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# Selective Impairment of Lexical Stress Assignment in an Italian-Speaking Aphasic Patient

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Psycholinguistic speech production models assume that lexical stress is stored and accessed separately during phonological encoding. We address the questions of the storage and computation of lexical stress in a case study of an Italian-speaking patient with an impairment of lexical stress assignment in naming, reading, and repeating single words. The patient's stress error pattern and his performance on tasks examining lexical stress in perception suggest an impairment in the retrieval of the stress pattern of irregular words. In contrast, his assignment of stress to nonstored phonological forms suggests that the computation of stress is unimpaired.


## INTRODUCTION

Psycholinguistic phonological encoding models (Levelt, 1992; Levelt, Roelofs, & Meyer, 1999; Butterworth, 1992) assume that a word's metrical frame and its segmental composition are accessed independently and then assembled to form phonological words. How lexical stress is represented in the lexicon at the metrical level and how it is assigned during phonological encoding constitute important and unresolved questions. Answers to these questions are thought to depend on language properties. For languages with a fixed stress pattern such as French lexical stress need not be stored but can be assigned by default. For stress-assigning languages such as Italian or English, the question of which lexical entries have stored stress and which items receive stress assignment by some processes is clearly posed.

Levelt et al. (1999) assume that lexical stress is not stored for every lexical entry for stress-assigning languages. In this theory, the language's most frequent stress pattern is assigned by default, and therefore, it is not stored for lexical items with a regular stress pattern; metrical information is stored and retrieved only for words with irregular (or less frequent) lexical stress patterns, i.e., polysyllabic English words that do not have main stress on the first syllable or Italian words that do not have a penultimate stressed syllable.

Data in support of the representation of lexical stress for languages with variable

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stress patterns have come essentially from ''tip of the tongue'' studies (Brown, 1991), stress misplacement in slips of the tongue (Culter, 1980; Magno Caldognetto, Tonelli, & Panzeri, 1997), and from psycholinguistic priming studies (Meijer, 1994).

However, the questions of how precisely lexical stress is stored, that is, independently or not of other types of metrical information, and how stress information is obtained (computed or retrieved) for the subset of lexical entries with no lexically represented information have yet to be addressed empirically. It appears that even for ''nonregular'' stress, a speaker's implicit phonological knowledge can contribute to stress assignment (Colombo, 1992), therefore questioning the need for lexical storage of stress.

If lexical stress is stored and accessed during phonological encoding independently from other phonological information, evidence for selective impairment of stress assignment should be available in acquired language pathology. To our knowledge, only one neurolinguistic study has reported data favoring a dissociation between segmental and metrical levels in phonological encoding. Cappa et al. (1997) described an Italian aphasic patient who produced primarily lexical stress errors in naming and oral reading. Two further cases of Italian-speaking patients with stress assignment impairment were reported by Miceli and Caramazza (1993) and Galante et al. (2000), but both patients produced stress errors in the oral reading task only so that the stress misassignment was interpreted as a consequence of phonological reading.

In this study, we provide neurolinguistic evidence for a dissociation between lexical stress assignment and retrieval of other phonological representations. We present a single-case study of an Italian speaking aphasic with an impairment of lexical stress assignment in single word naming, reading, and repetition.

### *Some Facts about Lexical Stress in Italian*

Primary stress on the penultimate syllable as in *ancòra* (more/still) and *leggère* (light) is the most frequent pattern (''regular'') in Italian. It involves 84% of Italian words (Thornton et al., 1997). Stress on the antepenultimate syllable (''irregular'') as in *àncora* (anchor) and *lèggere* (read) is less frequent (12%), followed by final stress such as *leggerò* (I will read) (4.1%). We will call ''regular'' the most frequent stress pattern, that is, on the penultimate syllable and ''irregular'' the stress on the antepenultimate syllable. Only these two stress patterns will be treated in the following sections and only tri- and quadrisyllabic words. Thornton et al. (1997) report that 80% of trisyllabic and 84% of quadrisyllabic words have regular stress, and 18% of trisyllabic and 14% of quadrisyllabic have irregular stress (verbs are not included in that count). Lexical stress is not predictable on phonological grounds alone: Regular stress is said to be predictable on a phonological basis when the penultimate syllable is heavy such as in *arancia* and *cappello.* However, there are exceptions to this rule and a few words with a closed penultimate syllable have irregular stress (see Nespor, 1993).

## CASE REPORT

MS is an Italian-speaking 42-year-old ambidextrous man with 13 years of education who worked as a technical designer until he suffered a left hemisphere ischemic stroke. Initial global aphasia evolved to a nonfluent aphasia with phonetic disturbances and phonemic paraphasias, impaired repetition, and agrammatism; writing was better than oral expression and comprehension was impaired for complex sentences. Neuropsychological testing revealed that the patient was well oriented in time

and space, no visual nor spatial agnosia were observed, written calculation was good, short-term and long-term visual memory were normal and nonverbal reasoning (Raven's Progressive Matrices) and executive functioning were unimpaired on testing. Oral apraxia was observed.

Extensive language examination on BADA (Miceli et al., 1992) was conducted 9 months poststroke. Spontaneous speech was nonfluent with phonological transformations, *conduites d'approche,* and agrammatic sentence structure. Sublexical tasks were performed well with 97% correct in phonemic discrimination and 90% correct in syllable identification. Transcoding was impaired for nonword repetition (46% correct on BADA and 12% on a specially designed test which included 42 bi-, tri-, and quadrisyllabic nonwords); nonwords reading (78% correct) was less impaired than writing nonwords to dictation (48%), whereas the ability to perform delayed copy was spared. MS scored 79% correct on an oral lexical decision task and 89% correct on written lexical decision. Word repetition was impaired with 64% correct. Performance was somewhat better on word reading (72% correct) and on writing to dictation (77%). Spoken and written word comprehension was spared (100% correct). Picture oral naming was 77% correct for common nouns and 61% for verbs and written naming was performed better than oral naming (84% for nouns and 77% for verbs). Written and oral grammatical judgment, sentence repetition, and sentence reading were all impaired (less than 50% correct), whereas sentence comprehension in a picture matching task was successful 83%. Digit span was very impaired (2). On all production tasks, errors were essentially phonological transformations. Nine months postonset, some errors of stress assignment were observed in evaluating oral naming, reading, and repetition. In a subsequent examination (1 year postonset) there was a decrease in the number of phonemic paraphasias leaving the stress assignment errors the most dominant type. The present study was carried out between thirteen and fourteen months post stroke.

## EXPERIMENT 1: SINGLE WORD NAMING, READING, AND REPETITION

Single word productions were elicited through picture naming, repetition, and oral reading tasks in order to collect stress assignment errors. MS was asked to produce three- and four-syllable words whose lexical stress pattern and frequency were manipulated as described in the next section.

### *Method*

MS's responses were recorded and transcribed by two judges.

*Picture Naming.* MS was asked to name 140 pictures corresponding to 114 trisyllabic and 26 quadrisyllabic words. Half of the items had an antepenultimate stress pattern (''irregular'') and half had a penultimate syllable stress pattern (''regular''). Only 14 regular words were predictable on the basis of phonological structure (heavy penultimate syllable). Two levels of lexical frequency were manipulated on the basis of the frequency count by De Mauro et al. (1993).

*Repetition.* One hundred ninety-two words were selected for repetition; 136 were trisyllabic and 56 quadrisyllabic words; half of them had antepenultimate and half had penultimate stress. Twenty-one regular words were predictable on the basis of phonological structure. Lexical frequency was manipulated as in the naming task.

*Reading aloud.* MS read aloud the same 192 items used for the repetition task and 80 trisyllabic words from Colombo (1992, Experiments 1 and 2), including 40 words with antepenultimate and 40 with penultimate stress.

### *Results*

MS produced 68 lexical stress errors on the three tasks. Thirty-three additional errors, essentially phonemic paraphasias, were observed in naming and repetition.

TABLE 1
Percentage and Number of Lexical Stress Errors on Each Word Production Task

| | Picture naming | Repetition | Reading aloud | Total |
|---|---|---|---|---|
| Stress errors | 10% (14) | 10.4% (20) | 12.5% (34) | 11.2% (68) |

MS's lexical stress errors occurred in about 11% of the words on each production task (Table 1). The similarity of stress misassignment errors in picture naming, word reading, and repetition led us to group together the three tasks for further analyses.

The error pattern shows a stress ''regularity'' effect (Table 2): stress assignment errors are more frequent on antepenultimate syllable stressed words (''irregular'') than on penultimate syllable stressed words (''regular''). Chi-square analysis was carried out on these results, showing a significant difference between ''regular'' and ''irregular'' words ($X^2 = 55.7$, $p < .0001$). Errors on irregular words consisted of shifting the stress to the regular position (penultimate) and errors on regular words to the antepenultimate position. Table 2 indicates more errors for less frequent than for frequent words and for four-syllabic compared to three-syllabic words, but differences are not significant for either lexical frequency or word length.

Consistency of errors was calculated on 157 words that were repeated at least twice in the course of the three different word production tasks. Repeated lexical stress misassignment was observed for only 29% of the errors, whereas 71% of the errors occurred only once on the words presented twice.

Autocorrections of lexical stress errors did not occur spontaneously, but MS could correct 42% of his erroneous stress assignments when immediate autorepetition was required after an erroneous production.

*Discussion*

MS produced lexical stress errors in all tasks that involved phonological encoding of single words (recalling that MS cannot repeat nonwords, that is, repetition is performed through a lexical route). Moreover, stress misassignment occurs more frequently on irregular words than on regular words. Only a few stress errors were observed on regular words, and none of them occurred on regular words with a ''pre-

TABLE 2
Percentage and Number of Lexical Stress Errors as a Function of Stress Pattern, Word Frequency, and Length across All Tasks

| | Percent of stress errors | Number |
|---|---|---|
| Stress pattern | | |
| Penultimate stress (''regular'') ($N = 302$) | 1.6 | 5 |
| Antepenultimate stress (''irregular'') ($N = 302$) | 20.8 | 63 |
| Lexical frequency | | |
| High frequency ($N = 302$) | 9.9 | 30 |
| Low frequency ($N = 302$) | 12.6 | 38 |
| Length | | |
| Three syllables ($N = 466$) | 10.5 | 49 |
| Four syllables ($N = 138$) | 13.7 | 19 |

dictable'' stress pattern (i.e., words with penultimate stressed heavy syllable). Preserved stressed assignment on regular-predictable words has been reported for lexical stress assignment disorder (Cappa et al., 1997) and for stress misassignment in acquired dyslexia (Miceli & Caramazza, 1993; Galante et al., 2000).

MS presents a similar stress misassignment pattern to that shown by patient GM described by Cappa et al. (1997), who also produced more errors on irregular than on regular words. MS differs on two points from GM: No significant lexical frequency effect was shown on MS's error pattern and consistency of errors was lower for MS than for Cappa et al.'s patient. Moreover, MS produced a similar pattern of stress misassignment in all word production tasks, whereas only errors in naming and reading have been reported for GM.

What do MS stress assignment errors indicate about lexical stress representation and retrieval during phonological encoding? On the one hand, the difference observed between regular and irregular words in stress errors suggests that regular and irregular stress is encoded in different ways. This result is consistent with the idea that regular lexical stress is assigned by default, whereas irregular stress is stored along with other phonological information as described by Levelt et al. (1999). In the light of the error patterns, it seems that predominant lexical stress is assigned by default during phonological encoding only when the stored information is not available.

It should be pointed out, however, that some errors occurred on regular words too: MS produced 5 errors on regular words (and GM made 12 errors). It seems difficult to explain these errors on regular stressed words by the assumption that regular stress is assigned by default. This observation, together with the fact that MS presented a nonfluent aphasia with some signs of anarthria, does not exclude the possibility that MS's stress errors reflect difficulty in rhythm assignment at a more peripheral (prearticulatory) level. Even if the lack of spontaneous autocorrection suggests that the representation of lexical stress in the lexicon is affected, it is necessary to analyze MS's lexical stress representation in receptive and metaphonological tasks that do not require overt production.

## EXPERIMENT 2: METALINGUISTIC TASKS

Experiment 2 was carried out to analyze whether MS's lexical stress representation was intact on the receptive side and to determine what metalinguistic awareness he showed in stress judgment tasks.

### *Silent Stress Pattern Judgment*

MS was asked to judge silently the position of the stressed syllable in 84 pictures and 80 written words. A picture with three or four circles representing the syllables of the words was presented with each picture or written word, and the patient had to indicate the location of the stressed syllable by pointing to the appropriate circle. He was asked not to sound out the word. Four Italian-speaking control subjects matched for age and education were administered the same task.

### *Auditory Lexical Decision*

MS performed an auditory lexical decision task on 76 items, including 38 words and 38 ''stress pseudowords'' [words with wrong lexical stress, for example, *ospíte* (óspite), *pédale* (pedále): most of them were taken from MS's earlier errors]. One half of the stimuli were regularly stressed words and one half were irregularly stressed; length (tri- and four-syllabic) and frequency were controlled. Words and

nonwords were read aloud by the examiner in random order and the patient had to decide if they were real words.

*Results*

On stress pattern judgment task MS made 27% errors in the stressed syllable pointing task. However, the four control subjects made a similar number of errors as MS (24%) and reported great difficulty in performing the task, suggesting that native speakers do not have explicit awareness of lexical stress unlike other types of metalinguistic knowledge. Thus, stressed syllable judgment does not appear to be a valid task for investigating problems in stress assignment.

In the lexical decision task five errors (6.6%) were observed. The number of stimuli was not sufficient to allow extensive analyses. However, we observed that four of the five errors involved pseudowords derived from low frequency words with a lexical stress shifted from the antepenultimate to the penultimate position. MS accepted these items as words (ex. *cellúla* accepted instead of *céllula*).

*Discussion*

The errors observed in lexical decision task were mainly on ''regular stress pseudowords'' that were accepted as words, indicating a partial loss of the stress representation in the lexicon. These results, taken together with the pattern of errors observed in Experiment 1, support the hypothesis of a partial disruption of lexical stress representation in the phonological lexicon rather than a difficulty in rhythm assignment at a prearticulatory level. Moreover, as for stress misassignment errors, lexical decision errors appear mainly to occur for nonwords derived from words with irregular stress shifted to regular position.

At this point one can ask whether the assignment of irregular lexical stress is based on a stored representation only or whether it also depends on other variables. If regular lexical stress is assigned by default every time that no stored stress information is available, nonword production should result in regular stressed pattern only. A pseudoword reading task was proposed in Experiment 3 in order to study the assignment of lexical stress on nonstored phonological forms.

## EXPERIMENT 3: NONWORD READING

MS was subjected to a nonword reading task consisting of 20 trisyllabic and 20 quadrisyllabic nonwords with an unpredictable stress pattern. These were created from nonpredictable regular and irregular real words by changing the order of the consonants (ex. *cemidina* from ''medicina'' and *dorefa* from ''fodera'') so that CV structure was maintained.

The patient was asked to read aloud each nonword and to repeat it again immediately after reading. Ten native Italian-speaking students were asked to read aloud the same nonwords. For those subjects, the words were presented on a computer screen and the productions were tape-recorded.

*Results and Discussion*

On reading nonwords MS produced penultimate syllable stress on 77.5% of nonwords and 22.5% antepenultimate syllable stress (Fig. 1). MS always kept the same stress pattern in reading on the second attempt.

The frequency of the antepenultimate stressed syllable pattern produced by MS is

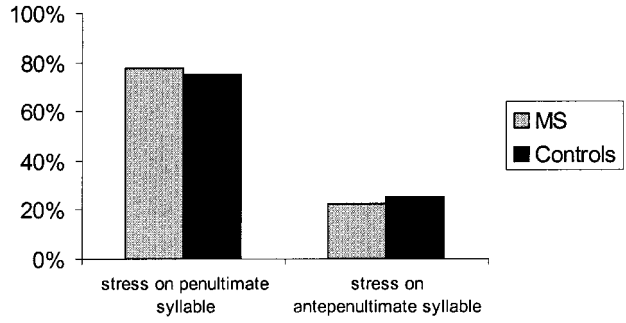


**FIG. 1.** MS and control's stress pattern production on non-word reading.

similar to that observed with our control subjects, who produced 25% irregular stress on nonwords reading, and it is similar to the percent of irregular stress attribution to nonwords described in Colombo's (1992) study (26.6%).

On six nonwords controls showed a clear preference for irregular stress (at least 7 of 10 subjects produced antepenultimate stress), and MS produced antepenultimate stressed syllable on 5 of them.

These results show that MS uses not only the default stress assignment on nonstored phonological forms, but also irregular stress patterns. Two kinds of implicit knowledge could have been used in this stress pattern production. First, nonwords stress assignment could have been guided by implicit knowledge of the relative probability of occurrence of each type of stress in the language (i.e., that 80% of trisyllabic words have regular stress; Thornton et al., 1997). Second, stress attribution on nonstored phonological forms could have been computed on the basis of implicit knowledge of phonological rules as proposed by Colombo (1992). In Colombo's experiment, nonwords were formed by adding three or four letters to the ending of real words. Her results showed a correlation between the proportion of irregularly stressed pronunciations of nonwords and the proportion of real words that shared the same ending.

Unlike Colombo, our nonwords did not always share the same ending as a real word; however, MS's irregular stress pronunciation occurred most frequently (six times on nine irregular pronunciations) on nonwords created from real words with stress on antepenultimate syllable, like *giánipa* (from *página*) and *súbbola* (from *bússola*).

## GENERAL DISCUSSION

The current study aimed to investigate the representation of lexical stress and its organization in the lexicon through the study of a single case with an impairment of lexical stress assignment. In the first part of the study, a nonnegligible (about 11%) and equal proportion of lexical stress errors was observed in naming, reading, and word repetition. The pattern of errors showed a stress ''regularity'' effect in that irregular words were most affected and presented a shift in stress from the correct irregular (antepenultimate) to a regular (penultimate) position. In the second part of the study our patient's lexical stress representation was studied in a perception and a metalinguistic task. MS had difficulties with ''stress pseudowords'' in the auditory lexical decision task. Here, most false positive errors occurred for nonwords constructed from irregularly stressed real words where stress had been shifted to the regular position. Finally, the assignment of stress on nonstored phonological forms

was studied by means of a nonword reading task. In this task MS produced a pattern of regularly and irregularly stressed items in the same proportion as the normal subjects.

Our case study supports the idea that lexical stress information is stored and retrieved independently of the other types of suprasegmental information. As discussed in the first part of this study, MS's pattern of errors is similar to that showed by GM, a case described by Cappa et al. (1997), except that MS also produces stress errors in word repetition. Taken together, these lexical stress impairment cases suggest that stress information is stored only for irregularly stressed words, as proposed by Levelt et al. (1999). In fact, most errors are found on words with irregular (antepenultimate stressed syllable) lexical stress and are produced by shifting the stress to the regular position. The errors made by MS in the auditory lexical decision task also support the hypothesis of an impaired access to stress representation of irregular words. Butterworth (1992) suggested that when part of the information is not available during phonological encoding, it is generated by default. Lexical stress error patterns seem to support this idea that when stored information is not accessible, the default regular stress is attributed, resulting in a preference for regular stress.

However, our third experiment shows that the retrieval of a stored stress pattern or the attribution of the default stress pattern are not the only processes used in stress assignment. If this were the case, only a default regular stress pattern would be assigned to nonwords which have no stored phonological forms. MS produced regular as well as irregular stress patterns in a nonword reading task and further respected the frequency of occurrence of each type of stress within the language. A similar stress assignment pattern on nonwords was described for normal subjects by Colombo (1992). How is irregular stress attributed to nonstored phonological forms? Colombo (1992) suggests that the speaker can compute a stress pattern on the basis of implicit phonological knowledge which depends essentially on the segmental composition of the word's last two syllables. In addition, the syllabic structure of the words also seems to be relevant to stress attribution (for example, the heavy penultimate syllable attracts regular stress). In sum, stress assignment appears to involve two processes: (1) the retrieval of a stored stress representation and (2) the computation of stress pattern on the basis of statistical (regular/irregular) and/or phonological knowledge. The properties of the stored information and of the processes involved in the computation of lexical stress probably depend on language specific properties. To assess the relative contribution of the retrieval of stored representations and the computation of stress and to address the question of the implicit knowledge (phonological rules or analogical processes) involved in the computation further psycholinguistic and neurolinguistic investigations are required.

## REFERENCES

Brown, A. S. (1991). A review of the tip-of-the-tongue experience. *Psychological Bulletin,* **109,** 204–223.

Butterworth, B. (1992). Disorders of phonological encoding. *Cognition,* **42,** 261–286.

Cappa, S. F., Nespor, M., Ielasi, W., & Miozzo, A. (1997). The representation of stress: Evidence from an aphasic patient. *Cognition,* **65,** 1–13.

Colombo, L. (1992). Lexical stress effect and its interaction with frequency in word pronunciation. *Journal of Experimental Psychology: Human Perception and Performance,* **18,** 947–1003.

Cutler, A. (1980). Errors of stress and intonation. In V. A. Fromkin (Ed.), *Errors in linguistic performance* (pp. 67–86). New York: Academic Press.

De Mauro, T., Mancini, F., Vedovelli, M., & Voghera, M. (1993). *Lessico di frequenza dell'italiano parlato.* Estalibri.

Galante, E., Tralli, A., Zuffi, M., & Avanzi, S. (2000). Primary progressive aphasia: A patient with stress assignment impairment in reading aloud. *Italian Journal of Neurological Science,* **21,** 39–48.

Levelt, W. J. M. (1992). Accessing words in speech production: Stages, processes and representations. *Cognition,* **42,** 1–22.

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences,* **22,** 1–75.

Magno Caldognetto, E., Tonelli, L., & Panzeri, M. (1997). *Atti del XXVIII congresso della SLI: Evidenze dai lapsus per modelli di produzione del parlato* (pp. 329–356). Roma: Bulzoni.

Miceli, G., & Caramazza, A. (1993). The assignment of word stress in oral reading: Evidence from a case of acquired dyslexia. *Cognitive Neuropsychology,* **10,** 273–296.

Miceli, G., Laudanna, A., Burani, C., & Capasso, R. (1991). *B.A.D.A., Batteria per l'analisis dei deficit afasici.* Roma, CEPSAG, Università Cattolica del Sacro Cuore.

Meijer, P. (1994). *Phonological encoding: The role of suprasegmental structures.* Doctoral dissertation. Nijmegen University.

Nespor, M. (1993). *Fonologia.* Bologna: Il Mulino.

Thornton, A. M., Iacobini, C., & Burani, C. (1997). *BDVDB—Una base dati sul vocabolario di base della lingua italiana.* Roma: Bulzoni Editore.