DIFFERENT FORMS OF DYSGRAPHIA IN BRAIN-DAMAGED PATIENTS

VANESSA COSTA
Department of Experimental Biomedicine and Clinical Neurosciences (BioNeC), University of Palermo, Italy

[Differenti forme di disgrafia in pazienti cerebrolesi]

ABSTRACT

Normally a neurological accident (stroke, head injury, degenerative processes, tumour) to the left hemisphere produces disorders of linguistic functions (aphasia). Among these deficits, the comprehension (reading) and production (spelling) of written language are frequently altered. In this communication will be described the different types of acquired dysgraphia following a cerebral damage. A cognitive model of the spelling system is reported to explain the different level of processing that can be impaired. The aim is to highlight the complexity of the different clinical pictures that the dysgraphic patients can to show: indeed a careful diagnosis on damaged cognitive functions and processes can lead to an effective rehabilitative schedule.

Key words: dysgraphia, brain-damage patients, spelling processing.

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Introduction

In the neurological sphere, writing disorders were classified in relation to other deficits. Agraphia with aphasia, agraphia with alexia, pure agraphia, agraphia with apraxia and spatial agraphia were the first taxonomic classifications of dysgraphia[1].

Performance of brain-damaged, dysgraphic individuals constituted the primary source of evidence on the organization of the writing system and contributed to the development of the model normally assumed in many researches on spelling. This model proposes different levels of processing of orthographic representation: semantic, lexical, sublexical, orthographic/segmental.

The spelling process

The two-routes model proposes two separate procedures for writing new and known words. Figure 1 describes the processes that are active during the spelling of a word introduced through the auditory pathway.

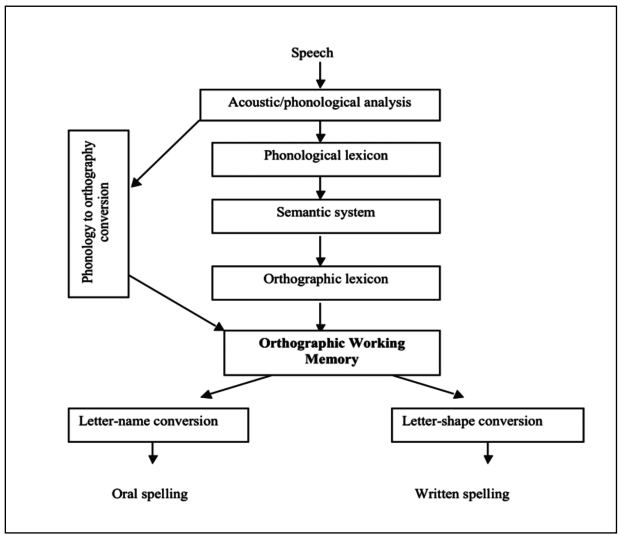

Figure 1: Schematic representation of the functional architecture of the spelling

First of all, acoustic-phonological processes convert sounds into a phonological representation. If the word is familiar (e.g., table), the phonological input lexicon activates the semantic-lexical system, which provides the meaning associated with the word.

The semantic representation serves as a basis for the output orthographic lexicon, the long-term memory for the orthographic form of familiar words, in order to choose and produce a lexical orthographic representation associated with the meaning.

If instead the word that we hear is a word that we do not know or a pseudo word, it is the sublexical conversion procedures that are activated. In this case the phonological form represents the input for the phoneme-grapheme conversion system, which produces a reasonable spelling of the stimulus phonemes, using the information stored on the relationship between sounds and letters.

Following the model in Figure 1 we see that the lexical and sublexical pathways converge on the graphemic buffer, a working memory system whose role is to keep the orthographic representation sent by the two upper processes active, until each grapheme (the abstract form of the letter) has been turned into a specific form (in the written spelling) or into a specific name (in the oral spelling).

Since a word can be written in very different ways, it is believed that the orthographic representation stored in the buffer does not have a precise form but is rather an abstract representation, independent from a specific format.

After the level of the buffer a differentiation takes place between the processes required for written spelling and oral spelling. In written spelling, for each letter the allographic system conversion specifies the case (upper/lower), the character (italics, capital, etc.) and subsequently the form of the letters. Lastly, the motor processes produce the movements required to produce the letters in the specific desired form. In oral spelling the abstract orthographic form of the letters is transformed into the phonological form of the letters and into the oral articulatory movements required for producing them.

Numerous studies have shown that each component of the spelling system can selectively be impaired by cerebral damage[2]. The different forms of dysgraphia that have been reported in the literature are referable to weakening of one or more parts of the spelling process just described.

In the next section I will look more closely at the fundamental elements constituting the spelling process, and for these I will trace out a general picture of the behavioural pattern in the case of functional damage.

Orthographic lexicon

The orthographic output lexicon is the long-term memory containing the orthographic representations of the words that we have learned during our lives. It is recruited in the writing of familiar words; it is related to the semantic system that as a rule activates it in response either to an auditory stimulus (writing under dictation) or to a figure (naming) or simply when we want to write a word whose meaning we have in our minds. When the orthographic lexicon is impaired[3-4], the subject can make semantic errors because the target word does not reach the level of activation required for production, and at its place a word is produced with which it shares some characteristics (e.g., lion instead of tiger or table instead of chair) and which has reached the necessary level of activation.

Another type of error that characterizes impairment of the orthographic lexicon is the phonologically plausible error (PPE). As a rule these errors are made when the subject is given an auditory stimulus, as in writing under dictation. Since the orthographic lexical form of the word is not available because of damage to the orthographic lexicon, in order to write subjects rely on sublexical conversion procedures. PPEs originate from transformation of the phonological form of the target word into its corresponding orthographic form. The result is a string of graphemes that, though phonologically suitable, does not correspond to the correct spelling of the word (for example writing yot instead of yacht). Normally PPEs are sensitive to the frequency of the phoneme-grapheme mapping of a specific language, that is to say the frequency with which a sound is turned into graphemes.

Sublexical system

The phoneme-grapheme conversion system can only be studied in writing under dictation, in which a string of sounds must be transformed into a corresponding orthographic string. It is employed in writing words that the subject has never heard before or in writing pseudo words (e.g., zood). It can also be used for accurately writing words that have a regular spelling (e.g., cat). It is believed that this system is separated into two processes: phonological parsing, which organizes representation into smaller units (single phonemes or syllables), and the real conversion process, which turns every phoneme into a reasonable graphemic form.

In languages like Italian, in which at a segmental level the relations between writing and pronunciation are almost entirely transparent, the sublexical system could also be used for writing known words correctly.

When phoneme-grapheme conversion procedures do not work because of brain damage[5-6], the subject will prove to have difficulty about writing new words or pseudo words but should preserve the ability to write familiar words. In non transparent languages like English and French, the phoneme-grapheme conversion system contains the necessary information on all the possible ways in which a phoneme can be written. As a rule the phoneme-grapheme conversion system is the one used with the greatest frequency in such a language.

The orthographic lexicon and the phoneme-grapheme conversion procedures can be impaired independently, but also simultaneously. When both systems are affected by a neurological accident[7-9], the subject will not succeed in writing non-words, will not show sensitivity to the frequency of phoneme-grapheme mapping and will produce semantic errors and lexical substitutions when he/she writes words.

Orthographic working memory

The product of lexical and sublexical processing converges on the graphemic buffer, the working memory of the writing system. As we are talking about a sequential task, in which letters are written one after another, the abstract orthographic representation of the word has to remain active until it has been entirely written. It is therefore necessary to hypothesize a working memory system inside the spelling process because of the computational incommensurability between the representations produced by the lexicon (whose order of greatness is the word) and the representations with which the post-buffer systems have to work (whose order of greatness is the letter).

The graphemic buffer, like every other element of the spelling process, can selectively be compromised by cerebral damage. The clinical picture shown by subjects with this deficit[10-12] is compatible with the role and the position that the buffer has in the writing process. The performance will be comparable regardless of the input modality (dictation, naming, spontaneous writing) and the output modality (written spelling, oral spelling, typing); no lexical, frequency or grammatical effects will be present and the errors will be of a segmental type (substitutions, omissions, transpositions, insertions); lastly, the performance will be very characterized by reduced accuracy in writing longer words.

Post-buffer processes

While the buffer deals with keeping the representation of the word active, the subsequent processes transform the abstract form of the representation into a specific form (written spelling) or into a specific sound (oral spelling). The distinction between modality-specific mechanisms, devoted to written spelling and oral spelling, is based on double dissociations found in neuropsychological patients: some subjects have selective deficits for one of these modalities and not for the other.

Post-buffer deficits concern selective difficulty about recovering the names that correspond to graphemes[5], and the production of the written form of words[13-15]. In the latter case the subject can have difficulty about assigning the character (italics, block capitals) and the case (upper, lower) and/or about assigning the form to the letters.

Though in the spelling process each component has a specific role and can be selectively affected by cerebral damage, the various levels of the system present complex interactivity.

Interaction between orthographic lexicon and sublexical system

Considerable evidence exists, based on studies carried out with dysgraphic subjects[16-17] that lexical and sublexical processes may interact in spelling. On one side the writing of known words, mainly conducted via the lexical pathway, may be integrated by sublexical information; on the other, the lexical system may intervene on the sublexical system in the writing of pseudo words.

One neuropsychological indication that has suggested an interaction between sublexical and lexical mechanisms is the case of JJ[17]. This subject has a deficit in the semantic-lexical system, while the phoneme-grapheme conversion procedures are intact. If familiar words were only written via the lexical pathway (which is damaged in JJ), then semantic errors should be produced in all tasks involving writing of familiar words; instead, JJ makes semantic errors in written picture naming but not in writing-to-dictation.

It has been hypothesized that in naming the figure, for example a pear, this subject activates an

impoverished semantic representation of the word, which in turn activates in the orthographic lexicon a series of candidates with which it shares some semantic characteristics (pear, apple, orange, etc.). The most active word, either correct, or semantically correlated with the target, "will win" the competition and will be selected. In writing under dictation, to the semantic input a phonological input (/pɛr/) is added, which is converted into a graphemic string that, though not correct from the orthographic point of view (pair), is useful however for constraining the selection of the target word in the orthographic lexicon. For this reason in written picture naming, in which the figure activates a lexical mechanism that is damaged, JJ makes semantic errors; instead, in writing-to-dictation, in which the auditory stimulus also produces a phonological representation of the target, participation of the sublexical system avoids the production of semantic errors. The authors maintain that the sublexical and lexical systems sum their information in order to eliminate the semantic errors in the writing of words.

Conclusions

This paper wants to highlight the complexity of cognitive deficits in brain-damage individuals. In the case of acquired dysgraphia I showed how patients diagnosed as generally dysgraphic could produce a very different pattern of errors depending on the level of processing (see Figure 1) involved. It is worth to detect these differences especially in order to schedule the better rehabilitative program.

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Request reprints from:
Dr VANESSA COSTA
Via La Loggia 1
90129 Palermo
(Italy)