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Alexia

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GLOSSARY

affixes Grammatical word endings (e.g., *ly*, *ing*, *ed*).

derivational paralexia A paralexia in which the root morpheme, but not the part of speech, is retained.

functors Grammatical words, including pronouns, prepositions, articles, conjunctions, and auxiliary verbs (e.g., *him*, *the*, *with*, and *are*).

inflectional paralexia A paralexia in which the root morpheme and the part of speech are retained, but the form of the word is incorrect.

orthographic Pertaining to the letters of which a word is composed and the order in which the letters occur.

orthographic paralexia A paralexia in which the response shares at least 50% of its letters with the target word.

paralexia The incorrect production of a word in oral reading.

part of speech Syntactic classification of a word (e.g., noun, verb, adjective, adverb, and functor).

phonologic Pertaining to the pronunciation of the word.

pseudowords Pronounceable nonwords (e.g., *zilt* and *rog*).

semantic Pertaining to the word's meaning.

semantic paralexia A paralexia that consists of a real word that is related in meaning to the target word.

In this article, *alexia* is the term used to refer to acquired disorders of reading, subsequent to brain injury, in persons who had been literate prior to the injury. This is distinguished from dyslexia, which refers to devel-

opmental disorders of reading. In other texts, the term *acquired dyslexia* is used synonymously with alexia and is distinguished from *developmental dyslexia*.

I. INTRODUCTION

Alexias are common in patients who have sustained damage to the left hemisphere of the brain and are present in most patients with aphasia. In recent years, several different varieties of alexia have been identified. This is not surprising: Reading is a skill consisting of many cognitive components. Although there are many different models of reading, most agree that certain basic processes must occur: The written symbols are processed perceptually; letters are segregated and identified; orthographic units are matched to stored orthographic representations (knowledge of the letters that comprise a word and the order in which they occur); and the activation of orthographic representations, in turn, leads to activation of phonologic representations (the word's pronunciation) and semantic representations (the word's meaning). Disturbances in these various subcomponents of reading might very well be expected to disturb the process of reading in different ways. The identification of different types of alexia has led to new, more specific, approaches to treatment as well as to more detailed assessments of acquired reading disorders.

II. SYMPTOMS OF ALEXIA

The different types of alexia are distinguished from one another on the basis of two basic features: The

properties of the words that the patient has difficulty reading and the types of *paralexias*, or reading errors, that are produced.

A. Paralexias

The term *paralexia* is applied to an error produced in response to a task requiring the oral reading of a written word. Ordinarily, this term is used only for single-word responses and does not include multiword phrases.

Orthographic paralexias are reading errors in which the response shares at least 50% of its letters with the target word, in approximately the same order. Some examples are shown in Table I. These paralexias have sometimes been called “visual paralexias.” This is a misnomer: The overall visual similarity between target word and response is often minimal with regard to overall shape and length (e.g., *political* → “police”). Another reason not to use the term visual paralexia is that in most cases, orthographic paralexias are not caused by visual problems. Orthographic paralexias are produced by patients with all forms of alexia, but the reasons these errors are produced differ between alexias. Therefore, these paralexias are not particularly useful in the classification of an alexia.

Semantic paralexias are reading errors in which the meaning of the response word is related to the meaning of the target word. Semantic paralexias are of many types. The response word may be a synonym, an antonym, a subordinate, a superordinate, a coordi-

nate, or an associate of the target. Examples of semantic paralexias are provided in Table I. By definition, all alexic patients who produce semantic paralexias as more than 5% of their total reading errors are classified as having “deep alexia,” which will be discussed later.

Inflectional and derivational paralexias are reading errors in which the root morpheme is retained but the incorrect form of the word is produced. Inflectional paralexias refer to errors in which the correct part of speech is retained (e.g., *happiest* → “happier” and *buy* → “bought”). Derivational paralexias refer to errors in which the part of speech has been changed (e.g., *applaud* → “applause”). Inflectional and derivational errors are always seen in patients with deep alexia. They are often produced by patients with phonologic alexia as well. They are not characteristic of pure alexia, surface alexia, or attentional alexia. Prefix errors may occur in left neglect alexia, and suffix errors may occur in right neglect alexia.

Function word substitutions are errors in which a function word such as a preposition, conjunction, pronoun, or auxiliary verb is incorrectly read as another, seemingly unrelated, function word. Many of these paralexias are easily classified as function word substitutions; there is simply no other way in which the response word and the target word are connected (e.g., *her* → “which”). On other occasions, function word substitutions may be related orthographically (e.g., *her* → “here”) or semantically (e.g., *her* → “she”). Although these latter paralexias may indeed represent instances of orthographic or semantic paralexias, they are typically all categorized as function word substitutions. Function word substitutions are produced by all patients with deep alexia, and by some patients with phonologic alexia.

Regularization errors are paralexias that are produced when an alexic patient reads a word as it *would* be pronounced if it were being read via some sort of spelling-to-sound correspondence rules (e.g., the word *come* is read as “comb”). These errors are not always easy to classify because the “rules” that were employed are not always transparent. Regularization errors may occur, sometimes with great frequency, in patients with surface alexia.

Orthographic-then-semantic paralexias are the result of two processing errors. The target word is first altered orthographically, then the altered word is misread semantically. These paralexias may at first appear to be random, unrelated responses until the mediating word is deduced (e.g., *pivot* → [pilot] → “airplane”).

Table I
Examples of Paralexias

Type	Example
Orthographic	winter → “water” badge → “bandage”
Semantic	river → “stream” play → “game”
Derivational	instructive → “instructor” strength → “strengthen”
Inflectional	wished → “wishing” wants → “want”
Orthographic-then-semantic	sympathy → “orchestra” favor → “taste”
Functor substitutions	before → “into” his → “our”
Regularization errors	bread → “breed” shoe → “show”

B. Word Properties Affecting Reading Accuracy

Written words differ along many dimensions. Some differences among written words, such as the word's initial letter or physical characteristics such as color, height, or type font, have little relevance to alexia. Other characteristics of words are extremely important in diagnosing and understanding alexia. These include part of speech, concreteness, length, regularity, and familiarity.

1. Part of Speech

For some alexic patients, the probability of reading a word correctly is dependent on the word's syntactic class. What is remarkable is that when a patient shows such a part-of-speech effect, the order of difficulty of the word classes is usually predictable. Nouns and adjectives are typically read best; verbs are read with greater difficulty; and functor words, including prepositions, conjunctions, pronouns, articles, and auxiliary verbs (e.g., *have* and *was*), are read most poorly. Part-of-speech effects are always seen in deep alexia and often in phonological alexia.

2. Concreteness

Another dimension along which words can be divided is the degree to which their referents are concrete or accessible to the senses. This is highly correlated with imageability, the ease with which a word's referent can be imaged. For some alexic patients, words that are highly concrete or imageable (e.g., *chair*) are more likely to be read correctly than words low in imageability or concreteness (e.g., *truth*). Patients with deep alexia always display a concreteness effect, and patients with phonological alexia may show this effect as well.

3. Length

The length of a written word will affect its likelihood of being read correctly for patients with certain types of alexia but not for others. For some patients, particularly those with pure alexia, words containing more letters will be more difficult. For other patients, especially those with phonologic/deep alexia, the number of syllables (not letters) might affect the difficulty of reading the word. For many patients, however, neither of these measures of length will be significantly correlated with reading success.

4. Regularity

This refers to the degree to which a word's pronunciation can be determined by its spelling—that is, whether it can be “sounded out” on the basis of spelling-to-sound correspondences. For some patients, particularly those with surface alexia, words that are highly regular such as *pin* and *tub* are more likely to be read correctly than irregular (also called “exception”) words such as *pint* and *touch*.

5. Familiarity

Familiarity, whether or not a word is known to the reader as a real word, affects the reading of some alexic patients. An unimpaired adult reader can read both familiar real words and unfamiliar pronounceable nonwords (pseudowords), such as “rithy” or “Mr. Jamport.” The reading of patients with phonologic/deep alexia is sensitive to this variable; real words such as *rot* may be read better than pseudowords such as *bot*.

III. TYPES OF CENTRAL ALEXIA

A. Pure Alexia

The syndrome of pure alexia was first described in the 19th century. The most striking feature of this reading disorder is that the patient retains the ability to write and spell; thus, pure alexia is also known as alexia without agraphia. Patients who have alexia without agraphia cannot read that which they have just written.

A characteristic feature of pure alexia is that patients with this form of alexia retain the ability to recognize words that are spelled aloud to them. That is, although patients with pure alexia have difficulty recognizing written words, they do not have difficulty identifying those same words upon hearing the names of the letters in the word in serial order. In fact, many of these patients discover that they can “read” written words if they name the letters of the words. The use of this compensatory reading strategy has been termed letter-by-letter reading. The ability to identify letters may be impaired early in the course of pure alexia. However, letter-naming ability often recovers over time, or it can be successfully retrained in most cases. The error most likely to be produced is the orthographic paralexia. These errors may be the result of incorrect letter naming or failure to hold on to all letter names in a word while the word is being identified (Table II).

Table II
Central Alexias and Their Characteristic Paralexias

Alexia type	Paralexias
Pure alexia	Orthographic
Surface alexia	Orthographic Regularization
Phonological alexia	Orthographic Inflectional and derivational Function word substitutions
Deep alexia	Orthographic Inflectional and derivational Function word substitutions Semantic
Phonological text alexia	<i>Errors occur only in text reading</i> Orthographic Inflectional and derivational Function word substitutions

Pure alexia is also characterized by a length effect, in which words with more letters are read more slowly and are less likely to be read correctly than words with fewer letters (Table III). The length effect is likely a consequence of the explicit letter-by-letter reading strategy: The more letters that must be identified and named, the longer it must take to do so. There are no effects of concreteness, part-of-speech, regularity, or familiarity either when these patients are attempting to read words or when words are spelled aloud to them.

Patients with pure alexia usually have intact language, although there may be some degree of anomia (difficulty retrieving words), which may be particularly pronounced for colors (color anomia). They frequently have a visual field cut called a right homonymous hemianopia, in which the right side of visual space cannot be seen.

Both the retained ability to spell and write and the retained ability to recognize orally spelled words suggest that orthographic information about words remains intact in patients with pure alexia. Thus, it has been suggested that the disorder reflects a disconnection of visual information from intact language processing areas of the brain.

The anatomy of pure alexia is consistent with the notion of a disconnection between visual and language processing centers of the brain. Pure alexia typically results from a stroke within the distribution of the left posterior cerebral artery or from a tumor located in the posterior left hemisphere of the brain. In most cases, the left occipital lobe is damaged such that the primary

Table III
Central Alexias and Word Properties Affecting Reading

Alexia	Word properties affecting reading
Pure alexia	Letter length
Surface alexia	Regularity
Phonological alexia	Part of speech Concreteness Syllable length Familiarity
Deep alexia	Part of speech Concreteness Syllable length Familiarity
Phonological text alexia	<i>Errors occur only in text reading, except PW reading errors</i> Part of speech Concreteness Syllable length Familiarity

visual cortex is destroyed. This accounts for the right homonymous hemianopia. All visual input, then, must be processed initially by the right visual cortex. The results of this processing must then be transferred to the left angular gyrus for orthographic processing. However, this relay of the information is not possible because the lesion also damages the splenium of the corpus callosum, which connects the hemispheres in the posterior part of the brain, or the lesion damages the fibers adjacent to the angular gyrus within the left hemisphere. In either case, the visual information cannot reach the left angular gyrus, and reading fails (Table IV).

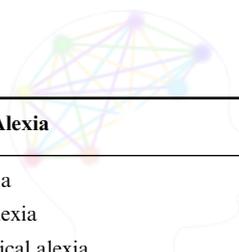
B. Surface Alexia

The cardinal feature of surface alexia is the presence of a measurable regularity effect in reading. When presented with a list of words with regular spelling-to-sound correspondences and a second list of words matched to the first list in letter length and frequency but consisting of words with irregular spelling-to-sound correspondences, patients with surface alexia have considerably more difficulty reading the second list. The regularity effect is likely to be even more pronounced when the words are of low frequency.

Some patients with surface alexia produce regularization errors; that is, an irregular word is pronounced (incorrectly) as it would be according to the

Table IV
Alexias and Site of Lesion

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Alexia	Lesion site
Pure alexia	Left occipital lobe and splenium of the corpus callosum
Surface alexia	Parietal or temporoparietal, multifocal cortical degeneration, or closed head injury
Phonological alexia	Variable sites, but usually in the distribution of the left middle cerebral artery
Deep alexia	Left frontal extending into the parietal and temporal lobes
Phonological text alexia	Variable sites, but usually in the distribution of the left middle cerebral artery
Attentional alexia	Left posterior tumor or left parietal infarct
Neglect alexia	Typically right parietal lesion

spelling-to-sound correspondence rules of the language. However, not all surface alexic patients produce regularization errors in reading. Indeed, some of these patients produce a large number of errors that appear to be the result of a *misuse* of correspondence rules. Vowels, which typically have more than one pronunciation, are often mispronounced. One common error is the production of the short vowel rather than the long vowel in syllables consisting of vowel–consonant–e (e.g., reading *hate* as “hat”). Consonants with multiple pronunciations may be misread as well (e.g., *get* → “jet”).

The patient with surface alexia appears to be unable to access the meanings of written words without first accessing their pronunciations. Comprehension of written words appears to depend on the pronunciation given to the word. Thus, if a written word is read incorrectly, the meaning attributed to that word will correspond to the pronunciation given. For example, if the word *come* is read according to spelling-to-sound correspondence rules, and is thus pronounced so as to rhyme with “home,” then the surface alexic patient may interpret the word to mean an implement used for fixing one’s hair.

As might be predicted, homophones are the source of a great deal of confusion for surface alexic patients. Intact readers make use of the orthography (spelling) of words such as *for* and *four* to determine that the former is a preposition and the latter a number. The surface alexic patient, upon pronouncing them both identically, may not know which for/four is which.

Indeed, the surface alexic patient frequently relies on the pronunciation of a written word not just to determine its meaning but also to determine whether or not it is a real word. If the patient reads the word *pint* so as to rhyme with *mint*, then the word will be judged to be a nonword, because there is no English word with

that pronunciation. The patient is unable to rely on the familiarity of the sequence of letters in a previously known word to determine that it is a real word.

Similarly, pseudowords are not immediately recognized as being nonwords and must be pronounced before such a judgment can be made. Pseudowords that are homophonic with real words (e.g., *hoam*) may be accepted as real words by surface alexic patients.

The reading of patients with surface alexia usually does not show an effect of familiarity. [If anything, there is a reverse familiarity effect, in that pseudowords are read better than many (irregular) real words.] Likewise, effects of concreteness, part of speech, and length are not typically seen in surface alexia. In most reported cases of surface alexia, spelling is impaired in a manner analogous to the reading deficit. That is, words with irregular or ambiguous spellings are likely to be spelled incorrectly more often than words with predictable spellings (lexical or surface agraphia).

Most patients with surface alexia have lesions in the parietal or temporoparietal region of the left hemisphere. Surface alexia has also been described in cases of multifocal cortical degeneration and is frequently seen following closed head injury.

C. Phonological Alexia

The defining feature of phonological alexia is a strong familiarity effect (i.e., a marked deficit in reading pseudowords) in the face of a relatively intact ability to read real words. Although this may seem to have little relevance for reading in the real world (we are rarely called on to read pseudowords), in fact patients with phonological alexia do complain of difficulty reading, although their complaints are often nonspecific.

Some patients with phonological alexia also have difficulty reading functor words (prepositions, conjunctions, etc.) and may have a tendency to delete, add, or substitute affixes (e.g., read *faded* as “fade” or “fading”).

An explanation of phonological alexia that accounts for both the primary difficulty reading pseudowords and the secondary difficulty reading functors is that it represents a disturbance in connections between written words (orthography) and their pronunciation (phonology), forcing reading to proceed via direct connection between orthography and meaning (semantics). Most functors and affixes serve primarily a syntactic role and have weak representations within the semantic network. Pseudowords, of course, have no semantic value and thus cannot be read via meaning.

The errors that these patients produce when attempting to read pseudowords often seem to be derived from the target word in some way. Commonly, the initial phoneme (sound) is correct. Often, a word that is orthographically similar to the target word is produced. Some very short pseudowords may be read entirely correctly; long pseudowords are rarely read correctly.

The reading of patients with phonological alexia does not exhibit a regularity effect. If a length effect is seen, it is dependent on the number of syllables or phonologic complexity, not the number of letters. A part-of-speech effect may be seen, particularly for functors, as noted previously. A concreteness effect is occasionally seen in phonological alexia. Patients with phonological alexia do not always display the analogic deficit in writing (phonological agraphia).

The lesion causing phonological alexia is quite variable but is normally located within the distribution of the left middle cerebral artery.

D. Deep Alexia

The reading of patients with deep alexia displays all the alexia symptoms of phonological alexia, with the addition of the defining feature of the disorder, the production of semantic paralexias. When semantic paralexias are produced at a rate that is greater than chance, the entire symptom complex is almost guaranteed to be seen: poor pseudoword reading, a part-of-speech effect in which verbs are read more poorly than nouns, and functors are read more poorly than verbs, a concreteness effect, and the production of derivational errors and functor word substitutions. The pseudo-

word reading deficit in deep alexia tends to be more severe than that seen in phonological alexia. Responses may be completely dissimilar to the target pseudoword, or no response at all is produced.

It has been suggested that deep alexia represents the (most impaired) end point of a continuum that includes the various manifestations of phonological alexia. As in phonological alexia, the pronunciation of written words cannot be accessed directly; reading proceeds semantically. However, in deep alexia there is an impairment within the semantic reading route that results in the semantic paralexias. This impairment may be within the semantic processing system or in the ability of that system to access the correct phonological code.

The typical lesion that produces deep alexia is a large one, affecting much of the left frontal lobe and extending into the parietal and temporal lobes as well. It has been posited that the symptom complex of deep alexia is actually a manifestation of right hemisphere reading in the presence of a left hemisphere that is greatly damaged. Support for this notion has come from studies of reading in split-brain patients. It has been demonstrated that the right hemisphere of some of these patients can read concrete words but not abstract words or functors and cannot determine the pronunciation of nonwords (ascertained with a rhyme task). This pattern is similar to the reading pattern of patients with deep alexia.

E. Phonologic Text Alexia

Some patients complain of difficulty reading following a stroke or head injury, but the examiner may be unable to find any class of words—or indeed any words at all—that the patient cannot read correctly. However, the accurate reading of words presented singly is not replicated when the words are presented within the context of text. When reading text, these patients tend to produce functor word substitutions, and they make errors on affixed words, as is frequently observed when phonological/deep alexic patients are asked to read single words. Also, like phonological alexic patients, these patients have difficulty reading pseudowords. It therefore appears that the reading problems of these patients are related to the problems seen in patients with phonological alexia. Hence, this reading disorder has been labeled phonologic text alexia.

Patients with phonologic text alexia typically have auditory comprehension deficits as well as reading

comprehension deficits. They also have impaired short-term phonologic memory, as demonstrated by decreased span for recall of digits, words, and pseudowords. The combination of all symptoms associated with phonologic text alexia leads to the proposition that the reading disorder seen in these patients is in some way the result of a deficit in phonologic processing and/or retention of phonologic information.

The paralexias produced by patients with phonologic text alexia in text reading (few errors are produced in single-word reading) are predominantly derivational paralexias and orthographic paralexias; semantic paralexias are not part of this syndrome, nor are regularization errors. A length effect may be observed, but this will be dependent on the number of syllables, not the number of letters, reflecting the phonologic processing deficit.

As with phonological alexia, phonological text alexia is normally the result of a lesion in the distribution of the left middle cerebral artery.

IV. TYPES OF VISUAL ALEXIA

Some acquired reading disorders are not the result of deficits within the language/reading processing systems per se, but rather reflect difficulties at a more peripheral stage of visual processing. Attentional alexia and neglect alexia are the most common of these visual alexias.

A. Attentional Alexia

Attentional alexia, like phonologic text alexia, is seen only when the patient is attempting to read text; the reading of words in isolation is basically intact. However, when viewing a multiword display (typically normal text), the patient appears to have difficulty maintaining the separation between words. Letters from adjacent words somehow infiltrate the word being read, resulting in errors that appear to be similar to those of orthographic paralexias. Attentional alexia does not appear to be a problem specific to reading. Rather, it is part of a more general problem with selective attention. The reported etiologies of attentional alexia include left posterior tumor and left parietal lobe infarct.

B. Neglect Alexia

The term neglect alexia refers to a pattern of reading in which one side of each word and/or one side of a page of text is not read or is misread. Often, although not always, this is seen within the context of a neglect syndrome that is not specific to reading. That is, the patient tends to ignore one side of space, even when not engaged in reading. Typically, neglect is produced by a lesion in the right parietal lobe, resulting in neglect of the left side of space. However, there have been reported cases of right-sided neglect alexia following left hemisphere lesions and even some cases of left-sided neglect alexia following left hemisphere lesions.

See Also the Following Articles

AGRAPHIA • ANOMIA • DYSLEXIA • LANGUAGE AND LEXICAL PROCESSING • LANGUAGE DISORDERS • READING DISORDERS, DEVELOPMENTAL

Suggested Reading

- Coltheart, M. (Ed.) (1996). Phonological dyslexia. Special edition of *Cognitive Neuropsychol.* **13**(6).
- Coltheart, M., Patterson, K., and Marshall, J. C. (Eds.) (1980). *Deep Dyslexia*. Routledge and Kegan Paul, London.
- Friedman, R. B. (1996). Phonological text alexia: Poor pseudoword reading plus difficulty reading functors and affixes in text. *Cognitive Neuropsychol.* **13**, 869–885.
- Friedman, R. B. (1996). Recovery from deep alexia to phonological alexia: Points on a continuum. *Brain Language* **52**, 114–128.
- Friedman, R. B. (2002). *Clinical diagnosis and treatment of reading disorders*. In *Handbook of Adult Language Disorders: Integrating Cognitive Neuropsychology, Neurology, and Rehabilitation* (A. E. Hillis, Ed.) Psychology Press, Philadelphia.
- Friedman, R. B., and Alexander, M. P. (1984). Pictures, images, and pure alexia: A case study. *Cognitive Neuropsychol.* **1**(1), 9–23.
- Friedman, R. B., Ween, J. E., and Albert, M. L. (1993). *Alexia*. In *Clinical Neuropsychology, Third Ed.* (K. Heilman and E. Valenstein, Eds.), pp. 37–62. Oxford University Press, New York.
- Marshall, J. C., and Newcombe, F. (1973). Patterns of paralexia: A psycholinguistic approach. *J. Psycholing. Res.* **2**, 175–199.
- Patterson, K., and Kay, J. (1982). Letter-by-letter reading: Psychological descriptions of a neurological syndrome. *Quart. J. Exp. Psychol.* **34A**, 411–441.
- Patterson, K., Marshall, J. C., and Coltheart, M. (Eds.) (1985). *Surface Dyslexia: Neuropsychological and Cognitive Studies of Phonological Reading*. Erlbaum, Hillsdale, NJ.
- Riddoch, M. J. (Guest Ed.) (1990). Neglect and the peripheral dyslexias. *Cognitive Neuropsychol.* **7**(5/6) (Special issue).