between techniques. Subsequent studies that directly assessed differences between errorful and errorless treatment techniques (Conroy, Sage, & Ralph, 2009; Fillingham, Sage, & Lambon Ralph, 2006; Fillingham, Sage, & Ralph, 2005) also indicate that errorful and errorless therapy techniques were equally beneficial to participants who were responsive to treatment.

Whether errorful or errorless learning is more beneficial to individuals with anomia may depend on the degree to which their working memory, recall memory, and attention are intact, because the integrity of these skills may impact their ability to self-monitor and incorporate feedback (Fillingham et al., 2005). Oomen, Postma, and Kolk (2001) suggested that individuals with Broca’s aphasia rely primarily on prearticulatory self-monitoring for detecting and repairing errors, as opposed to healthy controls who use both prearticulatory and postarticulatory self-monitoring. Possible explanations for this finding are that individuals with Broca’s aphasia (1) better detect errors via a production-based monitor, as opposed to an auditory loop monitor, or (2) attempt to optimize their speech before articulation in an attempt to compensate for dysfluencies. Oomen et al. (2001) suggested that explicit training of postarticulatory self-monitoring via the auditory loop may be beneficial for these individuals to facilitate better speech fluency; however, additional research is necessary to substantiate this claim.

Classically, errorless learning paradigms were used as a treatment approach in amnesic disorders to capitalize on automaticity and procedural memory (Middleton & Schwartz, 2012). One reason the limited evidence on the application of errorless learning to individuals with anomia shows no clear advantage may be that prior to speaking the words, errors are reinforced simply by the internal word retrieval process. Hence, treatments that ask a participant to say the word only if he or she is confident that the word is correct may still be allowing ample opportunity for reinforcement of lexical retrieval errors. To truly capitalize on errorless learning, then, the participant must not be given the opportunity to independently retrieve a label (and potentially make errors), but rather listen to or repeat correct responses. There is limited evidence that a treatment approach without word retrieval demands can improve the word retrieval process (Conroy et al., 2009).

In sum, research to date indicates that there is no clear advantage to errorful or errorless treatment techniques for anomia (Conroy et al., 2009; Fillingham et al., 2005, 2006; McKissock & Ward, 2007). A person’s ability to correct errorful productions may depend in part on his or her attention and working memory in order to monitor productions and self-correct (Fillingham et al., 2005). Individuals with Broca’s aphasia seem to be less able to monitor productions after they have occurred, but do show some evidence of prearticulatory monitoring (Oomen et al., 2001).

Feedback versus No Feedback

Approximately 35 years ago, Brookshire and colleagues (Brookshire, Nicholas, Redmond, & Krueger, 1979) analyzed videotaped aphasia treatment sessions to determine if clinician behaviors or characteristics of the treatment task were related to the correctness of response of the individual with aphasia. They found patterns that suggested that indeed, some clinician behaviors were associated with errors by the person with aphasia. Specifically, people were more likely to make errors following explanation events, whereby the clinician explained or instructed on an upcoming task, which tended to occur at the beginning of a session or during a transition from one task to another. They also found that positive spoken or gestural feedback occurred after acceptable responses that followed unacceptable responses, suggesting that the unacceptable responses did not occur because of a lack of clinician feedback. Further analysis indicated that clinicians tended to repeat and elaborate after acceptable responses, but did not provide this type of feedback as often after unacceptable responses. In

fact, when any clinician feedback was provided after unacceptable responses, it was more likely to be negative and contain corrections. Moreover, when the individual made an error, the clinician was likely to ask for the same response during the subsequent trial, which was often in error again. Although this research did not explicitly investigate word retrieval deficits, it does provide some evidence that the type of feedback may differentially impact performance on subsequent trials.

Feedback may not be necessary in language relearning for individuals with aphasia because it is not necessary in typical language development (Breitenstein, Kamping, Jansen, Schomacher, & Knecht, 2004). Breitenstein et al. (2004) were able to train one individual with chronic nonfluent aphasia and one individual with chronic fluent aphasia on an associative learning paradigm using pseudowords. Associative learning occurs when a stimulus is paired with an outcome (e.g., pseudoword and picture), and the learner begins to associate items based on repetition of their cooccurrence (Breitenstein et al., 2004; Vallila-Rohter & Kiran, 2013), as opposed to feedback-based learning that requires monitoring of feedback about performance to a goal. These two types of learning paradigms have different demands and depend on different brain regions, with feedback-based learning relying on corticostriatal loops and associative learning relying on medial temporal lobe memory systems (Poldrack et al., 2001). Breitenstein et al. (2004) found that both individuals demonstrated the ability to associate the pseudowords with pictures of real objects without explicit feedback. They were also able to pair the pseudoword with the correct word after completion of the training. The same paradigm found that healthy participants were able to associate the pseudowords with pictures in both a feedback and no feedback condition. The feedback group learned faster, but both groups demonstrated similar retention at 1 week, 1 month, and 2 months. Breitenstein et al. (2004) stated that therefore "... language acquisition in adults can be achieved through bottom-up processing of statistical properties, and [that] top-down processing through feedback is not required for successful word learning" (p. 454). In individuals with aphasia, feedback may contribute to the avoidance of speech via operant conditioning (Breitenstein et al., 2004). Thus, limiting top-down processing by eliminating feedback may assist with rehabilitating language in a bottom-up manner. Similar processing models that exclude feedback loops have been proposed for speech recognition, phonemic decisions, and language processing as well (Norris, McQueen, & Cutler, 2000).

One recent experimental strategy for limiting top-down, conscious processing of language during picture-naming treatment is masked repetition priming (Silkes, Dierkes, & Kendall, 2013; Silkes & Rogers, 2012), whereby a masked visual prime showing the object name is presented before the picture to be named. Preliminary evidence shows that this strategy has the potential to elicit changes in naming (Silkes et al., 2013). Further research is necessary to determine the degree to which implicit learning assists with word retrieval and production in individuals with aphasia.

Vallila-Rohter and Kiran (2013) investigated feedback and no-feedback instruction of nonlinguistic material via paired-associate versus feedback-based instruction in healthy individuals and individuals with aphasia. They found that healthy individuals were able to learn by both instruction types, but individuals with aphasia showed more variable performance. Interestingly, they found no significant difference between paired-associative and feedback-based learning in individuals with aphasia, even though the material was nonlinguistic. They demonstrated that new category learning that was nonlinguistic in nature was impaired in individuals with aphasia. Implications of this finding are that learning and memory systems may be impaired in individuals with aphasia, which may impact the ability to respond to treatment.

Currently, there is no clear advantage of treatments incorporating feedback over no feedback approaches. Just as someone with aphasia may or may not be able to incorporate knowledge of errors in learning based on working memory, recall memory, and attention, it is possible that the ability to incorporate feedback may rely on memory and attention systems as well.

Intensity of Treatment

Recently, studies on treatment for anomia and other language disorders have been investigating the potency of intensity or dosage on treatment outcomes (Bhagal, Teasell, & Speechley, 2003; Cherney, 2012; Cherney, Patterson, Raymer, Frymark, & Schooling, 2008; Cherney, Patterson, & Raymer, 2011; Harnish, Neils-Strunjas, Lamy, & Eliassen, 2008; Harnish et al., 2014; Ramsberger & Marie, 2007; Raymer, Kohen, & Saffell, 2006; Sage, Snell, & Lambon Ralph, 2011). The investigation of dosage is both theoretically and practically driven. From a practical standpoint, intensive treatment schedules tend to be more difficult to implement in a clinical setting due to

insurance reimbursement rates, clinician availability, and patient fatigue. For this reason, investigations of dosage are necessary to determine the most efficient and cost-effective way of providing treatment to individuals with anomia. Theoretically, there is a critical number of repetitions of a behavior that is necessary in order to change cortical maps (Kleim et al., 2004; Kleim & Jones, 2008). Kleim et al. (2004) demonstrated in an animal model that despite behavioral gains on a skilled reaching task, cortical maps did not change until after several days of training, implying that lasting change requires many repetitions (Kleim & Jones, 2008) and perhaps continual practice. Animal research has shown that a skilled reaching task delivered 400 times per day elicited increases in the number of synapses in the motor cortex (Kleim et al., 2002), whereas the same task delivered 60 times per day did not elicit these changes (Luke, Allred, & Jones, 2004). Intensive treatment schedules allow for a greater number of repetitions of a skill, resulting in an increased likelihood of changing cortical maps. Indeed, a recent systematic review of the intensity of aphasia treatment (Cherney et al., 2008) found that moderate evidence exists favoring more intensive treatment schedules on behavioral outcomes. Of the studies that specifically investigated the effects of intensity of treatment on word retrieval outcomes, Ramsberger and Marie (2007) and Raymer et al. (2006) reported similar results between intensive and nonintensive treatment, whereas Sage et al. (2011) reported more favorable outcomes with nonintensive treatment.

It has been proposed that in order to consider the effects of dosage on treatment outcomes for different aphasia treatments, it is necessary to have a systematic way of defining dosage (Baker, 2012; Cherney, 2012). More intense treatment could mean (1) a greater number of therapeutic events in a shorter amount of time; (2) a greater number of hours spent in treatment in a shorter amount of time (massed practice), as opposed to the same amount of treatment delivered in a longer total amount of time (distributed practice); or (3) a greater number of total hours spent in treatment. Warren, Fey, and Yoder (2007) define a set of dosage terms that may be helpful in aphasia treatment to identify dosing effects. These terms include *dose form*, or the therapeutic task or activity that delivers the teaching episodes; *dose*, or the number of times a teaching episode or active ingredient occurs per session; *dose frequency*, or the number of intervention sessions per unit of time; *total intervention duration*, or the total period of time in which a particular intervention is provided; and *cumulative intervention intensity*, or the product of dose × dose frequency × total intervention duration. Documenting these dosage parameters, Harnish et al. (2014) demonstrated the feasibility of creating an intensive aphasia treatment session without extending the amount of daily time a person spends in treatment by saturating practice so that multiple teaching episodes or therapeutic events occurred per session. Six of eight participants achieved significant gains from baseline after 400 teaching episodes, or approximately 1 hour of treatment, and all eight participants showed significant increases from baseline after 1200 teaching episodes, or approximately 3 hours of treatment. Additional research is necessary to determine the optimal dosage for a variety of word retrieval treatments to facilitate acquisition, generalization, and maintenance.

Generalization of Naming Treatment Effects

Generalization can refer to transfer of a trained skill to untrained items using the same task (e.g., better picture naming for untrained pictures) or to untrained tasks using the same items (e.g., better naming to definition for items trained using picture naming). Investigations of the former have found mixed results (Raymer et al., 2008), but have yielded principles that seem to guide this form of generalization. Specifically, complexity of trained items (e.g., typicality) and semantic relationships between trained and untrained items seem to play a role in generalization of word retrieval gains to untrained items (Kiran, 2007; Kiran & Thompson, 2003). When more complex items, such as atypical prototypes in a category, are trained, they tend to generalize to simpler, typical prototypes (Kiran, 2007). However, the reverse is not true. When simpler items are trained, they do not generalize as well to more complex items. A caveat noted by Wambaugh et al. (2013) is that studies investigating typicality (Kiran, 2008; Kiran & Johnson, 2008; Kiran & Thompson, 2003) have primarily included individuals with fluent aphasia. Two participants with nonfluent aphasia showed less clear typicality effects (Kiran, 2008). A subsequent study by Wambaugh and colleagues (2013) investigating generalization effects of semantic feature analysis in individuals with nonfluent aphasia found that naming of typical and atypical trained items improved in eight of nine participants, but generalization to untrained items was limited. Hence, more research is needed to investigate the interaction between the typicality of trained and untrained items and the degree of fluency in individuals with aphasia.

There is conflicting evidence about whether phonological treatments prompt generalization to untrained items.

Miceli, Amitrano, Capasso, and Caramazza (1996) reported that if semantic representations are spared, and anomia results from a deficit in linking semantics to phonological form, then generalization of trained items to untrained items typically does not occur. However, there have been other reports that participants who learn to adopt a phonological strategy for self-cueing, such as better phonological sequence knowledge, may be able to apply this strategy to untrained items (Kendall et al., 2008; Vitali et al., 2010). The key between these two views may be the degree to which a person is able to adjust a strategy to fit new situations (e.g., rote memorization versus strategy utilization).

Semantic treatments, such as semantic features analysis, sometimes show generalization to untrained items that share semantic features with trained items (Boyle, 2004; Boyle & Coelho, 1995; Coelho et al., 2000; Conley & Coelho, 2003). As previously noted, two theories of therapeutic actions of semantic feature analysis have been proposed (Boyle, 2004; Wambaugh et al., 2013). The first is to repair the semantic network. If the process of repeated productions of semantic features and labels of items strengthens or repairs the semantic network, then trained items within that same semantic category and network should benefit from the treatment, whereas items that are not in the same semantic category would be unlikely to benefit. The other proposed therapeutic action of semantic feature analysis is that it is a mediating strategy to assist the individual with aphasia with naming. If the individual with aphasia is successful at implementing the mediating strategy, it is plausible that untrained items in the same semantic category as trained items, as well as items in different semantic categories from trained items, would respond to training. Studies investigating Semantic Feature Analysis have shown inconsistent generalization within and between semantic categories (Boyle, 2004; Lowell et al., 1995; Rider et al., 2008), which may indicate that the ability to generalize using this treatment depends on which therapeutic action most applies to each participant: repairing the semantic network or adopting a mediating semantic strategy.

Although generalization of trained items to untrained items is relatively uncommon, there is preliminary evidence that when treatment effects generalize to untrained items, they share neural correlates, possibly reflecting generalization of the trained cognitive strategy to untrained material (Vitali et al., 2010). Vitali et al. (2010) found delayed generalization of trained to untrained items. They investigated the effects of a phonological training program on naming performance of two individuals with chronic aphasia. Results indicated that the training yielded immediate behavioral gains on trained items and delayed generalization (6 months later) on untrained items. A connectivity analysis using structural equation modeling showed immediate coupling in connectivity for areas involved in naming trained items and delayed coupling in connectivity among regions involved in naming untrained items. The authors' interpretation of these results is that the participant may have learned to use a compensatory phonological strategy to lexical retrieval, as indicated by the immediate behavioral gains in naming trained pictures as well as the connectivity between the left pars triangularis and left supramarginal gyrus, an area that is important in phonological processing. Vitali et al. (2010) noted that although the naming performance and connectivity analysis of untrained items did not show the same patterns immediately after training, they did approximate these patterns 6 months after training (e.g., improved performance and increased coupling of the pars triangularis and left supramarginal gyrus), possibly suggesting the participant began adopting the phonological strategy to untrained items.

Another form of generalization is for trained items to untrained tasks. Functionally, it is important to know that items trained in therapy can be used in other contexts. There are limited examples of this type of generalization in the literature. Typically, measures of discourse, such as picture description or story retell, are used to assess generalization of word retrieval treatment to a functional skill (Conroy et al., 2009; Rider et al., 2008). The difficulty in evaluating narrative speech after word retrieval training is that in order to directly assess the word retrieval abilities of trained items, the target for the narrative speech sample should incorporate the words trained in treatment; however, deficits are specific to the individual and items are often chosen based on words the individual was unable to retrieve prior to treatment. Therefore, choosing a discourse target that will provide an opportunity for trained words for a given individual to be used in narrative speech becomes a challenging endeavor. An example is Rider et al. (2008), who investigated generalization effects of semantic feature analysis treatment for word retrieval using story retelling and procedural explanation. They found that all three individuals improved naming for trained items and showed an increased number of target words produced in narrative. Prior studies of this treatment technique showed no generalization to connected speech tasks (Boyle & Coelho, 1995; Coelho et al., 2000), possibly due to the methodological difficulties in assessing narrative for word retrieval generalization.

Although picture naming is often a useful training tool for word retrieval, it produces limited generalization and

maintenance, potentially due to direct activation between the visual stimulus and the phonological form (sounds) without access to word meaning⁴ (Maher & Raymer, 2004; Raymer & Kohen, 2006). Conroy et al. (2009) investigated generalization of gains produced in picture-naming treatment to connected speech (i.e., picture-supported retell of a narrative and unsupported narrative) in seven individuals with aphasia. They found that picture naming elicited the most correct responses, followed by picture-supported narratives and finally unsupported narratives. However, additional research is needed to address generalization issues more robustly.

Kleim and Jones (2008) reviewed principles of experience-dependent neuroplasticity that play a role in rehabilitation after injury. The principle of “specificity” refers to neural and behavioral changes that depend on specific types of experiences. A limited subset of the neural circuitry may change in response to specific skilled training, which may not translate to a change in more general function (Kleim & Jones, 2008). The result of this is that the context in which items are trained likely determines the context in which they will best be retrieved. Functionally, picture naming has limited utility in social communication. Thus, the ability to retrieve an item in a variety of word-retrieval conditions is necessary for communicative activities of daily living.

Conclusions

A variety of treatments for anomia have been developed to address the underlying psycholinguistic causes of the impairment. A given treatment can work in different ways for different people. Semantic treatments may assist with word retrieval even when a person has good semantic abilities and performs well on semantic tasks. Phonological tasks are appropriate for individuals with and without phonological impairments, as they may assist by enhancing activation at the lemma level, which is often disrupted in individuals with semantic impairment due to weak semantic representations (Nickels, 2002). Multicomponent or combination treatment approaches using semantic and/or phonological cueing may be most promising for people with anomia (Drew & Thompson, 1999; Nickels, 2002).

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Notes:

⁽¹⁾ It is worth noting that some accounts of lexical retrieval do not include a lemma stage, but indicate that phonological code is mapped directly onto semantic information. Once semantic activation reaches a threshold then phonological encoding occurs. The fact that some individuals with anomia are able to access information about sound structure, such as the first sound of the word or the number of syllables, but are unable to identify the correct word from among competitors, can be seen as support for direct access to phonological information from semantics, without an intermediate lemma or lexical access stage.

⁽²⁾ Word meaning deafness is when a person is unable to understand a spoken word despite a preserved ability to repeat it and understand it in written form (Ellis & Young, 1996).

(³) Note that although theoretically the nature of the treatment task and the targeted process should be similar (e.g., deficits in semantic knowledge may be best treated by semantic treatment tasks), it should not be assumed that they are always the same (Nickels, 2002).

(⁴) The alternative view is that semantics are always accessed in picture naming by virtue of visual processing of a real object (Nickels, 2002).

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