Written communication involves the linking of ideas and words to their appropriate spellings, and then moving the hand to actually write the desired words. Acquired impairments of writing are referred to as apraxia and can result from damage to various stages of the writing process. These impairments may reflect degraded knowledge about spelling and the correspondences between sounds and letters or difficulty with the selection and formation of letters. Characteristic features of apraxia syndromes are reviewed in this article, along with example approaches to remediation. The treatments variously serve to strengthen weakened abilities, take advantage of residual skills, and develop compensatory strategies.

**Key words:** apraxia, aphasia, handwriting, spelling, language, remediation, treatment, writing

The ability to communicate ideas in writing is a skill that most people rely on for daily tasks at home, school, and work. The written information may be as mundane as a grocery list, as personal as a heartfelt letter or email communication, or as significant as a term paper, a manuscript, or legal document. The performance of such tasks may be impaired, or abolished, by damage to the language-dominant hemisphere that interferes with the thought processes necessary to recall the spellings of words and to form the component letters. Written communication can be impaired for different reasons depending upon what regions of the brain are damaged and what cognitive processes are impaired.

The impact of the impairment will depend upon the importance of written communication in the life of the affected individual, as well as the status of spoken language after brain damage. It is the role of the speech-language pathologist to discern the nature of the writing impairment and the needs of the individual patient so that appropriate treatment can be implemented. The occupational therapist may deal with the peripheral motor impairments that affect writing.

**Cognitive Processes That Support Spelling**

To appreciate the ways in which writing may be impaired, let us consider some basic principles about how single words are represented in our mind. Words convey concepts, which can be considered part of semantic knowledge, that is, our knowledge about the world. During language development, a child learns to associate objects, ideas, or attributes with specific spoken words. By the time most children begin kindergarten, they have learned hundreds of words as well as the skills necessary to combine words into meaningful sentences to express complex thoughts. During the early primary school years, a child typically learns the rudiments of written language production. They learn how to write the alphabet and what sounds are associated with different letters. They also learn what combinations of letters represent spoken words and their associated concepts. Thus, the knowledge of written language is overlaid on spoken language. This involves the learning of letter shapes, the association of sounds to letters, and the building of a corpus of written words that represent concepts and spoken words.

The cognitive processes necessary for writing are depicted in Figure 1, which shows that concepts in the semantic system are linked to both spoken (phonological) and written (orthographic) word forms. This allows us to think of a word and then say it or write it. The figure also depicts a direct link between phonology and orthography, suggesting that we can access spelling directly from the spoken word as well as from the semantic.
Figure 1. A simplified model of language processing.

tic system. When spellings are accessed directly from phonology without giving thought to their meaning, "slips of the pen" may result, such as writing flower for flour. Most of the time, however, semantic knowledge is activated as familiar words are spelled, so that orthographic representations are accessed via semantics along with input from phonology. Since word forms are referred to as lexical representations, semantically guided retrieval of written spelling is referred to as a lexical-semantic spelling procedure.

In contrast to the spelling of familiar lexical items, the spelling of unfamiliar words is typically accomplished at a subword level by sounding out the word and assembling a plausible spelling on the basis of sound-to-letter correspondences (see Figure 1). This phonological approach to spelling is depicted in Figure 1 as the "sound-to-letter conversion" route. A child may use these procedures to sound out the spellings for words not yet mastered. Children and adults alike use a sound-to-letter conversion approach to spell unfamiliar words such as uncommon proper names. Children learn that for languages like English, which present many exceptions to strict sound-to-letter correspondences, errors will be made if they rely too heavily on a sounding out approach to spelling (e.g., "night" might be misspelled nite). Thus, dependence upon a phonological approach to spelling decreases as orthographic knowledge grows.

To actually write words on paper, a person must convert the spellings derived either via the lexical-semantic route or the phonological route to the appropriate movements of the hand. There is evidence to suggest that spellings are held in short-term memory (a so-called graphemic buffer), whereas the motor programs for specific letter shapes are selected from the possible range of forms including upper versus lowercase, print versus cursive, and so on. This conversion of abstract spelling knowledge to specific letter shapes has been called allographic conversion, because each unique production of a grapheme can be considered an allograph. Finally, spatial and temporal information contained in the graphic motor programs guide the positioning of the hand and the direction, sequence, and range of
hand movements for writing. The stages of letter selection and the planning and implementation of the motor movements can be considered as the peripheral aspects of writing, whereas the retrieval or assembly of spelling reflects the more central (or linguistic) aspects of spelling.

Nature of Acquired Agraphia

Writing impairments may result from damage to any of the central or peripheral components of spelling and handwriting. Impairment to certain aspects of the writing process results in characteristic features that have been identified as specific agraphia syndromes (see Table 1). There is evidence from individuals with acquired agraphia to suggest that specific regions of the brain are critical for the lexical-semantic and phonological spelling procedures and that these regions are distinct from those that support the motor planning and implementation of handwriting (for reviews, see Rapcsak & Beeson, and Roeltgen). As might be expected, many individuals with acquired impairments of spelling have concomitant impairments of reading and spoken language, such as those discussed by authors in this issue.

Spelling impairment due to damaged orthographic knowledge

Damage to the lexical-semantic spelling route is characterized by impaired memory for the spellings of words. It reflects a loss or degradation of orthographic representations or failed access to that knowledge and has been referred to as lexical agraphia to denote the fact that lexical knowledge is impaired. When an individual cannot recall the spellings of once familiar words, he or she may be able to rely on phonological procedures to sound out the spelling of a word using sound-to-letter conversion rules. This procedure works for words with regular spelling, such as home and dome, but will lead to errors for irregularly spelled words like come or comb. “Come” might be spelled as kum, whereas “comb” might be spelled heme. Such errors are considered phonologically plausible because they logically result from the application of strict phonological rules of spelling. Such an approach to spelling might be considered writing with “surface” knowledge of sound-to-letter correspondences rather than lexical-semantic knowledge, and for that reason lexical agraphia is also referred to as surface agraphia. Words with predictable (i.e., regular) sound-to-letter relationships are more likely to be spelled correctly when compared to words with unpredictable (i.e., irregular) spellings. This difference in accuracy of the spelling of regular versus irregular words has been referred to as a regularity effect. Thus, in the case of lexical agraphia, spelling accuracy is strongly influenced by orthographic regularity. It has also been noted that spelling knowledge is typically more impaired for less common words, that is, words with a lower frequency of occurrence.

Table 1. The clinical features (or effects) associated with acquired agraphia syndromes

<table>
<thead>
<tr>
<th>Agraphia syndrome</th>
<th>Regularity</th>
<th>Frequency</th>
<th>Concreteness</th>
<th>Grammatical</th>
<th>Lexicality</th>
<th>Semantic</th>
<th>Word length</th>
<th>Letter selection</th>
<th>Poorly formed letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lexical agraphia (surface agraphia)</td>
<td>✓</td>
<td>✓</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Phonological agraphia</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Deep agraphia</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Graphemic buffer agraphia</td>
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<tr>
<td>Impairment of allgraphic conversion</td>
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<td></td>
<td>✓</td>
</tr>
<tr>
<td>Apraxic agraphia &amp; agraphia associated with neuromuscular disorders</td>
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<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Because individuals with lexical agraphia can use a phonological strategy to spell nonwords or pseudowords (such as toffer or lixon), their nonword spelling is typically better than spelling for irregular real words. Words that sound the same but have different spellings and meanings (e.g., homophones such as night and knight) are particularly difficult for individuals with lexical agraphia because they are likely to result in the same plausible spelling (e.g., nite).

Lexical agraphia is typically associated with left-hemisphere pathology that involves the angular gyrus and/or posterior lateral and ventral temporal cortex. The relative preservation of phonological spelling is most likely attributable to the fact that these lesions are posterior and inferior to the perisylvian language zone in the left hemisphere that is important for phonological processing.

**Spelling impairment due to damaged phonological abilities**

In contrast to spelling impairment associated with damaged lexical-semantic processing, some individuals incur damage to phonological spelling procedures. In such cases, spelling is accomplished primarily via a lexical-semantic strategy, and patients have marked difficulty using sound-to-letter conversion to spell unfamiliar words or nonwords. Such impairment is most noticeable when the individual is asked to spell nonwords (such as flig), which have no lexical representation so that they require phonological procedures. This type of spelling impairment is referred to as phonological agraphia due to the impairment of phonological processes. The hallmark of phonological agraphia is the marked difference in spelling performance between real words and nonwords. This is referred to as a lexicality effect (i.e., real words spelled more accurately than nonwords). The loss or impairment of phonological processing abilities can also interfere with access to spellings of words that do not have strong semantic representations, such as abstract nouns (e.g., honest, pride) and function words that serve more of a grammatical than semantic function (e.g., articles and prepositions).

Lesion studies typically have shown phonological spelling impairments to be associated with damage to left perisylvian language areas including Broca’s area, Wernicke’s area, and the supramarginal gyrus.

**Spelling impairment due to damage to both orthographic and phonological spelling abilities**

Many individuals with marked language difficulty exhibit impairment to both lexical-semantic and phonological spelling abilities. Like those with lexical agraphia, such individuals show loss or degradation of their memory for spellings and, like those with phonological agraphia, they cannot rely on phonological spelling procedures. In such cases, spelling is typically attempted using a whole-word approach with reliance on the damaged lexical-semantic route. Errors are numerous and do not reflect plausible sound-to-letter correspondences. In fact, some spelling errors may be semantic in nature, such as “ship” written as boat. Such semantic errors are thought to arise due to the degraded status of semantic or orthographic representations or to disruption of the links between semantic and lexical knowledge. This agraphia profile is referred to as deep agraphia. The fact that the semantic errors often bear no resemblance to the correct spelling (e.g., “cognac” written as beer) highlights the fact that phonological spelling procedures are not used to check for correspondence between sounds and letters. In addition to the hallmark semantic errors, damage to the lexical-semantic spelling route results in greater difficulty with less common words, so that high frequency words are better preserved than low frequency. Words with stronger semantic representations that reflect concrete concepts also tend to be spelled more accurately than abstract words. As noted with phonological agraphia, the spelling of function words is typically more impaired than content words (nouns), presumably because of reduced semantic weight.

Individuals with extensive left-hemisphere damage lose spelling knowledge to such a degree that they write very few meaningful words or nothing at all. A writing impairment of this nature may be referred to as global agraphia. As might be expected, individuals with global agraphia often
have marked impairments of reading and spoken language, as well.

**Spelling impairment due to graphemic buffer dysfunction**

Some individuals demonstrate difficulty holding spelling information in short-term memory as they try to write a word. In such cases, it appears that there is an abnormally rapid decay of information about the identity and order of letters that make up a word.\(^1\)\(^{18}\) When spelling knowledge is not adequately retained in the graphemic buffer, spelling accuracy notably decreases as word length increases. In other words, individuals with graphemic buffer agraphia may be able to spell short words of three to four letters in length, but errors become evident with words of five, six, seven, or more letters. Well-formed letters are produced, but there are letter omissions (window → winow), substitutions (table → tbla), additions (flower → flowerr), and transpositions (chair → chiar). In most cases, letters at the beginning of words are most likely to be correct; errors are more prominent toward the end or middle of words.\(^18\)\(^{18}\)\(^{20}\) Lesions associated with graphemic buffer impairment have been variably reported in the left frontal and parietal lobes, so that this process is not well localized.

**Impairment to peripheral writing processes**

There are several final stages involved in translating abstract spelling knowledge into meaningful strokes of the pen. Breakdowns may occur in the allographic conversion stage wherein letter shapes are selected and mapped onto the appropriate graphic motor programs.\(^21\) There may be a disruption of the specific motor commands necessary to guide movements of the hand resulting in apraxic agraphia.\(^22\)\(^23\) Other sources of peripheral writing impairment include damage to neuromuscular mechanisms that control the force, speed, and amplitude of movements.\(^3\) Difficulty with neuromuscular control may result from motor neuron damage (as with hemiparesis from stroke), cerebellar dysfunction, or extrapyramidal diseases such as Parkinson’s disease.

An impairment of allographic conversion may cause the patient to produce incorrect but well-formed letters, or the patient may simply fail to recall how to form various letters. The errors may be specific to a particular case or style of writing, such as uppercase letters, lowercase letters, script, or print.\(^24\)\(^25\) In the case of apraxic agraphia and neuromuscular impairments, letters may be poorly formed to the point of being illegible. When the impairment is truly restricted to peripheral processes, the ability to spell words aloud is often retained. Thus, a marked difference between oral and written spelling is indicative of damage to peripheral spelling procedures.

**Treatments for Acquired Agraphia**

Similar to rehabilitation in other language modalities, treatment for writing impairment may serve to strengthen impaired processes and promote the use of residual abilities. As cognitive processes are strengthened and possibly reorganized, habitual use of new and compensatory behaviors must be established. Treatment approaches are reviewed here relative to different agraphia profiles (see Table 2). The examples reflect the modest but growing literature that serves to document the therapeutic effect of such treatments (for recent reviews, see Beeson & Hillis\(^26\) and Beeson & Rapcsak\(^27\)). It is important to keep in mind that treatment goals are influenced by the functional needs of the patients, therefore target words and skills are selected on the basis of personal needs.

**Treatment for lexical agraphia**

Two approaches to treatment for lexical agraphia will be reviewed here. The first is directed toward rebuilding orthographic representations for specific words. The second is more of a problem-solving approach in which relatively preserved phonological abilities are recruited to aid in the resolution of spelling errors.

**Copy and recall treatment (CART)**

CART refers to a protocol that uses repeated copying of target words and recall trials to re-estab-
lish the ability to spell specific words. The procedures are quite simple to implement, as detailed in Figure 2, but experience shows that success relies on repeated practice. Treatment sessions serve as a context in which to teach patients how to structure daily homework and as a means of accountability for adherence to the homework procedures. Positive outcomes from the use of this procedure, as well as similar approaches that use repeated copying of target words, have been reported for a variety of agraphia profiles.28-31 Behrmann12 used a similar approach to specifically train the correct spelling of homophones, which tends to cause confusion in patients who rely on a phonological spelling approach. It is important to note that CART is likely to be most successful when a limited number of words are trained to mastery (e.g., five words at a time), instead of when it is used as a general stimulation technique with a wide range of words. In other words, the goal of this method is to strengthen or rebuild the representations for specific target words before moving on to the next set.

Table 2. Brief summary of central and peripheral agraphia syndromes including example treatment goals, treatment approach, and expected treatment outcome

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Example treatment goals</th>
<th>Example treatment approach</th>
<th>Expected outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Central agraphias</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lexical agraphia</strong></td>
<td>Strengthen lexical-semantic spelling route</td>
<td>Copy and recall treatment (CART) to train spellings of irregular words</td>
<td>Improved spelling of trained words</td>
</tr>
<tr>
<td><strong>Impaired lexical semantic spelling</strong></td>
<td>Facilitate interactive use of lexical and phonological spelling routes</td>
<td>Problem-solving approach promoting interactive use of phonological &amp; lexical-semantic spelling</td>
<td>Self-detection and correction of errors with generalization to untrained words</td>
</tr>
<tr>
<td><strong>Phonological agraphia</strong></td>
<td>Strengthen phonological spelling route</td>
<td>Retrain sound-to-letter correspondences</td>
<td>Improved spelling of regularly spelled words (trained and untrained)</td>
</tr>
<tr>
<td><strong>Impaired phonological spelling</strong></td>
<td>Strengthen lexical-semantic spelling route</td>
<td>CART to train specific orthographic representations</td>
<td>Learn spelling for targeted words</td>
</tr>
<tr>
<td><strong>Deep &amp; global agraphia</strong></td>
<td>Strengthen lexical-semantic spelling route</td>
<td>Anagram and copy treatment (ACT) to train specific orthographic representations (regular or irregular words)</td>
<td>Learn spelling for targeted words only; develop corpus of written words to use for written communication</td>
</tr>
<tr>
<td><strong>Impaired phonological and lexical-semantic spelling</strong></td>
<td>Strengthen specific orthographic representations</td>
<td>CART for words of 5 or more letters</td>
<td>Reduced length effect for spelling of treated words</td>
</tr>
<tr>
<td><strong>Graphemic buffer agraphia</strong></td>
<td>Train self-detection and correction of spelling errors</td>
<td>Train search strategy (engage oral spelling if better preserved than written) to assist in error detection &amp; correction</td>
<td>Generalized improvement in spelling</td>
</tr>
<tr>
<td><strong>Impaired short-term memory store for spellings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Peripheral agraphias</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Allographic conversion impairment</strong></td>
<td>Improve letter selection</td>
<td>Train use of alphabet card as model for letter shape; use case conversion tasks for repeated practice; use self-dictation to prompt error detection &amp; correction</td>
<td>Reliance on compensatory strategy to retrieve letter shapes; or generalized improvement in letter retrieval</td>
</tr>
<tr>
<td><strong>Impaired ability to activate or select letter shapes</strong></td>
<td>Improve graphomotor control</td>
<td>Letter tracing and repeated copy to retrain graphomotor movements</td>
<td>If responsive, graphomotor control may increase and legibility may improve</td>
</tr>
<tr>
<td><strong>Apraxic agraphia</strong></td>
<td>Train compensatory strategies</td>
<td>Maximize compensatory strategies including use of keyboard, if possible</td>
<td>Use of keyboard may substitute for handwriting (in some cases)</td>
</tr>
<tr>
<td><strong>Damage to graphic motor programs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Impaired neuromuscular execution</strong></td>
<td>Hemiparesis: improve graphomotor control with nondominant hand</td>
<td>Repeated writing with nondominant hand, typically in context of treatment for central impairment of spelling (e.g., CART)</td>
<td>Improved motor control for nondominant hand</td>
</tr>
<tr>
<td><strong>Damage to motor systems that innervate hand movements</strong></td>
<td>Micrographia: increase letter size</td>
<td>External cues to increase range and force of hand movements for writing</td>
<td>Improved legibility with consistent self-monitoring</td>
</tr>
</tbody>
</table>
1. **Dictate** a word to be written.

   Example: “Phyllis. Write your sister’s name, Phyllis.” [note semantic information given]
   - Correct: Give feedback and then present the next word.
   - Incorrect: Proceed through the following steps.

2. **Copy**: Present a handwritten model of the word. Model may be written by clinician or may be an example from participant’s homework or previous written responses.

   Prompt copying of target word *three* times, providing feedback regarding accuracy.

   Example: “It looks like this, Phyllis. Can you copy it?” “Write it again.” “One more time, write Phyllis.”

3. **Recall**: Remove all examples of the written word and prompt recall of the word three times.

   Example: “Do you remember it? Write Phyllis.” [Give feedback, then cover the word]
   “Write it again.” [Give feedback, then cover the word.]
   “One more time, write Phyllis.”
   - Correct: Present the next word.
   - Incorrect: Repeat step 2 [If unable to correctly write the word without a model after several trials, move on to next item.]

4. **Recall**: Remove all examples of the target and prompt participant to write the word in a sentence.

   Example: “Write a sentence using Phyllis’s name.”

   Give feedback regarding spelling first, then feedback regarding the sentence. Note that treatment focuses on spelling, so that errors of grammatical structure are simply corrected. The purpose of the sentence-writing task is to place additional demands on recall of spelling and to train the procedure for use in homework.

**Homework**: Provide daily homework pages for 6 days a week. Each day’s homework includes the list of words targeted for treatment, with five lines for copying the written word, and a “recall” page to write the word from memory and write it in a sentence. As word sets are mastered, include homework for old and new word sets. Homework for mastered words may be reduced so that those words are practiced at reduced frequency.

**Problem-solving approach to spelling**

Another treatment approach that is appropriate for lexical agraphia is more of a compensatory strategy than the item-specific approach used in CART. The goal of the problem-solving approach to written spelling is to take advantage of relatively preserved sound-to-letter correspondences to facilitate retrieval of correct spelling.33 Because individuals with lexical agraphia can “sound out” words, this information from the phonological route may assist patients in problem solving to achieve correct spelling. The treatment procedures are intended to promote interaction between phonological and lexical-semantic spelling routes so that phonologically plausible spellings can help trigger recall of correct spellings.

The problem-solving approach involves training the patient to learn to self-correct phonologically plausible errors. Given such an error, the patient is encouraged to examine the word and try possible spelling alternatives, while keeping in mind that sounds often have several possible grapheme correspondences (e.g., kite, cat, choir). They are guided to try alternative spellings, aiming to find what “looks right.” Then, to check plausible spellings, the patient is trained to use an electronic spell-checker that provides feedback as to correct spelling. An example of such a device is the Franklin Speaking Dictionary®. The patient types the attempted spelling of a word into the handheld device and then pushes the enter key. A correct spelling simply stays on the screen; for misspelled words, phonologically close neighbors are offered as options. For example, if *karaker* is entered, the first alternative given is *character* (the correct target), with the other alternatives including *caretaker* and *cracker*. The patient is to select a spelling from the list that he or she thinks is correct. The patient can confirm the choice by pushing the “say” button to listen to the word.

Written homework is assigned to provide repeated practice with the problem-solving approach. Because individuals with lexical agraphia often have relatively preserved language competence with regard to the formulation of grammatical sentences, homework assignments can include self-generation of paragraphs about topics of interest. Such writing
tasks invariably evoke instances of spelling difficulty, which then prompt practice of the problem-solving approach. The content of written paragraphs should reflect the interests and needs of the patient. For example, we have had patients write autobiographical narratives, write paragraphs on topics of interest, or keep personal diaries or daily logs of activities. Patients are trained to use the problem-solving approach at home with the following steps:

1. When you are unsure about the spelling of a word, try spelling it as it sounds.
2. Examine the spelling and see if you can correct it by writing out different spellings.
3. Select the spelling that you think is correct or is the closest.
4. Enter your spelling into the electronic spell checker to see if it is correct or if the correct alternative is offered.
5. Copy the correct spelling into your homework passage.
6. Rewrite your homework paragraph with all spelling corrections made.

During the treatment session, the clinician reviews the homework with the patient, checking for evidence that the procedure is being implemented appropriately and looking for residual errors. Use of the problem-solving approach to spelling treatment should provide a compensatory strategy whereby many spelling errors can be resolved with relative independence. Research has shown that the treatment may also serve to improve spelling knowledge. In other words, use of the problem-solving approach may improve access to spellings or strengthen orthographic representations, or both. An additional potential benefit of the treatment relates to the content of the written narratives. Several of our patients generated written narratives to recount aspects of their changed lives after stroke and to explore issues of concern. One patient composed her “stroke story” during months of writing treatment. Her account was ultimately published, which gave her a sense of accomplishment and pride.

**Treatment for phonological agraphia**

Individuals with phonological agraphia have been shown to benefit from treatment designed to strengthen sound-to-letter correspondences so that they can use phonology to help guide spelling. Because these individuals have difficulty sounding out spellings, it may be necessary to train them in the use of “key words” to help them retrieve the correct grapheme for a given sound. For each targeted letter, the clinician works with the patient to find one word that he or she can consistently say and spell correctly. For example, one of our patients used the word “Kim” as her key word for the letter k. This patient was consistently able to say her sister's name and recall its spelling, so that “Kim” became her key word to help retrieve the letter k when spelling other words with a /k/ sound. Similarly, other single words were identified as key words for specific consonants, such as “Ron” for r and “nose” for n. Of course, there is some potential for confusion with certain sound-letter correspondences due to multiple graphemes corresponding to a given sound in the English language (e.g., the grapheme c is also associated with the /k/ sound). It helps that individuals with phonological agraphia retain lexical spelling knowledge to some extent, so that phonological retraining interacts with residual lexical knowledge.

Key words are typically trained for higher frequency consonants first, then lower frequency consonants are trained. For example, the following graphemes are suggested for training in groups of five because of their high frequency of occurrence in English spellings: [r, t, n, s, l], [k, d, m, p, f], [b, sh, v, g, z]. Phonological training focuses on consonants rather than vowels, which lack consistent sound-to-letter correspondences. It is often the case that the graphemic information provided by consonants combined with residual orthographic information is adequate to yield correct spellings. Once key words are established, a cueing hierarchy can be used as described in Figure 3, which facilitates the use of sound-to-letter correspondences to derive graphemes. The goal is to re-establish phoneme-grapheme conversion skills so that patients can generate plausible spellings for words.

**Treatment for deep or global agraphia**

Many individuals with acquired agraphia have such limited residual orthographic and phonolog-
ical abilities that the problem-solving approach to spelling or the retraining of sound-to-letter correspondences is unrealistic. Such individuals are likely to have significant aphasia and alexia, as well as agraphia. Writing treatment may be particularly important for these individuals, because writing may serve to cue spoken language or provide an alternative means of communication. Item-specific treatment to relearn the spelling for single words can be used to establish a corpus of written words for communication.

Anagram and copy treatment

One approach to strengthening orthographic representations involves the arrangement of component letters of target words (i.e., rearranging the anagram) followed by repeated copying of the target word. The arrangement of component letters places less demand on the patient than self-generated writing and supports trial and error ordering of letters as the patient tries to recall the correct spelling. The task hierarchy described in Figure 4 is intended to strengthen the mental representation of the written word. The anagram arrangement is followed by repeated copying and recall trials of the target word. This component is similar to the CART protocol described for lexical agraphia; but when CART is implemented with individuals with deep or global agraphia, pictured stimuli are used to ensure that written words are linked to meaning. In addition, homework typically consists of more repetitions of the written word than necessary for those with lexical agraphia. Both anagram and copy treatment (ACT) and CART protocols have been shown to facilitate relearning of a corpus of personally relevant written words for communication in individuals with severe aphasias.

Another component of writing treatment for individuals with severe aphasia may include training in the conversational use of written words. This pragmatic training promotes the use of single-word writing in conjunction with other communication modalities, such as gesture, spoken utterances, and drawing. The conversational use of writing can be trained in the context of individual or small group sessions.

Treatment for graphemic buffer agraphia

There is little evidence to suggest that it is possible to directly improve the performance of the graphemic buffer. However, several treatment studies have resulted in improved spelling in individuals who appeared to have reduced short-term memory for orthography. Some treatments have

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1. "Write the letter that makes the sound /k/.
   - If correct, move on to the next target phoneme.
   - If in error, proceed to step 2.

2. Provide an array of letters (five or more) including the correct target and say, "Point to the letter that makes the sound /k/.
   - If correct, remove array of letters and go to step 1.
   - If incorrect, proceed to step 3.

3. "Think of a word that starts with /k/.
   - If correct, say, for example, "Yes, a word that starts with /k/ is 'Kim.' 'Kim' starts with the letter k.”
   - Rearrange the letters in the array and go to back to step 2.
   - If incorrect, go to step 4.

4. "A word that starts with /k/ is 'Kim.' Point to the letter that makes the first sound of 'Kim.'
   - If correct, rearrange the array of letters and go back to step 2.
   - If incorrect, go to step 5.

5. Write your key word for /k/. Write 'Kim.' Now point to the letter that makes the first sound of "Kim."
   - If correct, rearrange letters in the array and go back to step 2.
   - If incorrect, go to step 6.

6. Clinician writes the key word for the target sound /k/, and says, for example, "The letter K makes the first sound of Kim. /k/ is the first sound of Kim. K makes the sound /k/. Point to the letter K. Now copy the letter K." Return to step 2.

Figure 3. Example of cueing hierarchy for teaching sound-to-letter conversion.
been directed toward strengthening orthographic representations with the assumption that stronger representations are more likely to persist in short-term memory. There is evidence to show that training specific words serves to improve spelling even for long words that tax the graphemic buffer.\textsuperscript{35,32,43} These treatment approaches use cueing hierarchies and repeated copying and recall of specific words in a manner similar to that used when attempting to rebuild orthographic representations (e.g., a protocol like CART). Although this is an item-specific approach, it has been shown to result in a generalized improvement in spelling\textsuperscript{44} and a reduction of the word-length effect.\textsuperscript{53} Other treatments involve the segmentation of long words into shorter syllable units.\textsuperscript{45} For example, the patient is trained to segment a word like “breakfast” into \textit{break} and \textit{fast} using self-dictation. This approach, combined with strategies to promote self-detection and correction of spelling errors, has been shown to improve spelling for trained and untrained words.\textsuperscript{30}

**Treatment for peripheral writing impairments**

The goal of treatment for peripheral writing impairments is to improve the accuracy of letter selection and the graphomotor control necessary to form legible spelling. Treatment may serve to improve the impaired skills or may involve the development of strategies to compensate for the impairment.

In the case of allographic writing impairment, the provision of a card with the printed alphabet may serve to provide the necessary model for letter shapes. If oral spelling is preserved, individuals can be trained to use self-dictation of spelling as a means to cue retrieval of letter shape or recognition of the shape on the alphabet card. Oral spelling may also be incorporated as a means of self-detection and correction of errors in letter selection.\textsuperscript{46} In some cases, typing may serve as a reasonable substitute for handwriting. A hand-held spelling dictionary may be suitable for some individuals to use as a typed model that can be copied. It is worthy of note that these relatively obvious compensatory strategies often require systematic training before they become used in an efficient manner.

Damage to graphic motor programs resulting in apraxic agraphia presents a considerable challenge for rehabilitation, and there is little documentation in the literature of positive treatment outcomes. The use of a keyboard should be explored to dis-

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**Figure 4.** Steps for implementing anagram and copy treatment (ACT) with individuals with deep or global agraphia.
cern if hand movements for typing are adequately controlled to substitute for handwriting. The ability to copy written words should also be examined. If copying skills are relatively preserved, repeated direct and delayed copy of written letters and words may result in a shift from highly intentional and monitored hand movements to more automatic graphomotor control. Trial treatment sessions with copying homework should serve to indicate the potential for improvement.

A variety of neurological conditions can cause significant impairment to neuromuscular control of the hand, making legible writing impossible. In the case of hemiparesis of the preferred hand, writing can be shifted to the nondominant hand. Some patients make this transition and adjust to the awkwardness with few complaints, whereas others need to be guided and provided with structured writing homework to make use of the nondominant hand for writing. Those with right hemiparesis often have significant language impairment as well, so that central as well as peripheral processes are impaired; treatment of these patients should address both aspects of spelling and writing.

Of the degenerative diseases that affect graphomotor control, Parkinson's disease is one that may be addressed behaviorally. The reduced force and amplitude of movement associated with the disease frequently results in small, compressed writing referred to as micrographia. An increase in letter size can be prompted by the provision of widely spaced parallel lines to provide an external cue to increase the range and force of movement necessary for writing. Even the instruction to "write big" may serve to recalibrate the motor plan so that writing becomes legible.

Conclusion

We have reviewed the cognitive processes that support written language, the nature of various acquired writing impairments, and a representative sample of treatment techniques for acquired agraphia syndromes. In general, the remediation approaches were derived from a cognitive perspective, which assumes that various component processes may be differentially impaired, and treatment should serve to strengthen weakened representations and procedures and take advantage of residual abilities. The extent to which patients can actively integrate the available semantic, phonological, and orthographic information should maximize their writing performance. Likewise, the use of written language in conjunction with or to complement other communication modalities is likely to significantly enhance overall communicative success.

REFERENCES


43. Ramage A, Beeson PM, Rapcsak SZ. Dissociation over oral and written spelling: clinical characteristics and possible mechanisms. Paper presented at the Clinical Aphasiology Conference; June 1998; Ashville, NC.


