Recovery and Treatment of Acquired Reading and Spelling Disorders

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ABSTRACT

In this chapter, acquired reading and spelling disorders are described with reference to a dual-route model of lexical processing. We report selected cases of treatment of cognitive reading and writing syndromes—deep, surface and phonological dyslexia and deep, surface and phonological dysgraphia. This is followed by a critical evaluation of the methodology. It is argued that these syndromes are not a rational starting point for therapeutic intervention since a given syndrome can arise following damage to different functional components. Surface dyslexia, for instance, can follow damage to any of the lexical components necessary for reading known words. To initiate a well-motivated treatment, one must know what components are damaged. Some therapeutic suggestions for treating all of the components involved in reading and writing are offered.

41.1. INTRODUCTION

The past 30 years have seen important progress in our understanding of the normal processing and acquired disorders of reading (dyslexias) and spelling (dysgraphias); diagrammatic models of lexical processing have become commonplace in the cognitive neuropsychological literature. The model of lexical processing referred to in this chapter is the dual-route model (Figure 41.1).

In the dual-route model here proposed, reading or spelling can be achieved through a lexical route, which allows the correct pronunciation and spelling of stored words, and a non-lexical route, which allows conversion of sub-lexical units of phonemes or graphemes into sequences of graphemes or phonemes, respectively. Only the conversion mechanisms are dedicated to reading and spelling; the lexical routes utilize parts of the lexical–semantic system which are also used in other tasks, such as auditory comprehension and naming (for a detailed description of the structure and processing of the lexical–semantic system see Basso, 2003).

Reading and spelling disorders are generally discussed in the framework of seven syndromes: deep dyslexia (DD) and deep dysgraphia, surface dyslexia and surface dysgraphia, phonological dyslexia and phonological dysgraphia and letter-by-letter dyslexia. Letter-by-letter dyslexia is characterized by disruption early in the reading process (component F in Figure 41.1); reading is slow and laborious and frequently performed by first naming the letters that make up the string. DD is due to the lesion of two components of the reading system: the non-lexical route (component M) and the lexical route (components G, C, H). The locus of damage to the lexical route can vary although the semantic system itself is frequently damaged. The most important defining symptoms of DD are impairment of nonword reading and semantic paraphasias in word reading. In surface dyslexia the nonword reading route is (relatively) preserved and the lexical route impaired. The preserved non-lexical route allows correct reading of nonwords and regularly spelled words that honor the grapheme-to-phoneme correspondence rules, but the application of sub-lexical conversion rules in reading irregular words spawns regularization errors such as reading PINT as MINT, PRINT and FLINT. Phonological dyslexia follows damage to the non-lexical...
route (component M) and is the only dyslexia syndrome that does not entail other language deficits. Reading of non-words is impaired and reading of known words preserved. The dissociation between preserved and impaired processes is never complete, in this as well as in any of the other forms of aphasia.

The dysgraphia syndromes correspond fairly well to the dyslexia syndromes. In deep dysgraphia, as in DD, damage to the non-lexical route (component L) causes difficulty in nonword writing and damage to the lexical–semantic route (components B, C, D) causes errors in word writing, the most characteristic being semantic paragraphias. Surface dysgraphia results from damage to the lexical route (components B, C, D). Writing of nonwords is preserved (or significantly better than writing of words); writing of regular words that honor the conversion rules is similar to writing of nonwords; the most frequent errors in the spelling of irregular words that cannot be rendered through the phoneme-to-grapheme conversion rules are phonologically plausible errors, such as writing YACHT as YOT. In transparent orthographies like Spanish and Italian, in which almost all words can be read correctly by applying conversion rules, surface dyslexia is difficult to demonstrate and regularization errors will occur only in reading unknown foreign words which have come to be regularly used in the oral language, such as, for instance, the word jeans. Finally, phonological dysgraphia follows damage to the non-lexical writing route (component L). Nonword writing is impaired or impossible whereas writing of known words, whether regular or irregular, is still possible (for a detailed description of the mechanisms of reading and writing see Chapter 20).

Below, illustrative rehabilitation cases for each dyslexia and dysgraphia syndrome are reported. I shall then argue that the analysis of errors subjects make on reading and spelling regular and irregular words and nonwords are not a sound basis for treatment. The diagnostic process should end only when the underlying cause of the reading or writing deficits is disclosed, that is when the damaged component/s – input buffers, input lexicons, semantic system, output lexicons, output buffers or conversion mechanisms – is/are identified. A brief description of suggested treatment procedures for each component involved in reading and spelling follows.

41.2. ILLUSTRATIVE CASES

41.2.1. Letter-by-Letter Dyslexia (or Pure Alexia)

Two treatment approaches have been shown to be effective for people with letter-by-letter dyslexia: cross-modality
cueing and brief exposure of words. In cross-modality cueing subjects are taught to trace the contour of the letters they are unable to name when visually perceived and to utilize kinesthetic information to name the letter. The second approach, brief exposure of words, is meant to discourage letter-by-letter reading. The motivation for such a treatment comes from the observation that some letter-by-letter dyslexics can derive meaning from words they are unable to name.

Maher et al. (1998) reported successful treatment for subject YT, a 43-year-old woman with chronic and stable pure alexia. She had difficulty naming letters when seeing them but could name them when allowed to pretend to copy them by tracing them with her finger. Using this motor cross-cueing strategy she reached a faster reading rate in 4 weeks.

Rothi and Moss (1992) presented single words on a computer screen and asked their letter-by-letter dyslexic subject to make a semantic decision about the word (e.g., is this an animal?). Correct responses were above chance, notwithstanding the subject reporting that he could not read the word. After 20 therapy session reading rate had improved.

41.2.2. Deep Dyslexia

Therapy for DD may address either the conversion rules (component M) or the semantic system (component C) or both. Bachy-Langedock and de Partz (1989) described SP (component M) or the semantic system (component C) or the phonological output lexicon (component H). The most frequently cited case of re-teaching the grapheme-to-phoneme correspondences. In the first stage SP was taught to generate code words for individual letters; he first had to say the word when seeing the letter, then the first phoneme only. He was then trained to read simple nonwords in which each letter corresponded to a phoneme. Stage 2 therapy targeted groups of letters that correspond to one phoneme; finally, in stage 3, three specific conversion rules which had caused most of his errors were specifically trained. The whole therapy lasted 2 years, after which time SP could read aloud, albeit slowly, his errors in reading aloud were significantly reduced.

Re-learning of grapheme-to-phoneme conversion rules and of phoneme blending was the focus of the successful treatment of another deep dyslexic subject (Yampolsky & Waters, 2002).

Patient JJ (Hillis & Caramazza, 1994), with semantic damage and impaired letter-to-sound conversion, underwent treatment directed at the semantic impairment (SI). A written word was presented along with 40 pictures from two semantic categories and JJ was asked to point to the corresponding picture. If the response was incorrect, JJ was shown the correct picture and the same item was re-presented after a short delay until the response was correct. Comprehension and oral reading of the treated words improved rapidly.

41.2.3. Surface Dyslexia

Before starting therapy of a surface dyslexic subject it is necessary precisely to locate the damage; it can be at the level of the orthographic input lexicon (component G), the semantic system (component C) or the phonological output lexicon (component H). The most frequently cited case of rehabilitation of a surface dyslexic subject is EE (Coltheart & Byng, 1989) with damage to the orthographic input lexicon.
Testing 4 months post-onset revealed better reading of regular than irregular words, regularization errors and relatively spared reading of nonwords; this pattern is consistent with surface dyslexia and EE’s impairment was located at the level of the orthographic input lexicon.

Therapy was aimed to improve the reading of irregular words using a whole-word training approach. Irregular written words were presented alongside a picture representing meaning; 24 words were presented during Phase 1, 54 during Phase 2 and 101 during Phase 3. There was significant improvement of the treated words.

Weekes and Coltheart (1996) reported a similar successful treatment for subject NW with surface dyslexia and surface dysgraphia.

### 41.3. LIMITS OF THE SYNDROME-BASED APPROACH

The (relatively) new syndromes of reading and spelling disorders are based on an analysis of errors in reading out loud and writing to dictation—known words and nonwords; however, normal subjects read for comprehension, be it the newspaper, a book, a note, or writing letters, filling out a

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Box 41.2 A case of SI

Subject SI suffered an ischemic stroke at the age of 55. An acute CT scan and a subsequent one performed at 8 months post-onset revealed a large infarct in the left temporal and parietal lobes. When evaluated at our aphasia unit she was 1-year post-onset and presented with Wernicke aphasia; her speech was fluent with frequent semantic errors that were also present in writing, repetition and reading aloud. Phonological errors were also present but were less frequent. Her husband complained of her comprehension disorders but she was 1-year post-onset and had already received a 6-month treatment. Her husband wondered whether it was still possible for her to ameliorate.

A language evaluation was carried out in order to locate SI’s functional impairment. Processing of input phonemes and graphemes was grossly spared; processing of the input lexicons was slightly impaired as shown by results of the auditory and visual lexical decision tasks (87% and 90% correct, respectively). In auditory and written word-picture matching tasks she made semantic errors that were also frequent in oral and written naming; she said, for instance, orange for cherry, key for lock and wrote nose for mone. Phonological and orthographic errors were present but less frequent. Semantic errors were also present in repetition, reading aloud and writing to dictation. Nonword reading and spelling were severely impaired; she could read or write almost none.

The ubiquity of the semantic errors allows a diagnosis of severe SI; the sub-lexical conversion routines (grapheme-to-phoneme, phoneme-to-grapheme) are also impaired. It was decided to treat the SI.

questionnaire and do not frequently read out loud or write to dictation. In the cognitive architecture of the reading and spelling processes here illustrated, reading for comprehension and spontaneous writing make use of lexical components (input lexicons, semantic system and output lexicons) that are not dedicated solely to reading and writing. Damage to any of these components will give rise to impairments that are not circumscribed to reading or writing and that may be more distressing for the aphasic subject. Damage to the output phonological lexicon as in surface dyslexia, for instance, will also cause problems in naming and in spontaneous speech production.

A diagnosis based on the location of the impaired component is more appropriate for a rational and motivated treatment than classification of the subject in one or the other syndrome. If a subject is diagnosed as having “surface dyslexia,” we do not know whether his or her reading errors arise from damage to the input lexicon, the semantic system or the output lexicon. On the other hand, if we know which component is damaged we know both the locus of damage and its consequences on all language tasks, including reading and spelling. In front of a subject with DD who has difficulty reading, comprehending, writing and speaking, the clinician must answer the question “what is the best treatment for a semantic damage?” and not “how can reading aloud be improved?” the “best” treatment may or may not include reading.

Careful reading of Boxes 41.1 and 41.2 should clarify the differences between a syndrome-based and a functional approach. DD and SI are in fact the same subject. In Box 41.1, the aim of the clinician was to analyze the reading disorder in order to be able to treat it, as requested by the subject herself; in Box 41.2, aim of the clinician was to locate the subject’s functional damage in order to be able to instantiate a treatment rationally linked to her deficits. It is well possible that the conclusion reached in both cases would be to treat the semantic damage but this would probably be pursued in different ways. The first clinician would resort to reading tasks whereas the second clinician could indifferently use naming or reading tasks as well as images instead of words (see below).

There are, however, hints that things are changing. In some of the more recent studies no mention is made of the reading and writing syndromes and therapy is directed to the damaged component (e.g., Cardell & Chenery, 1999; Beeson et al., 2002; Ska et al., 2003; Schmalzl & Nickels, 2006).

41.4. SUGGESTED TREATMENT OF THE LEXICAL COMPONENTS

In this section some suggestions for the rehabilitation of the several lexical components (e.g., input lexicon, output buffer, semantic system) involved in reading and spelling are presented. Even partial recovery of the processing of the damaged component will show up in all the tasks that involve that component. None of the proposed interventions is new; they all have been previously described and shown to be efficacious (for a review, see Basso, 2003). With respect to the cases illustrated above, the main difference lies in the fact that reading and spelling tasks may sometimes be omitted since recovery of the damaged component may be achieved through other tasks.

41.4.1. Orthographic Input Buffer (Abstract Letter Identification)

Damage to the orthographic input lexicon (component F) results in slow and inaccurate grapheme identification.
Computerized programs tackling the reading difficulties of letter-by-letter readers can easily be implemented. The use of computers allows an individual to work independently at home and the program can be manipulated so as to adapt to each individual’s needs. Single letters, words or nonwords appear on the screen and the subject is required to write them on the keyboard. If the response is correct the computer presents another stimulus; if the response is not correct, this is signaled to the subject and the stimulus represented. The duration of the exposure as well as the size, character and font of the stimulus can be manipulated.

41.4.2. Conversion Mechanisms

The phoneme-to-grapheme (component L) and grapheme-to-phoneme (component M) conversion routes are dedicated to reading and spelling. The two conversion routes are functionally independent and can be impaired separately but in most subjects they are both impaired. A third conversion route, the input-to-output phoneme conversion, which allows for the repetition of nonwords, is more resistant to functional damage, probably because the relationship between input and output phonemes is always one-to-one, without exception.

The rehabilitation program here illustrated involves all three routines at the same time. It may seem to be a loss of time to include a process that is intact, as is frequently the case for the input-to-output phoneme conversion, but the time spent by the subject to perform a task they can easily perform is trivial compared to the advantage of a varied and stimulating therapy in which subjects are encouraged by their successes.

In order to involve only the conversion mechanisms, it is suggested one work with nonwords that should be short in case of severe damage to any of the three routes and become longer and more difficult (from an orthographic and phonological point of view) as the impairment becomes less severe. If the subject has difficulty repeating, reading or spelling even single phonemes or letters, then simple CV syllables, where only the consonant varies whereas the vowel [A] is kept constant, should be used.

The subject is first asked to repeat a syllable; if he fails the stimulus is presented again. The subject is then required to write the syllable and to check whether what he has written corresponds to the syllable he heard just repeated. If this is not the case and the subject does not spot the error, the therapist should attract the subject’s attention to the error and ask him to read what he has written. If the subject fails, the therapist provides the correct answer and helps him to write the syllable. The subject is then invited to pay attention to the correct spelling and to copy the syllable after a short delay. A new stimulus is then given and the whole procedure is started again. After having repeated and written 3–4 syllables, the subject is asked to read them out loud in random order. Correct repetition of the syllables ensures that the subject has correctly identified the heard phonemes and can translate them from input-to-output phonemes. Writing the syllable requires the conversion of phonemes into graphemes, and reading it requires the conversion of graphemes into phonemes. After the subject is able to spell most of the single syllables, two-syllable nonwords are introduced.

Phonological awareness is held to be important for reading acquisition and is frequently impaired in phonological dyslexics. For this reason when two-syllable nonwords are introduced, exercises for phonological awareness are also proposed. After hearing the nonword, the subject has to repeat either the first or the second syllable, say what the last letter is, and so on. After this, the nonword should be written and then read aloud as illustrated before.

An interesting aspect of such a program is that it can be carried out at home with the help of any naive person who has been adequately instructed and this allows for a more intensive treatment.

The program is easily applicable in Italian and Spanish whose orthographies are transparent; very few phonemes must be rendered by two letters and very few letters correspond to more than one phoneme. Other languages, such as English and French, have more opaque orthographies with less transparent conversion rules that must be explained and trained one by one. Carrying out the program in an opaque orthography will probably require more time for the learning of specific conversion rules.

41.4.3. Semantic System

Damage to the semantic system (component C) is frequent in DD and deep dysgraphia. Because of its centrality, damage to the semantic system necessarily involves impairment in comprehension and production of spoken and written words. The internal organization of the semantic system has been a subject of much debate; a widely accepted opinion is that meaning is represented as a set of semantic features and that the semantic information associated with an object can be accessed from both words and pictures. This has an important consequence for rehabilitation since to address the semantic system language is not required. Pictures, compared to words, have a privileged access to the semantic system because they represent directly some of the semantic features of the corresponding concept whereas the relationship between a word and its meaning is arbitrary. The picture of a lion, for example, represents an animal but the word lion could be used to refer to a different concept. Severe semantic damage can therefore be tackled more easily with pictures.

Some examples of exercises involving the semantic system are the following: category sorting using increasingly specific categories (animals, → mammals, → ferocious), the odd-one-out (within increasingly semantically associated objects), semantic associations and relationship judgments. Otherwise the therapist may choose to work on a single concept at a time until the subject has demonstrated to have a clear idea of the concept. At this point a second
concept pertaining to the same category may be introduced and the differences and similarities between the two illustrated. Knowing what a hammer is can facilitate knowledge of what saws are.

The same exercises can then be carried on using words instead of pictures.

41.4.4. Input Lexicons (Components B, G)

Research papers on rehabilitation of word comprehension disorders are rare. One possible reason for this is the observation that comprehension disorders are the first to recover spontaneously in many subjects; in moderate and mild aphasic subjects rehabilitation of single word comprehension may not be necessary; only severe aphasic subjects have such impaired comprehension of single words as to need therapy. In these cases, however, a less impairment-based and a more pragmatic approach is better justified (Basso, 2003).

In general, tasks devised to evaluate processing of a given component can also be used to treat that same component. Oral and written lexical decision tasks are the task of choice for evaluation of the input lexicons and can be used therapeutically. A subject with damage to the orthographic input lexicon may be asked to recognize whether a written string of letters corresponds to a known word or not; if not, they may be asked to spot the error. Otherwise a written word may be presented with 3 or 4 very similar strings of letters and the subject has to identify the correct one. The same holds for the phonological input lexicon; given a string of phonemes the subject has to say whether it corresponds to a real word or not.

These exercises present an advantage compared to classic word-picture matching tasks. Most importantly, the choice of words is not limited to picturable objects or actions; all words can be used. Furthermore, in word-picture matching the correct picture may be selected without the subject having really understood the word but simply because they know that one of the pictures corresponds to the word and the selected picture seems the most probable choice.

Finally, treatment for the orthographic input lexicon may be carried out by the subject alone with the aid of a small dictionary containing only frequent words. The subject must look up in the dictionary words that sound familiar, pay attention to the spelling, read the definition (comprehension of one or two key words is sufficient), write the word down and look up in the dictionary to check if spelling is correct.

41.4.5. Output Lexicons (Components D, H)

The literature on therapy for naming disorders is quite rich. This is not unexpected since almost all aphasic subjects present with more or less severe naming disorders. Besides naming difficulties, damage to the output phonological lexicon will prevent correct reading aloud of words in case of concomitant damage of the conversion rules; if these are undamaged, only reading of irregular words will be difficult. Similarly, damage to the orthographic output lexicon will prevent correct writing of words in case of concomitant damage of the conversion rules; if these are undamaged only spelling of irregular words will be difficult.

In most cases anomic subjects have been required to produce the target word in a naming-to-confrontation task but the strategies used have differed; the most frequently used strategies have been phonemic or semantic cueing, repetition and reading. When the different cues have been compared, the phonological cue (saying the first phoneme or syllable of the to-be-named word) has been found to be the most efficacious, but its facilitation effect is short-lived.

The limited amount of picturable words, however, suggests resorting as soon as possible to a task that would allow learning of a large corpus of words. A small dictionary can be the answer.

Briefly, subjects look up in the dictionary a word that they believe was familiar to them, read the definition, write the word down in an exercise book and say the word aloud; each day they add 3–4 new words. The day after, the subject should first try to conjure up the words already written, check whether they have retrieved all words and then go on to learn a few new words and so on, as long as learning of new words can be demonstrated.

41.4.6. Output Buffers (Components E, I)

Buffers are working memory components assigned to the temporary storage of lexical and non-lexical representations for successive elaboration. Damage to a buffer will therefore contribute a length effect in the processing of words and nonwords.

Therapy for the output buffers is straightforward: repetition (for the phonological) and dictation (for the orthographic) of words and nonwords of such length that the subject makes many errors but does sometimes produce a correct answer. However, any task requiring the production of a string of phonemes (for the phonological) or graphemes (for the orthographic) necessarily involves activation of the corresponding output buffer.

41.5. CHALLENGES AND FUTURE DIRECTIONS

Continued advances in our understanding of acquired reading and spelling disorders provide new insights into the cognitive structure of normal processing.

A general but very important question that has been extensively studied concerns the efficacy of treatment for aphasia. There is now sufficient experimental evidence based on group studies to argue that language disorders evolve towards amelioration in many aphasic subjects and that rehabilitation has a positive effect (Basso, 2003).
However, subjects were rarely assigned randomly to treated or untreated groups and heterogeneous methods were used to treat heterogeneous subjects. Robey and Schultz (1998) remind us that outcome research should be programmatic and evolve through the traditional five-phases model illustrated in Box 41.3.

Box 41.3  Five-phase outcome research model (Robey & Schultz, 1998)

**Phase 1. Goal:** Develop hypotheses to be tested in later stages, study whether subjects improve, define target population. Experiments are brief with small groups, no control subjects are required. Research continues with Phase 2 if the results of the studies in Phase 1 are positive.

**Phase 2. Goal:** Refined hypotheses, standardize protocols, determine treatment dosage and subject selection criteria, find an explanation for the effect of the treatment. Utilizes small-group and single-subject experiments; no controls are required. Research continues if results are positive.

**Phase 3. Goal:** Test the efficacy of the treatment developed in Phases 1 and 2 in a randomized controlled trial with random subject assignment to treatment and no-treatment conditions. Large sample sizes are necessary. If efficacy is demonstrated research continues with Phase 4.

**Phase 4. Goal:** Test efficacy of treatment under typical conditions with typical subjects. Self-selected controls or subjects receiving a different treatment are adequate. Large samples are required.

**Phase 5. Goal:** Continue research on efficacy comparing, for instance, different intensity and duration of treatment, collecting subject’s satisfaction data and so forth.


From single-subject studies we know that almost all functional impairments, including reading and spelling disorders, are amenable to partial recovery. The problem with the single-case study is generalization, since no other aphasic subject will present exactly the same impairments as the subject being treated. Single-case studies pertain to Phases 1 and 2 and we must now proceed to Phases 3, 4 and 5.

A group of rationally similar subjects should be collected, minimal requirements on implementation should be established, a treatment successfully tested in single cases should be implemented and recovery of treated subjects should be compared to recovery of a group of randomly assigned untreated subjects.

In this chapter only knowledge gained from behavioral research has been considered. Further progress in the area of reading and spelling is likely to be best realized through extensions of current multidisciplinary research and clinical application. An important field of research that can in the future offer a lot to therapy is computer modeling.

Computer simulation models represent possible ways in which the brain may support reading and spelling processes and attempts have been made to simulate the effects of brain damage. The most important contribution of connectionist models to aphasia therapy is the importance given to learning and re-learning. Different treatment approaches have already been compared (Plaut, 1996) and it is possible that in the near future treatment approaches can be “tested” to find out what treatment are most effective for a given subject.

**References**


Further Readings


The chapter outlines the processes necessary for the comprehension and production of familiar and unfamiliar written words. Acquired impairments of reading and spelling are extensively described with reference to a dual-route model. The most frequently applied intervention strategies are described and selected cases are reported. The chapter ends with a glossary and an extensive reference list.


The handbook is organized in such a way as to present for each cognitive field a first chapter describing the cognitive architecture of the normal cognitive function under consideration, a second chapter describing the neuroanatomical correlates, and a third chapter about treatment. Reading is covered by Hillis, Hillis and Tuffiash, and Friedman; spelling by Rapp, Rapcsak and Beeson, and Beeson and Rapcsak. Taken together, the six chapters make a complete survey of the current state of reading and writing disorders.


The book is divided into three sections. In Part 1 the cognitive neuropsychological approach is described. Part 2 is devoted to assessment. Part 3 provides a review of the therapy literature on naming, comprehension disorders, reading and writing. The most important studies on therapy of reading and spelling disorders are described and detailed summaries of the treatment interventions are reported. Summary tables offer a clear overview of the studies reviewed and a comprehensive reference list closes the book.