Language Dysfunction

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ABSTRACT

Purpose of Review: Language is a complex brain function requiring a number of cognitive processes and is commonly affected by both focal brain lesions and neurodegenerative disorders. This article reviews the neuroanatomic basis of language, assessment techniques of language function, and disorders affecting language.

Recent Findings: Recent functional imaging studies of language suggest that the classic connectionist models of language function may be incomplete. These studies and those analyzing how the primary progressive aphasias (PPAs) affect language function suggest that language processing is completed through large-scale distributed networks. The use of structured, standardized techniques allows for the diagnosis of focal brain lesions affecting language function as well as neurodegenerative and psychogenic causes of language dysfunction.

Summary: By employing an accurate, neuroanatomically grounded language assessment technique, the neurologist can reach the correct diagnosis and implement the optimal management plan for patients with language disorders. Neurologists should also be aware of new information regarding the neural basis of language function as our understanding of the complex cognitive process of language continues to evolve.

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INTRODUCTION

Language is communication through use of symbols and is unique to humans. Language can be aural or visual (eg, writing or sign language). The development of language is universal to all healthy humans who are exposed to language during childhood and is integral to all human interaction. This article focuses on language and not on speech, the neuromuscular system required for verbal output, and covers the neuroanatomical basis of language, assessment techniques, and common disorders of language.

Similar to the experience of memory, healthy individuals perceive communication by language as seamless despite the fact that the complex process of linguistic communication involves a number of interconnected, yet functionally and anatomically separable cognitive processes. To understand the complex neuroanatomic basis of language, neurologists must have an understanding of the concepts used in linguistics, which is the scientific study of language.

The smallest unit of language that conveys unique information is the *phoneme* (termed *grapheme* when referring to writing). Phonemes are units of sound that, when put together, form a morpheme. A phoneme roughly corresponds to a letter of the alphabet, and different languages have different numbers of phonemes. (English has approximately 30 phonemes, whereas some languages such as Mandarin have more than 50). A *morpheme* is the smallest piece into which words can be separated. Some morphemes are words (eg, town), whereas other morphemes require a root to which they are attached (eg, ing) and are referred to as bound morphemes. The purpose of language is to convey meaning, and *semantics* refers to the meaning of language. This term overlaps with semantic memory. For more information on semantic memory, refer to the article

KEY POINTS

- Language is unique and universal to humans.
- Linguistics has shown that language contains separable units at the sound, word, sentence, and discussion levels of language.

''Memory Dysfunction'' by Brandy R. Matthews, MD, FAAN, in this issue of CONTINUUM.

The meaning of language can be conveyed at both the word level and the sentence level. At the word level, the meaning of a word includes two parts: (1) knowledge shared by a community about the word (eg, cows live on a farm; cows are used for meat) and (2) the features that all things called by that word share (eg, cows produce milk; cows eat grass). *Syntax* (or grammar) is the set of rules of a particular language that determine the ways words are combined to make sentences and what they mean when they are combined. *Prosody* is the rhythm and intonation of speech and is necessary for emotional communication such as sarcasm and humor. It also allows for clarification of whether a sentence is a question or a statement. *Pragmatics* (or *discourse*) is how language is utilized and includes how sentences are made to fit into a conversation.

NEUROANATOMY OF LANGUAGE

Normal language function requires proper neural function over a wide geography of brain regions. A person with dysfunction in this neural network has an *aphasia.* (This article will use the more commonly used term aphasia despite that, in most individuals, the term dysphasia,

TABLE 3-1 Classic Aphasia Syndromes

Aphasia	Disorder of Language	Classical Localization[a]	Spoken Fluency
Broca	Disruption of speech planning and production	Left posterior inferior frontal lobe involving Broca area	Impaired: Speech is sparse and effortful; function words and bound morphemes are often missing
Transcortical motor	Disruption of speech planning and production	Left frontal cortex and white matter sparing Broca area	Impaired: Speech is sparse and effortful; function words and bound morphemes are often missing
Wernicke	Disruption of representations of word sounds	Posterior half of left superior temporal gyrus involving Wernicke area	Normal, but speech has abnormal word sound and structure (paraphasic errors)
Transcortical sensory	Disruption of representations of word sounds	Left posterior temporal/parietal cortex and white matter sparing Wernicke area	Normal, but speech has abnormal word sound and structure (paraphasic errors)
Global	Disruption of all language processing	Left hemisphere involving the majority of the perisylvian area	Impaired
Conduction	Disconnection of representation of words and the motoric process of speech	Lesion of arcuate fasciculus	Mildly impaired with frequent paraphasic errors
Anomic	Disruption of the network allowing proper sound structure of words	Does not localize well; can involve the inferior parietal lobe	Intact with word finding pauses

[a] Presumes left hemispheric dominance.

implying dysfunction rather than absence of function, is probably more accurate.) The classic aphasias are summarized in **Table 3-1**.

The presumed deficit and common lesion locations of the aphasias has led to the connectionist models developed by Broca, Wernicke, Lichtheim, and Heilman[1] shown in **Figure 3-1**.[2]

Figure 3-2[3] shows the areas involved in language function in the classic connectionist model. The conceptual framework behind this model is that Wernicke area (Brodmann area 22) and the surrounding area mediate comprehension. Auditory stimuli are projected to Wernicke area from the nearby Heschl gyrus (Brodmann areas 41 and 42), whereas visual forms of communication (eg, reading and sign language) are processed by the primary and secondary visual cortices that then project to Wernicke area through the ventral visual stream. The arcuate fasciculus then projects from Wernicke area to Broca area (Brodmann areas 44 and 45) and the surrounding area to permit repetition. Broca area is the center for expressive language planning.

The majority of individuals are left dominant for language, meaning that language function is localized to the left hemisphere. Lateralization of language is associated with handedness, with approximately 90% of right-handed individuals

Auditory Comprehension	Writing	Reading	Repetition	Naming
Mostly normal	Impaired: Writing is effortful; function words and bound morphemes are often missing	Mostly normal	Impaired	Expressive naming affected
Mostly normal	Impaired: Writing is effortful; function words and bound morphemes are often missing	Mostly normal	Normal	Expressive naming affected
Impaired	Mostly normal, but contains paraphasic errors	Impaired	Impaired	Both expressive and receptive naming affected
Impaired	Mostly normal, but contains paraphasic errors	Impaired	Normal	Both expressive and receptive naming affected
Impaired	Impaired	Impaired	Impaired	Impaired
Intact	Intact	Mildly impaired with paraphasic errors	Impaired	Mostly normal
Intact	Intact	Intact	Intact	Impaired

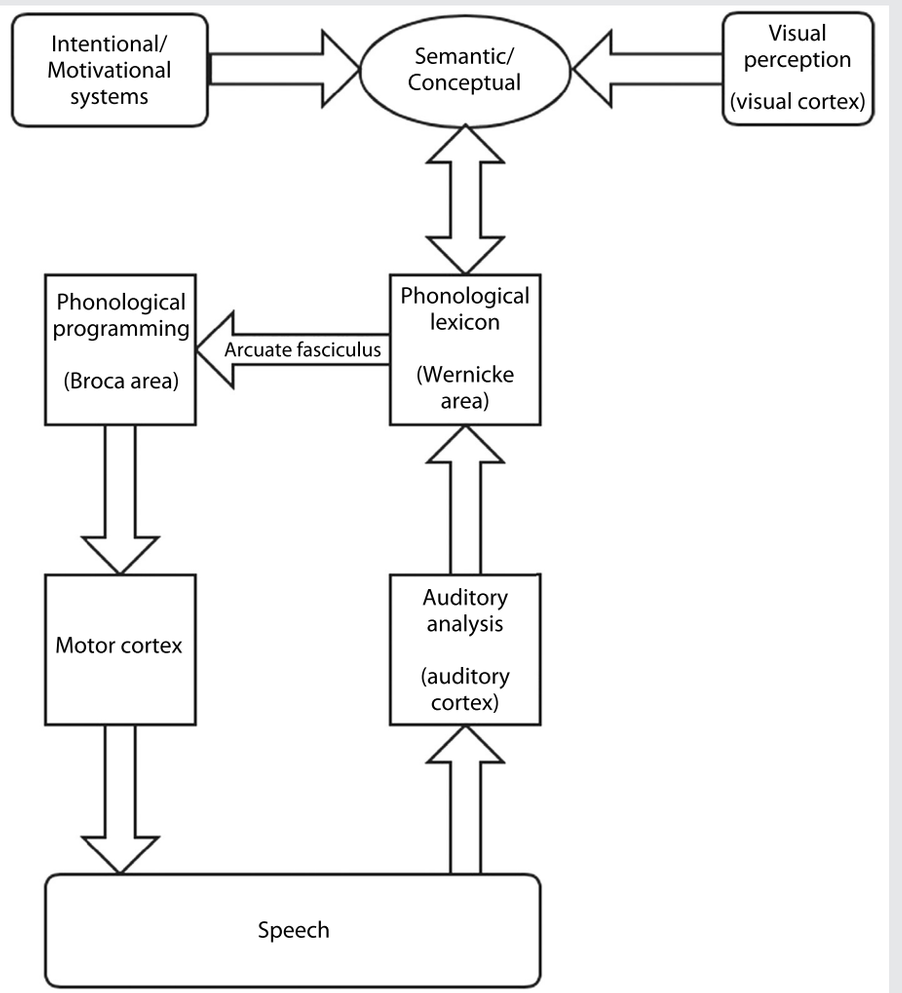

FIGURE 3-1 Classic connectionist model of language function. In this model, the frontal lobe may play a role in activating the semantic-conceptual areas, which then activate the phonological lexicon, allowing the person to produce spontaneous speech. When the phonological lexicon activates the semantic-conceptual field, the person is able to comprehend speech. The phonological lexicon is thought to contain memories of word sounds. Therefore, to understand speech, speech information enters the system through the auditory cortex, which is then sent to Wernicke area and then to semantic-conceptual areas (more widely distributed) to allow comprehension of the speech in the semantic-conceptual areas. To produce spontaneous speech, the frontal lobe (intentional/motivational systems) would activate the semantic-conceptual areas in order to activate the corresponding areas in Wernicke area, which would then project to Broca area and then to the motor cortex to activate the appropriate motor programs to produce the desired speech.

Data from Heilman KM, Oxford University Press.[2]

and 70% of left-handed individuals being left hemisphere dominant for language, although some debate exists about exact percentages. In left-handed individuals, about a third are either right hemisphere dominant or have language represented bilaterally. As over 90% of the world's population is right handed, this article will use the left hemisphere dominance for lateralization.

The right hemisphere is thought to play a role in the prosody of language. Prosody is often described as the lyrical aspect of language that conveys information

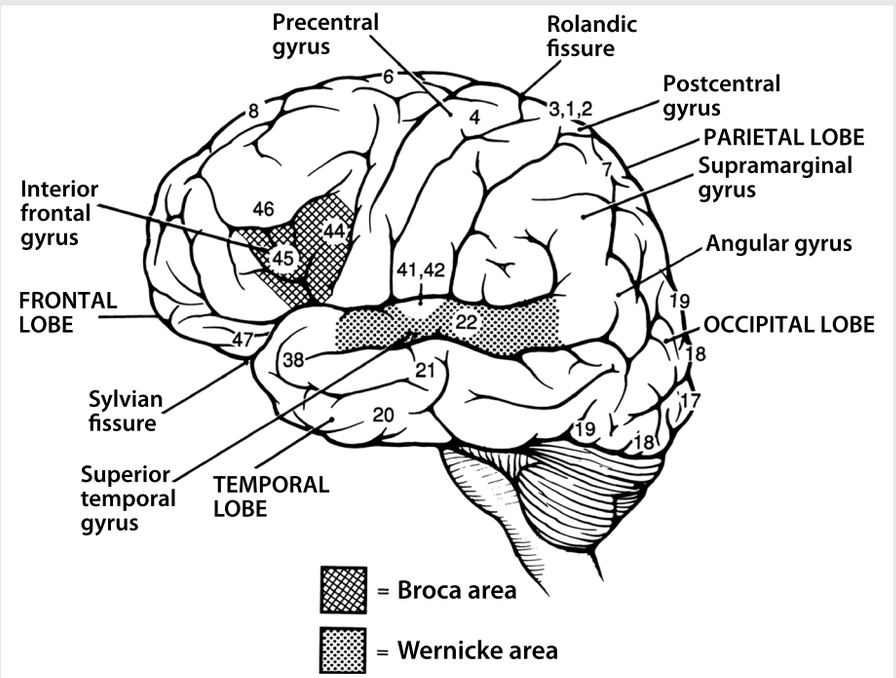

FIGURE 3-2 Neuroanatomy of language. Numbers refer to Brodmann areas.

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KEY POINTS

- The existing classic models of language function are being critically examined and updated based on use of functional imaging studies.
- Many patients with aphasia do not fit well into one of the classic aphasia syndromes.

beyond syntax and includes pitch, melody, cadence, and tempo.[4] The right hemisphere, in an analogous organization to the language representation in the left hemisphere, mediates both prosody and the interpretation of gesture.[4]

The connectionist model of language function, however, does not fully explain how words are organized into sentences. Therefore, the connectionist model, which is based on lesion studies, has recently come under scrutiny. Functional brain imaging[5] suggests language function is mediated by larger scale, distributed global networks in the brain, explaining why many patients with aphasia do not fit well into one of the classic connectionist aphasia syndromes.[1] The new models of the neuroanatomic basis of language are still under development[6] and will not be reviewed in detail in this article. Some of the emerging concepts include subregions of Broca area that serve different language functions,[7] a dual-stream, cortical organization of speech processing similar to that found for visual processing,[8] and a role for the cerebellum and subcortical structures in the temporal processing of speech.[9] Identifying the nodes and pathways of these distributed global networks will advance understanding of how both focal lesions and neurodegenerative disorders affect the networks involved in language function,[10] especially since different neurodegenerative disorders preferentially affect different large-scale brain networks.[11]

NONCLASSIC APHASIAS

In addition to the classic aphasia syndromes, neurologists commonly encounter a number of other aphasia syndromes.

Subcortical Aphasias

Thalamic aphasia. Thalamic aphasia has been identified after left thalamic hemorrhage and ischemic stroke (often

KEY POINTS

- Aphasia can develop after injury to either cortical or subcortical structures.
- Deficits in prosody can be mistaken for affective disorders and can be disabling.
- Due to the nature of the language network representation in the brain, deficits in written versus spoken expressive language can occur; for this reason, writing should be tested separately in patients with aphasia.

left tuberothalamic artery stroke). The aphasia that occurs after thalamic injury is variable and has been described as a fluent aphasia with normal repetition and more preserved comprehension than that seen in Wernicke aphasia. In this way, thalamic aphasia can resemble transcortical sensory aphasia. Perhaps due to involvement of other areas of the thalamus, this aphasia has been associated with a fluctuating course in not only language function, but also level of consciousness, alternating between an alert state with fairly normal speech and a lethargic state with dysarthria, paraphasic errors, and hypophonia.[3,12]

Striatal-capsular aphasia. This aphasia has also been associated with both hemorrhages as well as infarctions that involve the head of the left caudate nucleus, putamen, and surrounding white matter, including the internal capsule. Due to internal capsule involvement, a right-sided hemiparesis is often associated with this type of aphasia. Depending on which structures are affected, this aphasia can affect different parts of language, but a common syndrome is the anterior subcortical aphasia syndrome associated with lenticulostriate artery stroke, which produces a nonfluent aphasia often associated with dysarthria and paraphasic errors. Lesions of the body and tail of the caudate and putamen are not thought to cause aphasia.[12]

In general, a common, although not universal, distinguisher between thalamic aphasia and striatal-capsular aphasia is that thalamic aphasias are fluent, whereas striatal-capsular aphasias are nonfluent.

Aprosodias

Injury to the right hemisphere can impair the production, comprehension, and repetition of prosody, but leave the other aspects of language intact.[4] Lesions to the right frontal operculum can cause an expressive aprosody leading to a flat, monotonous speech pattern and decreased use of gesture.[13] A classification schema for the aprosodias analogous to the classic aphasias has been proposed,[4] and evidence exists that the primary progressive aphasias (PPAs) can affect both receptive and expressive aspects of prosody. Deficits in prosody can be mistaken for affective disorders and can be disabling, underscoring the importance of nonverbal aspects of language. Deficits in prosody have also been implicated in both autism spectrum disorders and schizophrenia.

Alexias

Alexias (inability to read) can be divided into the following three types:

Alexia with agraphia. Alexia with agraphia is essentially acquired illiteracy. In patients who have alexia with agraphia, reading and writing are both impaired, whereas other language functions are spared with the possible exception of paraphasias and naming errors. Alexia with agraphia is associated with a lesion in the left inferior parietal lobule, involving the angular gyrus. For this reason, it is often associated with Gerstmann syndrome (in which patients exhibit agraphia, acalculia, finger agnosia, and right-left disorientation) and other features of the angular gyrus syndrome such as anomia, constructional apraxia, and right inferior quadrantanopia.

Alexia without agraphia (sometimes called pure alexia). Alexia without agraphia is associated with an inability to read, but with an intact writing ability, ironically causing patients to be unable to read what they have just written. Associated symptoms include difficulty with color naming and right hemianopia. Some patients also experience anterograde amnesia difficulties since the causative lesion in the left medial occipitotemporal junction next to or involving the splenium of the corpus callosum can impact episodic memory networks.

Alexia associated with aphasia. Alexia associated with aphasia is the alexia found as part of an aphasia syndrome due to left frontal lesions causing Broca aphasia or global aphasia.

Pure Word Deafness

Pure word deafness, a type of agnosia, is the inability to understand speech despite otherwise intact language function. Patients are generally aware of their deficit and will sometimes describe speech as sounding like a foreign language. Because this deficit is often seen with bilateral superior temporal gyrus injury from stroke (or, rarely, only left-sided lesions) it can be accompanied by an auditory agnosia, which is the inability to identify nonspeech sounds. Pure word deafness is distinguished from cortical deafness in which the patients report that they are unable to recognize or differentiate any sounds. Cortical deafness is an uncommon disorder.[14]

ASSESSMENT OF LANGUAGE FUNCTION

Bedside Testing

All neurologists should be able to assess the key aspects of language efficiently and acutely at the bedside. A number of published bedside language assessments exist[15,16]; however, as the bedside assessment of language function is often more qualitative than quantitative, many examiners use one of their own creation. The following is a suggested approach to the bedside language examination:

- Observation: Listen to the patient's spontaneous speech to assess articulation of words, fluency, and prosody. If the patient produces little spontaneous verbal output, ask him or her to describe a picture such as the cookie theft picture from the Boston Diagnostic Aphasia Examination, although any picture showing action may be used. Paraphasic errors, sometimes referred to as paraphasias, are often identified during observation of speech and are the production of unintended phonemes, morphemes, words, or phrases. These are generally placed into the two categories of phonemic and semantic paraphasic errors, although other classification schemes exist. A phonemic paraphasic error occurs when a word is substituted with a nonword that retains a significant proportion (often over one-half) of the intended word's morphemes (the nonword sounds similar to the intended word). A semantic paraphasic error occurs when the intended word is replaced by another word that is inappropriate contextually, but often is semantically related (replacing "horse" for "cow").
- Comprehension (verbal and written): Start with one-step midline commands (''close your eyes''); progress to distal one-step commands (''hold up your left hand''); then progress to complex commands (''point to the door after you point to the window'').
- Repetition: Start with short complete sentences and progress to an open-ended phrase of at least five words in length, such as one used in the Boston Diagnostic Aphasia Examination (''near the table in the dining room'').[17]
- Naming: Start with whole items. Ask, ''What is this?'' and point to the object (eg, pen, watch), then progress to parts (eg, watchband cuff of shirt). In patients who either cannot perform these tasks or are nonfluent, test receptive naming by stating, ''Point to the pen,'' and hold out a pen and a watch.
- Writing: Have the patient write a sentence spontaneously. If the patient cannot produce a sentence spontaneously, have him or her

KEY POINTS

- Bedside testing of language function can be done efficiently, but for a comprehensive assessment of language, neuropsychological testing may be required.
- Neuropsychological testing provides a comprehensive and objective assessment of multiple cognitive domains, including expressive and receptive language function, repetition, naming, verbal fluency, and prosody.
- Neuropsychological testing allows for the precise assessment of language by using normative data to control for various demographic factors.

try to write by dictation. Because written expression can be affected separately from verbal expression, writing should be tested in addition to testing verbal output.

In addition, testing for an apraxia of speech should be part of the evaluation process for patients with a progressive aphasia. An apraxia of speech is a motor speech disorder characterized by a slow rate of speech and distorted speech sounds. To test for apraxia of speech, have the patient attempt to alternate between labial (produced by the lips), lingual (produced by the tongue), and guttural (produced by the soft palate and other throat structures) sounds by saying words such as ''patty-cake'' or ''irresponsibility.''

Neuropsychological Testing

Although the neurologist can test language function at the bedside, formal neuropsychological testing allows for a more comprehensive assessment of language with normative data corrected for age and a variety of demographic variables, such as gender, race, and educational level. Ample data support the utility of neuropsychological tests for both localizing organic brain dysfunction and providing some degree of predictive validity regarding the patient's functional ability in daily life **(Case 3-1) (Figure 3-3) (Table 3-2)**.[16] Neuropsychological evaluations are comprehensive, assess multiple cognitive domains, account for the patient's premorbid cognitive status, and can be performed with the help of an interpreter for individuals whose primary language is not English. In addition to a primary emphasis on language, the evaluation provides assessment of memory, attention and executive functions, and visual perceptual skills.

Neuropsychological evaluation of language includes assessment of expressive language (including writing), receptive language (including reading), repetition, naming, verbal fluency, and, in some cases, prosody.[18] Examples of comprehensive language measures include the Boston Diagnostic Aphasia Examination, Third Edition and the Western Aphasia Battery.[17,19] The Boston Naming Test[20] is a widely used instrument to detect impairments in naming associated with left temporal dysfunction. Whereas bedside assessment of naming usually relies on naming actual body parts and readily available objects, the Boston Naming Test uses pictures as the naming stimulus and provides robust normative data. **Table 3-3** provides an overview of common neuropsychological tests used to assess language function.

DISORDERS AFFECTING LANGUAGE

Aphasia can occur after any injury to the portions of the brain's language network. Stroke is a common cause of aphasia, and the common ischemic stroke syndromes associated with aphasia are summarized in **Table 3-4**. **Case 3-1** gives an example of the effects of an internal carotid artery occlusion on language function.

Other disorders causing structural lesions such as intracerebral hemorrhage, traumatic brain injury, and brain tumors may also produce aphasias. Since these lesions do not typically damage a predictable vascular territory, their associated neurologic features vary widely.

In addition to structural lesions, which can cause acute language dysfunction, many neurodegenerative disorders progressively degrade language. Understanding the distinguishing features of these neurodegenerative diseases aids the neurologist in making the proper diagnosis and implementing appropriate treatment. While many neurodegenerative disorders affect language, this section will provide an overview of disorders that have a language disturbance as a defining feature early in the clinical presentation.

Case 3-1

A 34-year-old right-handed woman sustained an unexplained, spontaneous left internal carotid artery dissection, which resulted in a large left middle cerebral artery stroke. Acutely, the patient evidenced dysphagia, global aphasia, right hemiplegia, left gaze preference (right neglect), and was following less than 25% of commands. Follow-up imaging several months later revealed large focal encephalomalacia along the left middle cerebral artery territory, particularly affecting the inferior division (**Figure 3-3**). On neuropsychological testing 18 months poststroke, the patient demonstrated impaired naming, vocabulary, reading, writing, auditory repetition, and spelling capabilities (**Table 3-2**). Her speech included decreased fluency and paraphasic errors. Examples of semantic paraphasias included ''saxophone'' for ''harmonica,'' and "buffalo" for "rhinoceros." Phonemic paraphasias were also present such as ''tactus, actus, and cascus'' for ''cactus.'' Her verbal output was greatly reduced as she did not speak phrases longer than two to three words. She often provided one-word automatic statements, such as ''sorry.'' She was able to read several key words in a passage, but because her reading was so nonfluent she had difficulty comprehending the context of the passage. The patient's repetition was also impaired. For example, the phrase, ''When you go climbing, watch for falling rocks,'' was repeated as, ''Outside, up, falling out.'' Basic receptive language skills were more functionally intact, such as understanding test instructions and following basic commands. Evidence of decreased insight and judgment was also present, contributing to concern about her ability to live independently and capacity for decision making. For example, the patient threw a lit cigarette into the trash can (which started a fire) in an attempt to avoid being caught smoking by her mother.

Neuropsychological test results from 18 months poststroke provided strong evidence of localization to the left hemisphere, including frontal (expressive), frontotemporal (receptive/comprehension), angular gyrus (reading), and temporal (auditory memory) brain regions. The arcuate fasciculus and other perisylvian connections were also affected given her impairments in repetition. Because of her severe deficits in language, impairment in executive functioning (eg, decreased insight and judgment), and conflicted family dynamics (eg, being subject to undue influence), she was determined to lack decision-making capacity by her family physician and neuropsychologist. A court concurred, deeming the patient incompetent to manage her affairs, and appointed the patient's sister as her legal guardian.

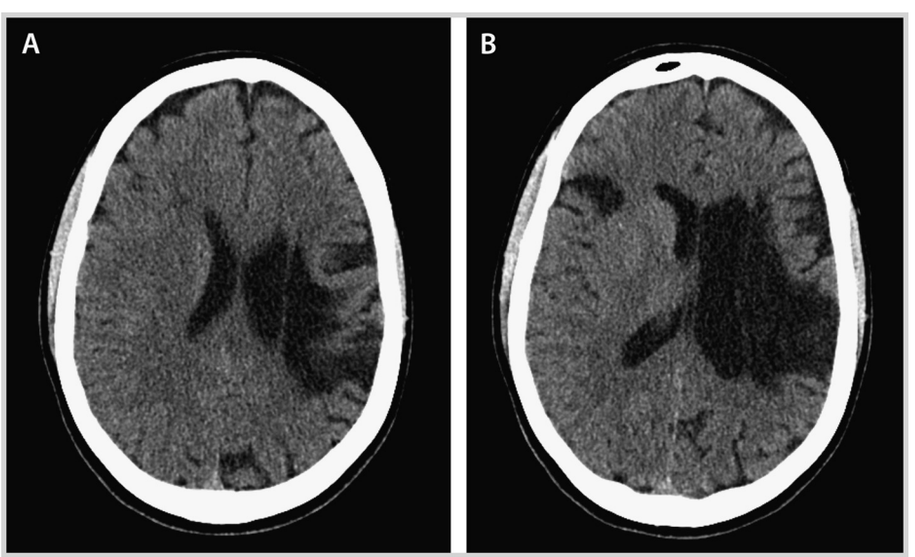

FIGURE 3-3 Axial noncontrast CT of the patient in Case 3-1 showing encephalomalacia in the left middle cerebral artery territory. *A* shows encephalomalacia of the inferior frontal lobe and parietal lobes. *B* shows full thickness injury to the left temporal lobe.

Courtesy of Christopher Schaeffer, MD, PhD, Borg & Ide Imaging, Rochester, New York.

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TABLE 3-2 Neuropsychological Test Results for the Patient in Case 3-1

Ability	Measure	Performance Description
Expressive		
Naming	Boston Naming Test	Severe impairment
Single word production	F-A-S Test	Severe impairment
	Animals	Severe impairment
Fluency	Clinical observation	Severe impairment
Semantic knowledge	Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV) vocabulary subtest	Severe impairment
Writing	Qualitatively assessed	Moderate impairment
Receptive		
Comprehension	Peabody Picture Vocabulary Test, Fourth Edition	Severe impairment
	Boston Diagnostic Aphasia Examination Complex Ideational	Severe impairment
Reading	Test of Premorbid Functioning	Severe impairment
	Wechsler Individual Achievement Test (WIAT), Third Edition Word Reading	Severe impairment
	Pseudoword Decoding	Severe impairment
Other Language		
Repetition	WIAT Sentence Repetition subtest	Severe impairment
Prosody	Qualitatively assessed	Functionally intact
Syntax	Qualitatively assessed	Impaired
Other Cognitive		
Visual perceptual	WAIS-IV Perceptual Reasoning Index	Average
Visuoconstruction	Rey Osterrieth Complex Figure Test	Average
Attention	WAIS-IV Digit Span Subtest	Severe impairment
Problem solving	Wisconsin Card Sorting Test	Mild impairment
Memory, auditory	Wechsler Memory Scale (WMS-IV) Logical Memory I and II	Moderate impairment
	Delayed Recall from Hopkins Verbal Learning Test, Revised	Average
Memory, visual	WMS-IV Visual Reproduction I and II	Low average to average
	Rey Osterrieth Complex Figure Test	Average

Comment. This case illustrates several important points. First, neuropsychological testing can delineate various aspects of language functioning associated with a particular diagnosis, such as a stroke. Second, the evaluation can provide increased specificity of localization. Additionally, testing can provide diagnostic clarity, particularly over time, as individuals may improve to some extent. In this case, the patient acutely demonstrated global aphasia, which improved to primarily Broca aphasia with less severe receptive language deficits at 18 months poststroke. Third, the case demonstrates that severe language deficits are often accompanied by other areas of cognitive dysfunction, such as impaired memory and executive functioning (eg, decreased insight and judgment, being subject to undue influence). Fourth, objective cognitive test data can be used to determine that a patient lacks decision-making capacity. Finally, the case illustrates the devastating effects that global aphasia has, even in an atypically young patient.

TABLE 3-3 Suggested Neuropsychological Tests of Language[a]

Ability	Sample Tests	Brief Description of the Test
Expressive		
Naming	Boston Naming Test	Sixty drawings of common objects are presented with increasing difficulty. Early items include scissors and a camel, with more difficult items being tongs and a trellis.
Single word production	Controlled Oral Word Association Test (F-A-S Test, animals)	The patient has 60 seconds to orally list words that start with the letters ''F, A, and S;'' proper nouns and repetitions are not counted.
	Delis-Kaplan Executive Function System (D-KEFS) verbal fluency subtest	The D-KEFS uses F-A-S Test and animals, but provides additional subtests for assessing semantic fluency, including boys' names and a category-switching test (ie, alternating between fruits and furniture).
Fluency	Cookie theft picture from the Boston Diagnostic Aphasia Examination (BDAE)	The patient orally describes what is happening in a scene, which the examiner records or writes down verbatim.
Writing	Thurstone Word Fluency Test	Five minutes are given to write down words that start with ''S'' and 4 minutes are given to write four-letter words that start with ''C.''
	Spontaneous writing and writing to dictation	Patients can be asked to write about any topic.
Receptive		
Comprehension	Token Test	Verbal commands of increasing complexity are provided using tokens of various shapes and colors.
	BDAE complex ideational	Patient responds to a series of yes/no questions after hearing a short story.
Naming	Peabody Picture Vocabulary Test, Fourth Edition	Assesses receptive vocabulary through a multiple-choice, nonverbal response format. The examiner says a word, and the examinee points to the corresponding picture from an array of four illustrations.
Reading	Test of Premorbid Functioning Wide Range Achievement Test 4 National Adult Reading Test Wechsler Individual Achievement Test, Third Edition (WIAT-III)	These four tests assess reading recognition by having patients read a list of words aloud. The words are irregularly spelled (eg, cough) to minimize patients' ability to apply standard pronunciation rules and maximize assessment of their prior learning of the word. Scores are often used to assess premorbid intellectual functioning.
Other Language Functions		
Repetition	Western Aphasia Battery repetition subtest	The patient repeats single words of increasing complexity, followed by short sentences. Points are deducted for phonemic paraphasias and errors in word sequence.
	WIAT-III sentence repetition subtest	The patient is asked to repeat sentences of increasing complexity.

Continued on page 638

TABLE 3-3 Suggested Neuropsychological Tests of Language[a] *Continued from page 637*

Ability	Sample Tests	Brief Description of the Test
Prosody	Advanced Clinical Solutions Social Perception Test	The patient listens to brief recordings and is asked to match the speaker's tone of voice with an emotion (eg, happy, sad, angry, afraid, surprised, disgusted, neutral, sarcastic).
Syntax	Northwestern Anagrams Test	A picture and corresponding word cards are presented in random order, requiring the patient to use all the words to make a sentence about the picture.
Semantic knowledge	Wechsler Adult Intelligence Scale, Fourth Edition vocabulary subtest	The patient orally defines various words of increasing complexity.
	Pyramid and Palm Trees Test	Forced choice format is used to assess the degree to which a patient can access semantic meaning from pictures and words. Six different versions of the test are possible by using either pictures or written or spoken words to change the modality of stimulus or response items.

[a] For a detailed review of neuropsychological assessment of language, including screening tests and comprehensive language batteries, see Lezak MD, et al, 2004.[16]

TABLE 3-4 Stroke Syndromes Causing Aphasia[a]

Arterial Territory	Aphasia Syndrome	Associated Signs	Associated Behavioral Symptoms
Superior division of middle cerebral artery	Broca	Right hemiparesis, possible right hemisensory loss	Depressed affect, frustration
Superior division of middle cerebral artery or anterior cerebral artery	Transcortical motor	Right leg more than arm weakness	Abulia (lack of motivation)
Inferior division of middle cerebral artery	Wernicke	Right superior quadrantanopia	Agitation, anosognosia
Watershed infarct	Transcortical sensory	Variable	Variable
Proximal middle cerebral artery or internal carotid artery	Global aphasia	Right hemiparesis, hemisensory loss, and hemianopia	Variable
Branch of inferior or superior division of middle cerebral artery	Conduction aphasia	Right hemiparesis, right hemisensory loss, apraxia	No typical symptoms
Many	Anomic aphasia	Variable	No typical symptoms

[a] Presumed left hemisphere dominance.

Alzheimer Disease

Memory impairment and anomia are often the earliest cognitive symptoms in Alzheimer disease, although primary language presentations occur, as is discussed in the section on the logopenic variant of primary progressive aphasia. Confrontation naming can be impaired early in the disease process and markedly worsens as the disease progresses. Alzheimer disease also impacts verbal fluency, affecting semantic fluency (eg, ability to name animals in 1 minute) greater than phonemic fluency (eg, ability to name words beginning with "F" in 1 minute).[21] However, verbal fluency has not been found to be a strong predictor of progression from mild cognitive impairment to Alzheimer disease, and semantic fluency deficits have not been consistently found to discriminate Alzheimer disease from other dementias such as patients with dementia from Parkinson and Huntington disease.[22] Advanced Alzheimer disease devastates multiple cognitive processes resulting in aphasia, agnosia, and apraxia as well as amnesia.[18]

Primary Progressive Aphasias

The primary progressive aphasias (PPAs) are progressive neurodegenerative aphasia syndromes that generally occur without other significant cognitive impairment early in the disease course. In fact, many patients remain dementia-free for at least 2 years and as long as 10 years,[23] although almost all progress to a dementia syndrome as the disease impacts other cognitive domains. Three variants of PPAs have been described: agrammatic variant of primary progressive aphasia (agPPA), semantic variant of primary progressive aphasia (svPPA), and logopenic variant of primary progressive aphasia (sometimes called logopenic phonological aphasia) (lvPPA). Diagnostic criteria have been proposed for the different variants,[24] although a number of patients with PPA are not well categorized by the current classification system.[25] The variants agPPA and svPPA are currently thought to be a subtype of frontotemporal lobar degeneration (FTLD) and share underlying pathology, most often tau-positive or TAR-DNA binding protein 43 (TDP-43)–positive neuronal inclusions, whereas lvPPA often has underlying Alzheimer disease pathology.[26] The PPA variants have corresponding patterns of regional atrophy affecting dominant hemisphere language networks. Disease progression is associated with more widespread left hemisphere atrophy and increasing involvement of the right hemisphere. Therefore, cognitive deficits evolve beyond language dysfunction, including the development of behavioral abnormalities.

Agrammatic variant of primary progressive aphasia. Patients with agPPA, sometimes referred to as progressive nonfluent aphasia or the nonfluent/agrammatic variant of PPA, have progressive impairment of grammar leading to a nonfluent style of expressive communication. Some patients exhibit an associated apraxia of speech. Both speech and writing become nonfluent and effortful, with phonological and grammatic errors progressively increasing. Comprehension of words and repetition remain intact except for syntactically complex sentences. Speech articulation can be disturbed if there is an associated apraxia of speech. On imaging, agPPA is commonly associated with atrophy and hypometabolism of the left posterior inferior frontal and insular cortices.[25,27] Pathologically, agPPA is associated with frontotemporal degeneration with tau-positive neuronal inclusions, in particular when there is an associated apraxia of speech; however, some patients with agPPA may have other underlying pathologies including progressive supranuclear palsy, corticobasal degeneration, and tau-negative frontotemporal degeneration.[28]

KEY POINTS

- The clinical syndrome of primary progressive aphasia can be caused by Alzheimer disease or frontotemporal lobar degeneration pathology.
- Agrammatic variant of primary progressive aphasia is characterized by loss of grammar leading to progressively nonfluent speech.

Semantic variant of primary progressive aphasia. Patients with the svPPA, sometimes referred to as semantic dementia, have progressive anomia and impairment in single word comprehension. Although patients present with word-finding difficulties, the most striking finding is impaired knowledge of word meaning, identified on testing as a single word comprehension deficit (**Case 3-2**). svPPA patients fail to comprehend the meaning of words, although the word may seem familiar. Grammar and syntax are often spared. Unlike other dementias, recent memories may be better preserved than remote memories.[29] On imaging, atrophy and hypometabolism of the anterior left temporal lobe is common, particularly the inferior and middle temporal gyri. The amygdala and hippocampus may also be affected.[25,27,30] The

Case 3-2

An 86-year-old woman presented for ''memory loss,'' but she could not relay her history because of frequent word-finding problems and difficulty with comprehension. The patient had begun referring to everyone as ''she'' and had been referring to words in a strange way. During a discussion about a hotel, she asked, ''What is Holiday Inn?'' More recently, the patient's children had to take over managing all of her daily activities. She lost the ability to use the microwave and television remote control, and she also became obsessed with household cleaning and spent all day performing the same cleaning activity multiple times.

Despite having no personal history of stroke, she was previously diagnosed with vascular dementia based on MRI findings that had been interpreted to be due to a stroke (**Figure 3-4**). Her examination was dominated by a comprehension deficit with frequent paraphasic errors. Some errors were phonemic, such as saying ''pretzel'' when asked to name a picture of a cello, but some responses were nonsensical, as when she said ''for rain, wine, onion'' when asked to name a picture of a saw. She did not have an apraxia of speech. The patient's neuropsychological testing is shown in **Table 3-5**.

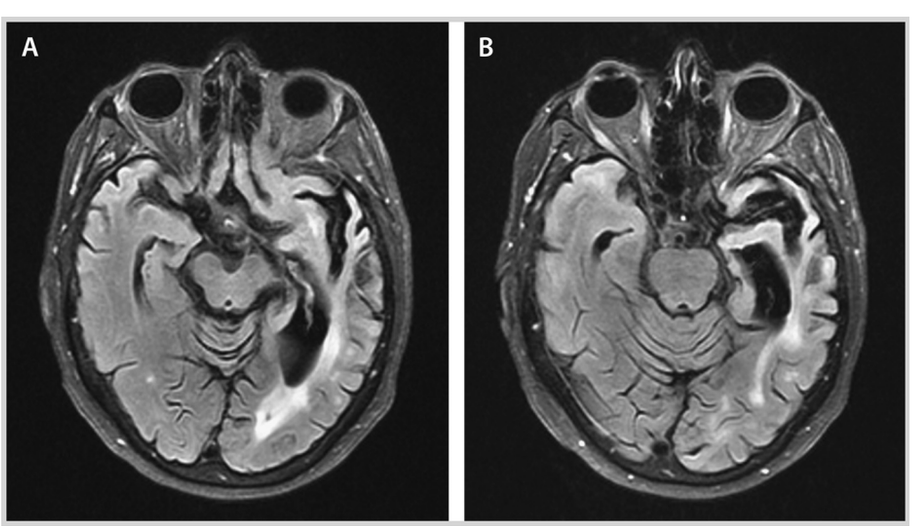

FIGURE 3-4 Axial fluid-attenuated inversion recovery (FLAIR) MRI of the patient in Case 3-2 showing left anterior temporal lobe atrophy with surrounding gliosis (*A, B*). Note atrophy of both the amygdala and hippocampus (left greater than right) in panel B.

Courtesy of Christopher Schaeffer, MD, PhD, Borg & Ide Imaging, Rochester, New York.

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TABLE 3-5 Neuropsychological Test Results for the Patient in Case 3-2

Ability	Measure	Performance Description
Expressive		
Naming	Boston Naming Test	Impaired
Single word production	F-A-S Test	Impaired
	Animals	Impaired
Fluency	Clinical observation	Fluent with paraphasic errors
Semantic knowledge	Pyramids and Palm Trees Test	Impaired
Writing	Qualitative assessment	Fluent with paraphasic errors
Receptive		
Naming	Peabody Picture Vocabulary Test, Fourth Edition	Impaired
Comprehension	Qualitative assessment	Impaired
Reading	Test of Premorbid Functioning	Low average
Other Language		
Repetition	Qualitative assessment	Impaired
Prosody	Qualitative assessment	Normal
Syntax	Northwestern Anagrams Test	Normal
Other Cognitive		
Visuospatial	Complex figure copy and judgment of line orientation subtests of the Repeatable Battery for Assessment of Neuropsychological Status (RBANS)	Average
Attention	Digit Span Subtest of RBANS	Impaired
Executive function	Trail Making Test A	Impaired
Memory, auditory	List learning task and story memory subtests of RBANS	Impaired
Memory, visual	Complex figure recall from RBANS	Impaired

Comment. The patients' case highlights several common issues that arise in patients with semantic variant of primary progressive aphasia (svPPA). First, patients are often referred for memory dysfunction, but this concern is often an overgeneralization, and identifying the actual initial presenting symptom is critical to making a correct diagnosis. Next, the patient's MRI findings of marked asymmetric anterior temporal lobe atrophy with surrounding gliosis is suggestive of svPPA, but these findings, not uncommonly, will be misread as a stroke or traumatic brain injury. Next, patients with svPPA have a single word comprehension deficit that makes them unable to follow even simple sentences and causes them to refer to words in the abstract, suggesting that the link to semantic knowledge of an item is disrupted. These deficits in receptive and expressive naming in svPPA often manifest on neuropsychological testing as difficulty understanding instructions for cognitive testing, leading to a pattern of diffuse impairment. Lastly, typical of patients with svPPA, the patient's language deficits progressed and affected other aspects of cognition and behavior seen in the behavioral variant of frontotemporal degeneration.

KEY POINTS

- Semantic variant of primary progressive aphasia is characterized by single word comprehension deficits.
- Logopenic variant of primary progressive aphasia is characterized by nonfluent, effortful speech with an anomia, but without a single word comprehension deficit.
- The current clinical classification systems for patients with primary progressive aphasia do not permit accurate prediction of underlying pathology.
- Detecting a psychogenic language disorder is a rigorous process of exclusion and requires understanding the psychosocial factors that contribute to symptom production.

consistent finding of anterior temporal lobe involvement in svPPA has suggested this area is part of a semantic memory network. Pathologically, svPPA is associated with non-tau neuronal inclusions, most often TDP-43 neuronal inclusions.[31,32]

Logopenic variant of primary progressive aphasia. Patients with lvPPA, sometimes referred to as logopenic phonological aphasia, have speech that is nonfluent, effortful, and have frequent word-finding pauses resulting in an anomia *without* a single word comprehension deficit. Patients may also exhibit difficulty with repetition, particularly of sentences and may make phonological errors, which involve patterns of sound errors. For example, patients may substitute sounds made in the back of the mouth like "K" and "G" for those in the front of the mouth like "T" and "D" (eg, saying "tup" for "cup" or "das" for "gas").[33] In addition to aphasia, patients have reduced digit span and, usually, impaired verbal episodic memory. On imaging, patients with lvPPA demonstrate cortical atrophy in the left posterior superior temporal, inferior parietal, medial temporal, and posterior cingulate gyri.[34] As the disease progresses, atrophy develops in the left anterior temporal and frontal cortices, moving to the right hemisphere, where it affects the temporoparietal junction, posterior cingulate, and medial temporal lobe. On fluorodeoxyglucose positron emission tomography (FDG-PET) imaging, lvPPA patients have the bilateral temporoparietal hypometabolism pattern typical of Alzheimer disease as well as left lateral frontal and medial parietal lobe hypometabolism.[27] Recent evidence suggests that lvPPA includes Alzheimer disease pathology in a high proportion of cases and may be the most common aphasia phenotype of Alzheimer disease,[35] leading some to refer to lvPPA as the "unihemispheric" or "language" presentation of Alzheimer disease.

Language Impairment of Unexplained Etiology (Functional or Psychogenic)

Slowed speech with an atypical halting or stuttering quality may be suggestive of a functional or psychogenic aphasia. The absence of a medical condition to account for the abnormal language symptoms is an important initial clue for considering a functional aphasia. For example, a concussion or mild traumatic brain injury resulting in significant focal language deficits (eg, impaired articulation, nonfluent speech, agrammatism, aprosodia) is highly atypical and should raise suspicion of a psychogenic origin.[36] Fluency impairment in conversational speech (as opposed to verbal fluency tests) following uncomplicated mild traumatic brain injury should alert clinicians to assess motivation, financial, psychosocial, and psychiatric issues perpetuating symptom maintenance.[37] Other potential indicators of psychogenic language disorders after mild traumatic brain injury include experiencing late-onset language difficulties (eg, months postinjury), reporting deficits worsening over time, and exhibiting an inconsistent abnormality in speech patterns. An example of language inconsistency is an inconsistent paraphasic error for a certain sound, such as incorrectly reproducing sounds, like saying "torry" for "sorry" but later correctly saying the word "scene."

Stuttering acquired in adulthood can also be indicative of a psychogenic cause and is more likely to be so if it does not improve in situations that usually improve fluency, such as speaking or singing in unison or when performing over-learned recitation tasks (eg, saying the days of the week or counting). Inconsistencies can also be associated with psychogenic stuttering. This includes periods of time

with no stuttering, marked differences between conversation and reading, and worsening of stuttering when performing less difficult tasks.[38]

Individuals with psychogenic language disorders often present with considerable distress about their condition while minimizing any potential psychological issues they may be experiencing. Common risk factors for conversion disorder include history of psychological trauma and histrionic personality disorder features associated with attention seeking, somatic symptom disorders, and secondary gain incentives (eg, litigation, disability claims, and increased attention from caretakers).

Evaluation of a functional or psychogenic language disorder includes a thorough physical examination and neurologic workup to ensure the proper differential diagnosis. Obtaining collateral information from the patient's primary care provider and family members or caregivers is necessary to provide a framework for understanding the patient's functioning. In many cases, referral for neuropsychological evaluation is useful to assess motivation, effort, and language skills. Psychotherapy is the treatment of choice for conversion and somatic symptom disorders, including functional or psychogenic language disorders.

TREATMENT/RECOVERY

Recovery from acute causes of language disturbance, such as stroke or traumatic brain injury, is dependent on multiple injury factors such as the size and location of the area injured. There is evidence for neuroplasticity as a mechanism for recovery. After ischemic stroke, areas of the brain recruited during performance of language vary for distinct language tasks and also across individuals with similar size and site of lesions. However, individuals with extensive lesions in Broca area are less able to recover language function.[39]

Noninjury factors also play an important role in a patient's recovery, including premorbid intellectual and educational levels and cognitive reserve, personality characteristics, emotional stability, level of family support, and accessibility of services. Patients with more diffuse cognitive dysfunction in addition to focal language deficits will experience other barriers to recovery. For example, patients with preaphasia frontal lobe dysfunction may experience decreased insight into their deficits as well as personality and mood changes that may adversely impact recovery. Patients with preaphasia temporal lobe dysfunction may experience memory impairment that may limit their ability to utilize compensatory strategies.

Length of recovery from focal damage to language areas varies but generally ranges from 1 to 2 years postinjury. While the most dramatic spontaneous improvements tend to occur in the first several months, the use of physical, speech, and occupational therapies can facilitate restorative gains and compensatory adjustments well beyond that point.

Referrals to speech therapy are appropriate for focal language deficits and other cognitive dysfunction. Acute therapy emphasizes brain stimulation to restore functioning and recruit new neuronal pathways. Patients can also benefit from returning to outpatient speech therapy and cognitive rehabilitation several years after their injury to develop and fine-tune compensatory strategies to adjust for persistent deficits. There has been some support for the efficacy of speech therapy to treat language disturbance in PPA; however, studies suggest that improvements on specific language therapy exercises are neither readily generalizable to other language tasks, nor maintained for more than several months after treatment discontinuation.[40]

In addition to speech therapy, some support exists for the use of donepezil to treat poststroke aphasia and memory

KEY POINTS

- Mild traumatic brain injury is not typically associated with significant focal language disturbance, and, therefore, focal language dysfunction after mild traumatic brain injury should raise concern for a psychogenic cause.
- Treatment of language impairment varies based on etiology but often requires addressing physical, cognitive, and emotional factors through a comprehensive rehabilitation program targeting restorative and compensatory approaches.

dysfunction.[41] Due to the lack of evidence for the cholinesterase inhibitors and memantine in neurodegenerative disorders outside of Alzheimer disease, use of these agents is not common for patients with agPPA and svPPA but could be considered in patients with lvPPA.

CONCLUSION

Language is a multidimensional and complex cognitive function that involves a defined network of brain regions in the left and right hemispheres. There are specific assessment techniques that allow clinicians to identify focal lesions and the neurodegenerative disorders that affect language. However, our current understanding of brain/behavior relationships in language function is incomplete. Future research will include further refinement of our knowledge of how the brain processes language, which will improve our ability to clinically assess and treat language dysfunction.

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