13

Aphasia

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13.1 Introduction

Aphasia is an acquired language disorder that is caused by a focal brain lesion after the period of language development. The most obvious symptoms occur in speech production. Frequent phenomena are: word-finding problems, speech errors and sentence construction problems. Apart from these difficulties, almost all individuals with aphasia encounter problems with language comprehension. However, language comprehension problems are usually less obvious and sometimes only detectable through language testing. Most aphasic people have reading and writing difficulties alongside disorders in speech production and comprehension of spoken language. In this chapter, the types of brain damage that may result in aphasia are examined. The symptoms and syndromes of aphasia, the relation between brain and language, and some current topics in aphasiology will also be addressed.

Although aphasia is usually manifest in the four language modalities of speech, comprehension of spoken language, writing and reading, the differences between individual speakers with aphasia can be large, both in nature and in severity. In many aphasic individuals, some linguistic abilities, such as spontaneous speech production, naming and reading (aloud), can be significantly impaired, whereas other language functions, such as comprehension of spoken language and (silent) reading, are relatively intact. There is a clear relation between the impairments of aphasia and the location of brain damage. Accordingly, aphasia can provide useful information about the neural basis of language and about the way different modes of language use (e.g. naming of objects, comprehension of written sentences) are organized in the brain.

13.2 Aphasia: some background

13.2.1 Definition of aphasia

> Aphasia is a disorder in the production and comprehension of spoken and written language. It is caused by a unilateral localized brain lesion in individuals who had normal language development.

Several features of this definition of aphasia are noteworthy. The first is that aphasia is a *language* disorder. In this chapter, the expression 'language disorder' is used to show that aphasia is a central deficit affecting both comprehension and production and both spoken and written language. Defining aphasia as a language disorder distinguishes it from articulation disorders, such as dysarthria (a motor speech disorder; see Chapter 11, this volume) and apraxia of speech (a disorder in programming and monitoring articulation, see Chapter 12, this volume). Such disorders often accompany aphasia, but can also occur without aphasia. Brain damage may affect articulatory abilities, for example, because the motor area is affected. In such cases, the person will display speech problems (a dysarthria). However, he or she will still be able to write and to understand both spoken and written language, because the language system itself is intact. Also, disorders in auditory and visual perception due to brain damage are excluded by this definition. Such disorders may result in auditory comprehension or reading problems, but these are not the consequence of a language disorder.

Communication disorders as a result of dementia are also excluded by this definition of aphasia. This is because there is no unilateral brain lesion and the language problems in dementia are progressive (see Chapter 15, this volume). Communication disorders due to psychiatric conditions (such as schizophrenia and depression) are also outside the scope of the definition, because in these cases there is no acquired brain lesion (Chapter 17, this volume). Aphasia should also be distinguished from developmental language problems in children. In order to make this distinction, aphasia is defined as an *acquired* language disorder. Developmental language disorders may have several origins: neurological damage that arises perinatally, specific genetic syndromes (as in Down syndrome; see Chapter 7, this volume), but often there is no known cause (as in specific language impairment; see Chapter 5, this volume). The nature and the development of all these disorders may be very different from those in aphasia and, therefore, they are excluded from the definition of aphasia. If children acquire brain damage during the critical period of language development (e.g. due to a traumatic injury or a stroke), language problems may arise. This is called '(acquired) childhood aphasia'.

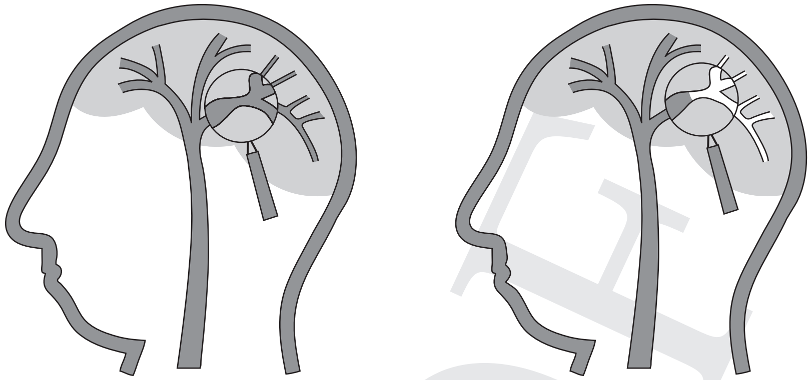

Figure 13.1 Illustration of how blood flow diminishes due to thrombosis (left) and how an embolus blocks the artery (right). (Reprinted from Bastiaanse (2010) with permission of the publisher.)

13.2.2 Causes and prevalence

By far the most frequent cause of aphasia is a cerebrovascular accident (CVA), commonly known as a stroke. A CVA causes around 85 per cent of aphasia cases (Bastiaanse 2010). It can occur in two ways. The first kind of stroke is an infarction. There are two possible causes of an infarct. First there is thrombosis. A thrombosis is a blood clot ('thrombus') in the artery. In damaged arteries blood clotting may occur because the inner tissue of the artery is affected. When these blood clots grow, they partially or entirely block the artery. As a consequence, the area behind the clot is insufficiently supplied with oxygen and necessary nutritional substances and, as a result, ceases to function (see Figure 13.1, left diagram).

A thrombosis may not be situated in the brain itself but be found in the heart or the carotid artery in the neck. Regardless of its location, parts of a thrombosis may tear off and flow into smaller arteries in the brain, which then may be (partially or totally) blocked. Again, the area behind the blockage will cease to function. A blood clot that tears off is called an embolus (see Figure 13.1, right diagram).

The second kind of stroke is a haemorrhage. This occurs when there is a rupture in one of the arteries supplying the brain. Blood flows out of the artery (see Figure 13.2) with the result that the area supplied by the damaged artery receives insufficient oxygen and other vital nutrients and ceases to function. Additionally, the blood that leaks out of the artery into the confined space within the skull increases the intracranial pressure. This blood puts pressure on the tissue surrounding the artery and prevents that area from functioning. Thus, the surrounding tissue is damaged as well.

The second most frequent cause of aphasia, after stroke, is traumatic brain injury (TBI). The term 'traumatic' refers to the fact that damage arises from some form of trauma, which in peacetime is most commonly

Figure 13.2 Illustration of a weak spot in the artery (left) resulting in a haemorrhage (right). (Reprinted from Bastiaanse (2010) with permission of the publisher.)

a road traffic accident. TBI may also be caused by violence, gunshots and falls. This explains why aphasia due to TBI is more often seen in younger people, whereas aphasia due to stroke is usually found in older people.

Within TBI, a distinction is made between open and closed head injury. This distinction refers to whether or not the skull is damaged. Open head injuries bring a risk of complications due to infection that add to the severity of the condition. In TBI, the lesion may be large and diffuse rather than focal or there may be multiple lesions. As a consequence, aphasia due to TBI is usually accompanied by other severe and often more prominent cognitive disorders, such as memory and behavioural problems. An exception to the large lesions in TBI is the small and well-defined lesion caused by a gunshot or shrapnel. These small lesions have contributed significantly to our knowledge of aphasia and the representation of language in the brain. Many soldiers who acquired head wounds due to gunshots or shrapnel in the first and second world wars have been extensively studied by aphasiologists in the Soviet Union, the UK and the USA.

The third type of brain damage that may cause aphasia is a tumour. Whether a tumour is malignant or benign is immaterial as far as the aphasia is concerned. A tumour is usually growing and occupies space. Since an inflexible skull protects the brain, the tumour will press on healthy tissue as it grows. If this tissue is involved in language, then aphasia is the result. The final and least common cause of aphasia is an infection in the brain, such as meningitis or encephalitis. This rarely occurs and the descriptions of aphasia after an infection are restricted to a relatively small number of case studies (e.g. Stewart *et al.* 1992).

Usually, aphasia is not a separate diagnostic category in medical registration systems and, therefore, there are no exact data on the frequency of occurrence of aphasia. For the USA and the UK, the estimate of the incidence (the number of new aphasia cases per year) is 170,000 for the USA and over 35,000 for the UK (Code 2010). The number of individuals suffering from aphasia (the prevalence) is around 0.37 per cent for both countries, that is, around 1 million for the USA and around 220,000 for the UK (Code 2010).

13.2.3 Recovery and prognosis

Brain cells only function properly if sufficient oxygen and essential nutrients are transported to the brain by the blood. In case of a lack of these nutrients, the brain cells become hypo-ischaemic and 'die'. This is known as necrosis. Until recently, it was thought that brain cells do not regenerate and that, therefore, brain damage is irreversible. It was thought that once a person becomes aphasic, the condition is permanent. However, it is now known that this is not the case. During the first few months after the occurrence of brain damage, significant improvement and even complete recovery in functioning are possible. Some cells that fail to function because of a lack of oxygen may regenerate. This phenomenon provides an explanation for the changes that are often seen in people with aphasia.

There are other explanations for improvement of aphasia after brain damage and these are more widely accepted. When the brain is wounded, swelling known as oedema often occurs. Because the brain is within the confined and non-expandable space of the skull, this swelling causes pressure in the brain to increase. As a result, some cells die while others may receive insufficient oxygen and nutrients to function (but enough to survive). After the immediate acute stage (around 2–3 months), the swelling diminishes as does the pressure on the brain. This allows non-functioning brain cells to regain their function. There is also some evidence that certain connections between the cells may regenerate during the first few weeks or months (e.g. Carmichael 2006). This explains why in most individuals spontaneous recovery of cognitive and physical functions takes place in the weeks and months immediately after brain damage. After this period of spontaneous recovery, aphasia in most cases will be permanent, although improvement of language and communication is still possible.

There are four major factors that further influence the recovery and prognosis of aphasia:

(1) Severity: Individuals with a severe aphasia, usually due to a large lesion, have a poorer prognosis than individuals with mild aphasia, especially beyond the period of spontaneous recovery.
(2) Age: In general, recovery is better for younger people. This age effect is shown in both stroke and trauma victims, although the degree of recovery is usually larger in the first group.
(3) Cause: Aphasia due to trauma has, in general, a better prognosis than aphasia due to a stroke. This may be related to the fact that people with TBI are usually younger than stroke victims.

(4) Left-handedness: Left-handed individuals and people who are ambidextrous have, in general, a better chance of (spontaneous) recovery than people who are right-handed. This is probably related to bilateral language organization in left-handed individuals.

It cannot be excluded that some factors such as the (premorbid) intelligence, general health condition and motivation have some positive influence on the recovery process in aphasia. However, the effect of these factors has not been clearly demonstrated. Furthermore, aphasia therapy aims to influence the recovery process, but as yet, there is no consensus about the most effective method (see Chapter 24, this volume).

13.3 Aphasia symptoms

Aphasia is virtually always manifested in both productive (speech and writing) and receptive (comprehension of spoken language and reading) language modalities. Although linguistic symptoms may vary, it is usually impairments in speech production, specifically everyday language use, that are most prominent and disturbing for the aphasic individual and people in his or her environment.

13.3.1 Spontaneous speech

Linguistic impairments in spontaneous speech may occur at the phonological, lexical-semantic and grammatical level. Phonological problems are evident in the production of phonemic paraphasias, in which one or more sounds ('phonemes') of the target word are substituted (e.g. 'diger' instead of 'tiger'), omitted (e.g. 'tain' instead of 'train'), transposed (e.g. 'sarmaphy' instead of 'pharmacy') or added (e.g. 'ancknowledge' instead of 'acknowledge'). If an aphasic speaker corrupts the word in a way that it is no longer recognizable for the listener, the result is called a 'neologism' (e.g. 'lackle'; 'fatalogle').

Most aphasic speakers have problems finding the right words at the right moment. These lexical-semantic difficulties or word-finding problems are most prominent during a naming task, in which pictures of objects and animals are shown to the aphasic individual who must name them. However, word-finding problems may also occur in spontaneous speech in one of the following ways:

(1) The aphasic individual has no articulation problems and speaks fluently, but his speech is characterized by a lack of explicit information ('empty speech'), because a relatively large number of content words (nouns, verbs and adjectives) are omitted and substituted by common words such as 'thing', 'there', 'do' and/or personal pronouns without a clear referent.

(2) The aphasic individual hesitates and blocks before key words, for example: 'and then I go wa- … eh with water … no with … yes with water yes … to make and then eh …' (searching for the word 'wash'). Often the aphasic speaker indicates that he or she cannot find the word, for example, 'I cannot say it, but …', or 'what's the name again?'
(3) The aphasic speaker produces verbal paraphasias (word substitutions) that are often related in meaning to the target word, for example, 'boy' instead of 'girl'. This is called a semantic paraphasia. If there is no relation with the target word, then such a word substitution is called an irrelevant or unrelated paraphasia. An aphasic speaker may produce so many paraphasias that he or she is hardly comprehensible. This is called semantic jargon. A typical example is the following fragment in which the aphasic speaker tries to explain how she usually spends her day (… = pause).

> Yes and I do like drying and riding my bike and … when the weather is nice here on the deck … and how I … well I know the most beautiful from I eh play me strike with gauze and I play with it me strike with my toe … I can do what I want on it and I give presents to everything with so called presents … what we do eh and I goes in the evening before we will, as they say … when we had dinner then I help the room help I all dipping.

Most aphasic speakers have additional problems with formulating sentences. These grammatical problems appear in two different forms: (1) impoverished sentence structure and simplification of the grammatical structure (agrammatism or telegraphic speech) and (2) erratic application of the grammatical rules (paragrammatism). Agrammatic speech is usually slow and effortful and is characterized by short sentences. It consists mainly of content words – function words (articles, prepositions and conjunctions) are largely lacking. A typical example of agrammatic speech is shown below. Here, the aphasic speaker is talking about her hometown (the words of the interviewer are between square brackets):

> Amsterdam … and eh … beautiful … eh … I … nice … walk [Okay. Where?] Where? Eh … Amsterdam [Are you walking around the city?] No bike or no eh … eh … car eh … shopping … and eh … eh call and eh … first eh … eh … cup of coffee … eh … Mary and eh … talking a bit.

Paragrammatic speech is fluent with normal speech rate and intonation. Although sentences are long and syntactically complex, they are often incorrectly structured. Many function words and inflections ('affixes') are substituted and sentence structures are often entangled or left incomplete. Paragrammatic speakers often use many phonemic and verbal paraphasias, making them hard to comprehend, as shown by the following extract:

[If I enter your house, what does it look like?] If you enter, you get immediately space that is for the space that is around the front door that is left rather small, but then furthermore for the rest everything in the house remained space. Downstairs, I should say a space that camou camouflage, downstairs a room that is left rather spacious. Herewith a space for the garage and above garage where you so big big/grit/ [neologism] your /grit/ with not in the middle in the house, out interior design rather bi rather big.

13.3.2 More expressive symptoms

Apart from these expressive characteristics, individuals with aphasia can demonstrate several other symptoms, such as stereotypes, speech automatisms, recurring utterances, echolalia and perseverations. In stereotypes, the aphasic speaker produces a word, phrase or sentence that is communicatively more or less appropriate, more frequently than normal, for example 'and so on', 'damned' (and other curses), 'I don't know', 'what's the name?', 'I can't say it'. The speaker cannot convey more specific information even when asked to do so. A speech automatism is a word or phrase that is repeated over and over again, but which is not communicatively appropriate. Most often, this is the only speech that the individual with (severe) aphasia is producing. It can be accompanied by (often unreliable) production of 'yes' and 'no'. Usually the speaker is able to apply a variety of intonation contours, resulting in (limited) transfer of information. Some aphasic speakers use the same speech automatism for years, for example 'Sunday morning special' and 'from the government'.

Recurring utterances are similar to speech automatisms, but are non-words that are continuously repeated. They usually have a very simple structure consisting of a vowel and a consonant or a consonant and a vowel. Consonant clusters are hardly ever observed. Examples are 'popopo' or 'tatatata'. As in speech automatism, prosody and intonation seem to be preserved which means that sometimes some information can be transferred. In echolalia, the aphasic speaker repeats the words or sentences of the conversational partner. This can be a literal repetition, with even the same intonation pattern (although this phenomenon is mainly observed in individuals with dementia), but usually parts of a sentence are repeated as an answer to a question:

Conversation partner: Did you sleep well last night?
Aphasic speaker: Slept well last night.

The term 'perseveration' refers to the repetition of a preceding activity at a moment when it is no longer appropriate. In relation to speech production, perseveration can occur at the sound level (e.g. 'ki-ki-king') and at the word level (e.g. the aphasic individual first names his nose correctly, but then refers to his eye and ear with 'nose' as well). Perseveration can also occur in spontaneous speech:

> [Have you been living in London?] No, in London, in London, no in London, oh, in Lond, no in London, it is London, it is *not* in London. [In Oxford?] Yes!!

The difference between a speech automatism and perseveration is that perseveration changes all the time, whereas a speech automatism is constant for a long time.

13.3.3 Auditory comprehension

Apart from the quite striking speech impairments described above, individuals with aphasia usually have language comprehension deficits as well. These can have different manifestations. Some aphasic individuals have problems distinguishing speech sounds. In extreme cases, this can result in 'word deafness', when the person cannot understand anything that is said to him, although hearing is unimpaired. However, most aphasic individuals have problems understanding the meaning of certain types of spoken words, specifically low-frequency words (e.g. 'snail', 'hour glass', 'sea horse') and abstract words (e.g. 'negotiation', 'redistribution'). Also, understanding of a word series (e.g. 'point to your nose, your eye and your ear') and grammatically complex structures such as passives (e.g. 'the lion is bitten by the tiger'), comparatives (e.g. 'the girl is taller than the boy') and genitive constructions (e.g. 'how would you call the brother of my wife?') is usually impaired.

13.3.4 Reading and writing

All aphasic individuals have problems with reading and writing. Reading disorders ('alexia') and writing disorders ('agraphia') are usually more severe than comprehension and production of spoken language, respectively. Most aphasic people cannot read the newspaper and hardly any aphasic person is able to write a letter without error. The fact that aphasic individuals usually experience more problems with written than spoken language cannot only be explained by the fact that they (like healthy people) have 'less experience' with written language. Reading and writing are derived from spoken language. They also demand additional skills such as visual recognition of letters while reading and application of spelling conventions and differential hand movements while writing. These skills can each be affected after brain damage. Moreover, many aphasic people are forced to write with their left hand because of a right-sided paralysis, delaying the writing process and distorting the handwriting. However, this poor motor control of the preferred hand is usually not the full explanation for the poor writing skills of aphasic individuals, because often the same writing errors (omissions, substitutions, etc.) are observed in typing.

13.4 Aphasia syndromes

Aphasia can manifest itself in different ways. The grouping of aphasia symptoms that is largely determined by the organization of language in the brain is far from arbitrary. That is, some symptoms often occur simultaneously, whereas other symptom combinations hardly ever occur. Although many different aphasia classification systems have been proposed over the last century, the most important aphasia types that are distinguished nowadays are still the same as the ones that were described at the end of the nineteenth century by German and French neurologists. The major so-called 'classical' aphasia types are Broca's aphasia, Wernicke's aphasia, anomia and global aphasia. For a detailed description of the classical aphasia types, see Goodglass *et al.* (2001).

13.4.1 Broca's aphasia

The most important characteristics of Broca's aphasia are effortful articulation, reduced vocabulary and grammatical limitation resulting in very simple sentences and stereotypical constructions. In severe cases, speech is limited to one-word utterances (often mainly consisting of 'yes' and 'no'). In less severe cases, speech is characterized by short, grammatically simplified sentences which consist mainly of content words (i.e. nouns, verbs and adjectives). This output is called 'telegraphic speech'. An example of telegraphic speech is shown below:

> [Where did you buy a new house?] In Cambridge, centre of Cambridge, middle of Cambridge. ah, beautiful place. [What does it look like?] new housing estate … premium estate … beautiful house … oh dear, yes, beautiful house … eh … magnificent from the outside … windows, very very lovely house [How big is it?] room … ninety metres … no! nine metres… all thresholds gone … beautiful garden … lovely.

Naming of objects, auditory comprehension (of single words and simple sentences) and silent reading are usually hardly affected. However, action naming, comprehension of grammatically complex sentences (such as reversible passives, e.g. 'the cat is chased by the dog'), reading aloud, repetition and writing are impaired. Nowadays, the term 'Broca's aphasia' is mainly used when grammatical comprehension disorders are studied. For production studies, the terms 'agrammatic aphasia' or 'agrammatism' are more common.

13.4.2 Wernicke's aphasia

The main characteristics are impaired auditory comprehension and fluent, well-articulated speech with paraphasias. In severe cases, an individual with Wernicke's aphasia will not understand spoken language and produce so many neologistic, phonological and/or verbal paraphasias that he or she is no longer understandable ('jargon aphasia'). Individuals with Wernicke's aphasia are usually not aware of their speech errors. In milder cases, they only have problems understanding low-frequency and abstract words and complex sentences and they only occasionally use paraphasias.

Although individuals with Wernicke's aphasia can produce long and complex sentences, these are often ungrammatical, because they are incomplete and grammatical constructions are mixed up. This is called 'paragrammatism'. In the following extract, the sentence endings have been marked with full stops, which are mainly based on intonation:

> [How are you these days?] I've got the idea that I've been taken better. You can hear that with the talking of course. On one side but I think it's nice, my idea too. But if it does not work then it does not work. I think quite easy about that. We never say it is not possible or it does not work. And that's what I did. That's the way I am, right?

Object and action naming, repetition of words and sentences, silent reading and writing are usually severely affected, while reading aloud can be more or less normal.

13.4.3 Anomic aphasia

The most important characteristics of anomic aphasia, or anomia, are the relatively severe word-finding problems that occur in the context of fluent, grammatically well-formed speech production and relatively intact auditory comprehension. In severe cases, the speech of these individuals is typically lacking explicit information. This is called 'empty speech'. Naming of objects and actions is relatively severely impaired, but repetition of words and sentences is usually good. Reading and writing can vary from normal to entirely impossible. An example of the word-finding problems that occur in anomia is given below (the speaker is attempting to name a picture of a tree):

> Ah … yes, how should I call this? You would like to know how you would how I would call it. People, but look, there are fat ones and fat ones (points to the branches) under a … how should I call it? A branch, I think that's enough.

13.4.4 Global aphasia

This form of aphasia is usually associated with large brain lesions. It is not mentioned in all aphasia classifications, since for a long time it has been considered to be a mixture of Broca's and Wernicke's aphasia. Since global aphasia is often observed in clinical practice and can also be caused by smaller lesions in which Broca's and Wernicke's areas are spared, there is no reason not to consider global aphasia as a specific aphasia type.

The most obvious features of global aphasia are very limited speech production with poor articulation and prosody, many speech automatisms and severely affected language comprehension. Only rarely is the individual with global aphasia able to produce a meaningful utterance, usually as an answer to a question and often in the form of echolalia. Many global aphasic speakers have a tendency to perseverate and sometimes speech production is even more hampered by dysarthria or apraxia of speech.

A specific form of global aphasia is characterized by speech restricted to speech automatisms or recurring utterances, for example, 'kitkit' or 'dododo'. These consonant–vowel combinations are produced fluently and with intonation that expresses affective information (e.g. agitation, question, doubt). Despite limited speech production, individuals with global aphasia may be able to repeat some words, albeit often with neologisms or perseverations. Naming of objects and actions is severely affected. There is either no reaction to the stimulus, or a neologism or speech automatism is produced. Perseveration on naming tests often occurs. Auditory comprehension, reading and writing are severely impaired.

13.4.5 Other aphasia syndromes

The four aphasia types examined above are the most common kinds found in clinical practice and research studies. However, there are other types of aphasia. Goodglass and Kaplan (1972, 1983; Goodglass *et al.* 2001), following the classical aphasia typology of Lichtheim (1885), mention three other aphasia syndromes. These syndromes can be distinguished from the ones above by a remarkable impairment or preservation of repetition of words and sentences.

Individuals suffering from conduction aphasia are severely impaired in repetition. Speech is fluent and grammatically well-formed and contains many phonemic paraphasias. Language comprehension is relatively intact. The person with conduction aphasia is aware of his or her errors and often tries to correct them. This can result in a sequence of approximations to the target word, for example 'scrapple, strapple, strample' for the game 'scrabble'.

Transcortical motor aphasia is a rather rare type of aphasia. Repetition is relatively well preserved compared to severely limited speech output. Individuals with transcortical motor aphasia hardly speak spontaneously, but they are able to give short, well-articulated answers to structured questions. Auditory comprehension, naming and reading are relatively intact, but writing is impaired to the same extent as speaking.

Transcortical sensory aphasia is a rare aphasia syndrome that has the same characteristics as Wernicke's aphasia. However, it differs with

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respect to the relatively intact ability to repeat words and sentences. Usually the aphasic individual does not speak spontaneously, but when addressed, may respond with fluent, well-articulated sentences that are littered with paraphasias and neologisms.

Finally, Goodglass *et al.* (2001) describe some aphasias that can arise from lesions in subcortical structures, such as the thalamus and the basal ganglia. These subcortical aphasias can occur in a fluent and non-fluent form depending on the lesion site. Anterior subcortical aphasia, in which the frontal branch of the internal capsule and the putamen are damaged, is characterized by sparse output with severe articulation problems and hypophonia (a weak voice resulting in soft speech). More extended lesions may result in global aphasia. In the case of more posterior lesions of the thalamus and adjacent white matter, fluent aphasia has been observed that, in some cases, may resemble Wernicke's aphasia.

13.4.6 Classification issues

Although a large part of aphasia research in recent decades consists of group studies with the classical aphasia syndromes, it is highly debatable whether individuals classified with the same type of aphasia form a homogeneous group. Evidence for this claim can be found in the fact that the frequency of occurrence of the classical aphasia types varies significantly by research centres. According to some researchers (e.g. Prins *et al.* 1978), only 20–30 per cent of aphasic individuals belong to a classical aphasia type, whereas other researchers (e.g. Kertesz and Sheppard 1981) claim that all individuals with aphasia (i.e. 100 per cent) can be classified as having one of the classical aphasia types. Such differences can only exist because researchers are not using the same classification criteria. For example, according to some researchers, 'telegraphic speech' is the defining feature of Broca's aphasia (Obler *et al.* 1978), whereas others (e.g. Lhermitte and Gauthier 1969) claim that less than 10 per cent of individuals with Broca's aphasia speak telegraphically. Opinions also differ regarding auditory comprehension in Broca's aphasia. According to some authors (e.g. Graetz *et al.* 1992), this is intact or at most minimally disturbed, while other authors (e.g. Kertesz 1981) claim that auditory comprehension in Broca's aphasia can vary considerably and may even be worse than in Wernicke's aphasia.

The above comments suggest that the results of many group studies on Broca's aphasia (and other aphasia types as well) may not be compared, because similar definitions of aphasia syndromes have not been used. Therefore, reliable generalizations about the psycholinguistic and neurolinguistic mechanisms underlying the classification of aphasia cannot be drawn. As a result, several researchers (e.g. Badecker and Caramazza 1985; Miceli *et al.* 1989) no longer accept group studies on the basis of classical aphasia typology and argue that research in aphasiology should only be conducted on the basis of case studies of carefully selected aphasic individuals. The debate between advocates and opponents of group studies has been quite heated, as is illustrated by the following quotations:

> … the classification of patients into categories such as Wernicke's aphasia, conduction aphasia, expressive aphasia …) is not only useless but positively harmful for research into the nature of cognitive disorders and the structure of normal cognitive processing (Caramazza and McClosky 1988: 519).
>
> … to prohibit group studies is to prohibit any generalization over data from more than one patient. Thus, an appeal to case-studies as the only one 'defensible methodology' guarantees a dead end … Experience has shown that maintaining the traditional classificatory system, or refined variations thereof, has borne results, and …) case-studies have led nowhere (Grodzinsky 1990: 76–7).

13.5 Localization of aphasia: language and the brain

Until the present century, almost all our knowledge of the anatomical structures underlying the language faculty was based on studies of the localization of brain lesions in aphasic individuals. The most important sources of information were postmortem studies of the brains of individuals with lesions due to vascular disease and trauma, the latter caused by gunshots and shrapnel wounds in young soldiers. These studies were undertaken in Russia by Luria (e.g. Luria 1970) and in the USA by a group of aphasiologists (Harold Goodglass, Edith Kaplan, Frank Benson, Norman Geschwind and others) who worked in the Aphasia Research Center of the Boston Veterans Administration Hospital (now called the Harold Goodglass Aphasia Research Center).

In the 1970s, brains could be observed in vivo for the first time by using computed axial tomography (CAT scans). It was then possible to see which areas in the brain did not take up oxygen and were, hence, affected by a brain lesion. In the 1980s, activity in the brain could be observed in healthy persons for the first time by using positron emission tomography (PET scans). In the 1990s, PET was followed by functional magnetic resonance imaging (fMRI). By using magnetic radiation rather than radioactivity, fMRI was supposed to be a safer brain-imaging technique. These latter two methods are adequate to localize cognitive functions, including language, in healthy brains. Hundreds of studies have now been conducted using these techniques. The results of these studies show a large degree of overlap with what we knew already from classical localization doctrine as formulated by Paul Broca (1861, 1865), Carl Wernicke (1874) and Lichtheim (1885) and updated by Geschwind (1974). This theory can be sketched as follows.

In 95 per cent of cases, aphasia is caused by a lesion in the left hemisphere of the brain. In less than 20 per cent of left-handed individuals, language functions are localized in the right hemisphere (Rasmussen and Millner 1977). This unilateral control of language functions is called 'cerebral dominance'. Recent neuroimaging studies have shown that the ('non-dominant') right hemisphere also plays a role in some specific language functions in right-handed individuals (for an overview, see Stowe *et al.* 2005), but damage to these areas does not result in aphasia. Three cortical areas in the dominant hemisphere are critical for language (see Figure 13.3): (1) Broca's area and its vicinity in the frontal lobe of the brain; (2) Wernicke's area and its surrounding areas, including the angular gyrus in the temporal and parietal lobes, respectively; and (3) the (in-between) area in the inferior part of the pre- and post-central gyri, including the (subcortical) arcuate fasciculus. A lesion in one or more of these interconnected language areas will most probably result in permanent aphasia. A lesion in the surrounding areas will seldom lead to aphasia and if it does, the aphasia is usually transient (Luria 1970).

The classical localization doctrine can explain a large number of aphasia symptoms and syndromes, such as poor speech production in combination with relatively good auditory comprehension in Broca's aphasia, the fluent speech production and poor comprehension in Wernicke's aphasia, and the poor repetition abilities in conduction aphasia. As an illustration of the explanatory power of the classical localization doctrine, a concise analysis of the anatomical model of the naming of objects is presented (based on Geschwind 1974). The choice of naming of objects is not accidental. Learning to name objects in the world around us can be considered to be the basis of our language faculty. One could argue that humans, in contrast to other mammals including apes, have a specific brain structure available for object naming.

In naming an object such as an apple, at least six anatomical sites and psycholinguistic stages can be distinguished (see Figure 13.4). First, the target stimulus (the visual image of an apple) is projected onto the primary visual cortex, where sensory-specific processing takes place. Second, the visual pattern is transferred to the visual association cortex for perceptual analysis and synthesis (i.e. object recognition). Third, the association between the visual image of the apple and the sound image for apple stored in Wernicke's area is made in the angular gyrus. This is where the 'rules' for recoding visual perception into auditory perception, and vice versa, are stored.

From both an anatomical and a functional point of view, the angular gyrus is a transition area between the temporal, occipital and parietal lobes, where auditory, visual and tactile-kinaesthetic information is processed, respectively. The angular gyrus performs a synthesis of these three kinds of sensory information by its typical location. It is especially important for generating auditory-visual associations that play a fundamental

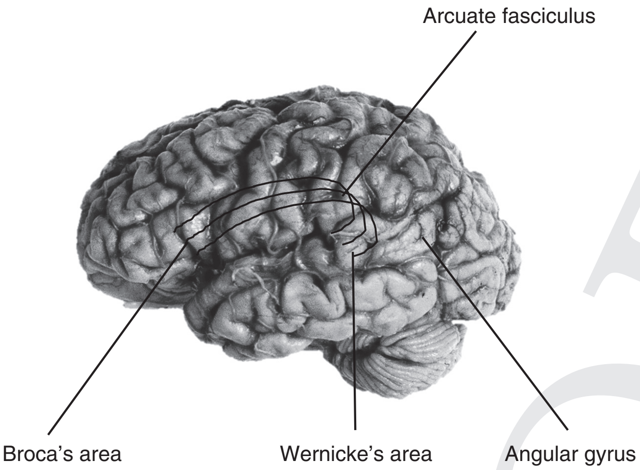

Figure 13.3 Localization of the 'language areas' of Broca and Wernicke, their connecting track, the arcuate fasciculus and the angular gyrus on a lateral view of the left hemisphere. (The photo of the brain is taken from The Digital Anatomist Project at the University of Washington, with permission.)

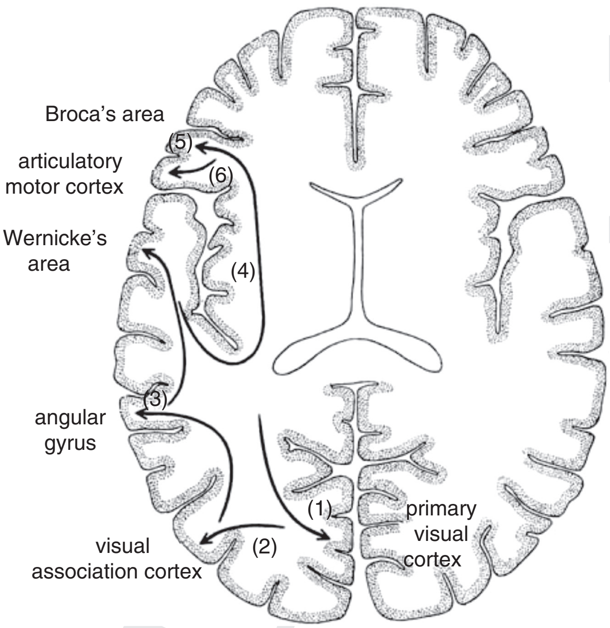

Figure 13.4 Six stages of naming a visually perceived object, shown on a horizontal slice of the brain. (Reprinted from Geschwind (1972) with permission of the artist, Bunji Tagawa.)

role in naming and, hence, in language acquisition. Fourth, the auditory form of the word 'apple' is (in abstract form, of course) transmitted to Broca's area through the arcuate fasciculus that connects Wernicke's area to Broca's area. Fifth, in Broca's area the articulation programme of the word ‘apple’ is triggered. Sixth, on the basis of the articulation programme the muscles of the articulatory organs (e.g. lips, tongue) are innervated via the primary motor cortex. The phoneme structure of the word ‘apple’ can then be pronounced.

Although this associationists’ model of the naming process is, of course, very simplistic and leaves many questions unanswered (for example, how does a child learn abstract words like ‘love’, ‘beautiful’, ‘but’ and ‘if’?), it can explain a variety of aphasic symptoms. For example, a lesion in Wernicke’s area disrupts not only the naming of objects, but also the comprehension of object names. This is because the underlying (phonological) word form is no longer present (or accessible) and can, therefore, not be matched with the corresponding meaning. When the lesion is in Broca’s area, comprehension of single words is unaffected, because the underlying word forms in Wernicke’s area are still intact. However, words cannot be pronounced properly, because the correct ‘articulation patterns’ are no longer available. In other words, the problems are not in selecting the correct word, but in the motor realization and/or linear organization of the speech sounds that, together, constitute the phoneme structure of the word.

Even though the classical localization doctrine of Wernicke, Lichtheim and Geschwind is still acknowledged by most modern aphasiologists, it should be emphasized that it is only a very simplified model of the anatomical and psychological organization of language use. Recent studies using modern neuroimaging techniques have shown that cerebral lesions that cause aphasia are not always in (the vicinity of) the classical language areas of Broca and Wernicke. These studies have shown that damage to subcortical areas such as the thalamus or the basal ganglia can also result in aphasia (e.g. Cappa and Vignolo 1979; D’Esposito and Alexander 1995). Also, lesions to Broca’s or Wernicke’s area do not necessarily lead to Broca’s and Wernicke’s aphasia, respectively (e.g. Basso *et al.* 1985). However, most importantly, the classical localization doctrine cannot explain some very prominent symptoms that are characteristic for some aphasia syndromes, such as telegraphic speech and grammatical comprehension deficits in Broca’s aphasia. This is not surprising because the classical localization doctrine only relates to word level. Research into sentence comprehension in aphasia only started in the 1970s (Parisi and Pizzamiglio 1970; Caramazza and Zurif 1976). This was the first time that sentence comprehension deficits in Broca’s aphasia were investigated.

The above discussion shows that the classical localization doctrine cannot explain all aphasia symptoms. This lack of explanatory force is not surprising, however, since language functions such as speaking and understanding spoken language are, even when restricted to the word level, too complex from a psycholinguistic point of view to assume that they can be stored in a few isolated brain areas (‘language centres’). They must be the result of collective functioning of several, probably overlapping networks of brain areas. As yet, little is known about the structure and functions of these cerebral networks, but it can be expected that in due course the classical localization doctrine can be refined and extended with the help of modern neurotechnology.

13.6 Recent developments

For the purposes of this section, the turn of the century is taken to represent the start of some recent developments in aphasia research. The word-production model that was described above only referred to nouns. However, we speak in sentences and sentences are built around verbs. Although the production of verbs and the comprehension of sentences have received considerable attention since the 1990s, no adequate anatomical model of these processes has so far been developed (see, however, Grodzinsky and Friederici 2006). Some theories of sentence comprehension and the production of verbs and sentences will be examined in this section. Also, an intensively debated issue in aphasiology will be addressed. This issue concerns whether linguistic knowledge is affected by brain damage in aphasia, or whether this knowledge is intact but not accessible to a normal extent. Finally, clinical researchers are increasingly examining aphasia across languages. It will be shown that studying language behaviour in bilingual aphasic speakers can reveal how language is represented in the (intact and damaged) brain.

13.6.1 Verbs and sentences in aphasia

It was in the late 1990s and early twenty-first century that retrieval of verbs began to receive the attention of investigators. Early studies focused on differences in performance on tests of object naming by nouns and action naming by verbs (e.g. Williams and Canter 1987; Miceli *et al.* 1988; Zingeser and Berndt 1990). They showed that both word classes may be selectively impaired in individual cases (e.g. Zingeser and Berndt 1988). However, group studies showed that the large majority of aphasic individuals (>95 per cent), regardless of aphasia type, have more problems with verb than noun production (Kohn *et al.* 1989; Jonkers 1998).

More recent studies of verb production do not focus on comparisons with nouns, but on differences within the class of verbs (Kemmerer and Tranel 2000a, 2000b; Luzzatti *et al.* 2002; Jonkers and Bastiaanse 2007) and on the inflection of verbs in the context of sentences (Berndt *et al.* 1997; Bastiaanse and Van Zonneveld 1998). Studies of different languages have shown that the argument structure of verbs plays an important role in verb production (English: Thompson 2004; German: De Bleser and Kauschke 2003; Hungarian: Kiss 2000; Italian: Luzzatti *et al.* 2002; Russian: Dragoy and Bastiaanse 2010). For example, 'to walk' is a verb that needs only one argument (the walker), whereas 'to give' needs three arguments (the person who gives, the person who receives and the gift). In agrammatic aphasia, the complexity of argument structure plays a role in verb retrieval (Thompson 2004). Other factors that play a role are instrumentality, which facilitates naming in agrammatic aphasia ('to cut' is an instrumental verb and is easier to retrieve than 'to push' for which no instrument is needed). Verbs with a name relation to a noun (e.g. 'to saw') are better retrieved than verbs without such a name relation (e.g. 'to cut') by individuals with anomic aphasia (Jonkers and Bastiaanse 2007).

At sentence level, most studies concern the comprehension of semantically reversible sentences, such as 'the woman is rescuing the man' compared to 'the man is rescued by the woman'. The latter sentence type, which is a passive construction, is harder to understand than the first one for individuals with Broca's aphasia. Sentences in which the agent (the one who performs the action, in the sentence above 'the woman') and the theme (the one who undergoes the action, here 'the man') are not in the preferred order are difficult to comprehend for individuals with a grammatical disorder as in Broca's aphasia. Many hypotheses have been proposed for why this should be the case. For comprehensive discussion of these hypotheses, the reader is referred to debates led by Grodzinsky (2000) and Drai and Grodzinsky (2006). Several studies have shown that these sentence comprehension problems are not restricted to Broca's aphasia and that similar performance has also been observed in Wernicke's aphasia (e.g. Bastiaanse and Edwards 2004).

Relatively few studies of sentence production have been conducted. Some researchers assume that it is only the beginning of sentences that is impaired, for example question words, and conjunctions such as 'because' and 'although' (Hagiwara 1995). However, several studies demonstrate problems further downstream in the sentence. These problems are found in sentences in which the word order is not the canonical one. Every language has its own canonical order, for example, subject-verb-object for English and subject-object-verb for Turkish. Usually, individuals with Broca's aphasia are able to produce these structures. However, when word order changes, sentence production and comprehension becomes harder for people with Broca's aphasia (Bastiaanse and Van Zonneveld 2006). This explains why sentences such as 'it is the man who the woman rescues' are hard for people with Broca's aphasia to understand. It also explains why yes/no questions in English (e.g. '*is* the boy eating an apple?') are difficult for agrammatic speakers to produce: the auxiliary verb 'is' is not in its canonical position (Bastiaanse and Thompson 2003). In other languages, such as Hebrew, the word order remains the same in yes/no questions and only the intonation changes. In those languages, agrammatic speakers have no difficulty producing these questions (Friedmann 2002).

13.6.2 Representational versus processing deficit

In order to understand the nature of aphasia, to do experimental research and to treat aphasic individuals, it is important to know the possible effects of brain damage on linguistic knowledge. Is this knowledge or 'linguistic competence' still available to the aphasic speaker, that is, does the aphasic individual still know the rules of his or her language? All aphasiologists agree that at least some of this knowledge is retained, because aphasic speakers obey the rules of their language. For example, if the verb always precedes the object, as in English, an aphasic speaker will not produce sentences with an object preceding a verb. Also, phonological rules are followed. In Dutch and German, for example, obstruents that are pronounced with vibrating vocal cords, the so-called 'voiced obstruents' such as /d,b,z,v/, are devoiced at the end of a syllable to /t,p,s,f/. A Dutch or German aphasic speaker will obey this rule and will never produce words ending with voiced obstruents. Grammar and phonology may be simplified, but not basically altered. The question is whether knowledge of complex linguistic structures is erased by the lesion or is only less accessible.

Some aphasiologists assume that linguistic knowledge is lost. Grodzinsky (2000) and Friedmann (2000), for example, assume that critical grammatical knowledge is lost when Broca's area is damaged, with the result that grammatically complex sentences are no longer understood or produced. This assumption has serious consequences, because it implies that an aphasic individual can never produce grammatical structures, the representations of which are gone. According to Friedmann (2000), individuals with Broca's aphasia can no longer produce subordinate clauses, because they lack the grammatical rules to do so. If this were true, no such individual would ever be able to produce a subordinate clause, which is obviously incorrect.

Although it is true that individuals with Broca's aphasia produce subordinate clauses to a lesser extent than non-brain-damaged speakers, such clauses are produced every now and then. Therefore, most researchers agree that the aphasic individual still has linguistic knowledge available, but has insufficient resources to process more complex linguistic structures. The interesting question then is what determines the complexity of the structures. This can be answered by theoretical linguistics. At sentence level, for example, it has to do with the order of the constituents; at phoneme level with phonological markedness. At word level, complexity effects can be seen in the different performance on action and object naming tasks: verbs are more complex than nouns and, therefore, harder to retrieve.

13.6.3 Aphasia as an integration deficit

In the previous section, it was concluded that aphasia should be viewed as a processing disorder: in the large majority of the aphasic population, linguistic knowledge is still available, but is not always accessible. (In very severe cases of global aphasia, when lesions are large, linguistic knowledge may be lost, although this is hard to prove.) This is shown, for example, when a test for naming objects is assessed twice in a week. On both occasions the aphasic individual may name only 50 per cent of items correctly, but the correct and failed items will not be the same in each assessment. Also, on sentence production tests, a simple sentence type is usually easier for the aphasic individual to produce than a complex sentence type. But even a number of complex sentences will be produced correctly, showing that the aphasic individual is able to form a complex sentence, but cannot do so all the time.

In a study of the spontaneous speech of a woman with Broca's aphasia, Bastiaanse (1995) showed that she was able to form complex sentences, including embedded sentences, but at the cost of verb and noun retrieval: she produced semantic paraphasias and was hard to follow. In a later part of the same interview, her sentences became very simple, verbs were not inflected any more, articles and prepositions were omitted, but she gave much more information by producing correct verbs and nouns instead of paraphasias. On the basis of these data and data from other agrammatic speakers it was concluded that it is hard for agrammatic speakers to integrate semantic information in correct syntactic structures, leading to either ungrammatical sentences with correct lexical-semantic information or more complex structure that lacks lexical-semantic content. Therefore, agrammatic aphasia can be seen as a deficit in integrating lexical-semantic and grammatical information, a view that is shared by other researchers (e.g. Yarbay Duman *et al.* (2011) who formulated the integration deficit hypothesis).

Interestingly, this problem with integrating information of two linguistic levels has been observed in the spontaneous speech of fluent anomic speakers as well. Bastiaanse (2011) found that the retrieval of lexical verbs in these speakers decreased when more grammatical information in the form of inflection needed to be computed. This also points to an integration deficit: these fluent aphasic speakers are able to retrieve verbs in spontaneous speech, but when these verbs have to be inflected, retrievability diminishes due to an integration deficit. Of course, it is not true that all aphasic symptoms are due to integration problems. However, in general, most symptoms become more prominent in more demanding linguistic environments. Such a phenomenon can only be explained within the framework of a processing deficit.

13.6.4 Aphasia across languages

In the twentieth century, the majority of experimental studies of aphasia were conducted on English-speaking subjects. Nowadays, aphasia has been studied in many languages, including languages with a far more complex grammatical structure than English. As a result, we have gained deeper insight into the disorders underlying aphasia. In 1990, a notable book on this topic by Menn and Obler was published. They recruited fellow researchers from many different languages to collect samples of spontaneous speech from individuals with Broca's (agrammatic) aphasia, as well as data from several tests, such as sentence construction.

Cross-linguistically, investigations at phoneme and word level are less interesting than those at sentence level, because across languages there are far more differences in grammatical than in phonological structure. However, one interesting aspect at the phonological level, which involves lexical tones, should be reported here. Several languages (e.g. Norwegian, Mandarin, Cantonese) use 'lexical tone' as a distinctive feature. This means that the same phonemic string can have different meanings depending on whether it has a flat, rising, falling or rising-falling tone. A famous example is the word 'ma' in Mandarin. When this is spoken with a flat tone it means 'mother', when spoken with a rising tone it means 'hemp', with a falling tone it means 'scold' and with a rising tone followed by falling tone it means 'horse'. It turns out that Chinese individuals with Broca's aphasia are no longer sensitive to these distinctions. In fact, they respond to tone differences in a similar way to non-native speakers of Chinese who do not have a tone language as their mother tongue: they are insensitive to different tones (Liang 2006).

Particularly interesting with respect to aphasia across languages are investigations of bilingual aphasia. This field of study is rapidly growing. Studying the patterns of language deficits in the two or more languages bilingual individuals used before acquiring aphasia may reveal insights into the representations of more than one language in the brain. Although most descriptions are rather anecdotal, several interesting patterns have been observed. In a so-called early balanced bilingual person (someone who acquired both languages during early childhood and is equally proficient in both languages), one language may be more severely affected than the other. Different patterns may be seen in late 'balanced' bilingual persons (individuals who learned their second language after childhood but who are more or less equally proficient in both languages). In some bilingual aphasic speakers their native language is better preserved. In others, their second language is better preserved, especially when they used that language most often later in life. In both early and late 'non-balanced' bilingual aphasic speakers, either language may be worse.

These patterns have been seen in single case studies. There are only a few group studies. Kambanaros and Van Steenbrugge (2006) studied the production of verbs and nouns in Greek-English late bilingual aphasic immigrants in Australia. They found no difference between the use of verbs and nouns between the two languages, although verb production was more impaired than noun production in both languages. Abuom and Bastiaanse (2012) also reported qualitatively similar behaviour in a group study of Swahili-English bilingual agrammatic speakers: the nature and severity of the deficit were the same in both languages, which are very different from a grammatical point of view. This seems to be the general pattern: the aphasia manifests itself similarly in both languages, but exceptional cases have been reported (for examples, see Fabbro 1999). A few studies have been conducted on recovery of the different languages spoken by bilingual aphasic speakers (Gil and Goral 2004; Goral *et al.* 2010; for an overview, see Paradis 2001). They show that in some bilingual aphasic speakers only one language may improve (either the first or second language), whereas both languages may improve to the same extent in other speakers.

13.7 Summary

Aphasia is a language disorder caused by brain damage, usually in the left hemisphere. The symptoms are dependent on the site and the size of the lesion. Co-occurring symptoms have been classified as aphasia syndromes, but these syndromes do not often appear in pure form. The selective deficits in aphasia at the phoneme, word and sentence level contribute to our knowledge of how language is represented in and processed by the brain. Experimental aphasiology started in the second half of the twentieth century and is still blooming. In the twentieth century, the emphasis was on comprehension and production of words (mainly nouns) and sentences and on spontaneous speech production. Nowadays, aphasia is studied in a wide variety of languages, making cross-linguistic aphasiology an interesting topic. Much attention is also given to the contribution to language of the right hemisphere, bilingual aphasia and language disorders at the discourse level.