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Italians use abstract knowledge about lexical stress during spoken-word recognition

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ABSTRACT

In two eye-tracking experiments in Italian, we investigated how acoustic information and stored knowledge about lexical stress are used during the recognition of tri-syllabic spoken words. Experiment 1 showed that Italians use acoustic cues to a word's stress pattern rapidly in word recognition, but only for words with antepenultimate stress. Words with penultimate stress – the most common pattern – appeared to be recognized by default. In Experiment 2, listeners had to learn new words from which some stress cues had been removed, and then recognize reduced- and full-cue versions of those words. The acoustic manipulation affected recognition only of newly-learnt words with antepenultimate stress: Full-cue versions, even though they were never heard during training, were recognized earlier than reduced-cue versions. Newly-learnt words with penultimate stress were recognized earlier overall, but recognition of the two versions of these words did not differ. Abstract knowledge (i.e., knowledge generalized over the lexicon) about lexical stress – which pattern is the default and which cues signal the non-default pattern – appears to be used during the recognition of known and newly-learnt Italian words.

Introduction

As listeners recognize spoken words, they must combine acoustic–phonetic information in the speech signal with stored knowledge about the sound patterns of words. This much is uncontroversial. But which sources of information do listeners rely on, what knowledge do they have about how words sound, and when do they integrate information that has been extracted from the speech signal with stored knowledge? We ask here when and how Italian listeners recognize polysyllabic Italian words that differ in their stress patterns. Answers to these questions provide constraints on the nature of the lexical access process, and on the nature of the knowledge stored in the mental lexicon.

How words are accessed and stored in the lexicon is a matter of ongoing debate. Two extreme theoretical positions can be defined. According to the first approach, the mental lexicon consists of episodic traces. Each word is represented by multiple traces that consist of detailed acoustic representations of episodic encounters with those words (Goldinger, 1998; Pierrehumbert, 2002). Word recognition entails comparison of the current acoustically detailed input with those stored traces. There thus needs to be no phonological abstraction prior to lexical access. The second approach assumes that the mental lexicon contains phonologically abstract forms (Gaskell & Marslen-Wilson, 1997; McClelland & Elman, 1986; Norris & McQueen, 2008). Word recognition again entails comparison of the current input with stored lexical knowledge, but this requires a prelexical stage of phonological abstraction so that contact can be made with the abstract representations in the lexicon.

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Neither of these extreme positions is tenable. Strictly episodic models cannot explain evidence of prelexical abstraction about speech segments (McQueen, Cutler, & Norris, 2006), and strictly abstractionist models cannot explain evidence that episodic details are maintained in long-term memory (Goldinger, 1998). What is required, therefore, is a hybrid model with both episodic and abstractionist components (Cutler, Eisner, McQueen, & Norris, 2010; Goldinger, 2007). An important question to ask, therefore, is what the division of labor is between these two components in the word-recognition process. For example, do listeners have abstract knowledge not only about speech sounds (McQueen et al., 2006) but also about the prosodic structure of words (that is, about their lexical stress patterns and about other aspects of lexical prosody)? Is that knowledge the result of forming generalizations over the lexicon? Furthermore, can listeners use that knowledge during the lexical access process? We asked these questions here, with respect to knowledge about stress in Italian words.

Italian offers an especially interesting test of whether abstract prosodic knowledge is used in word recognition because it has a strongly asymmetrical distribution of lexical stress patterns. Consider three-syllable words. There are two main stress types (Krämer, 2009): an antepenultimate stress pattern (i.e., the first syllable bears stress, e.g., TAvolo 'table'; capital letters indicate stress), and a penultimate stress pattern (i.e., stress appears on the second syllable, e.g., coLOre 'color'). The only rule to assign stress in trisyllabic words refers to the weight of the penultimate syllable: If it is heavy – that is, if it ends in a consonant – then it must be stressed (Krämer, 2009). Nevertheless, there is a strong distributional bias toward the penultimate stress pattern. In fact, 80% of Italian tri-syllabic words have penultimate stress, 18% have antepenultimate stress, and 2% have stress on the last syllable (e.g., serviTU, 'servitude'; Thornton, Iacobini, & Burani, 1997). This distributional asymmetry may be reflected in how Italians recognize spoken words. If they have abstracted the knowledge (generalized over the relevant entries in the Italian lexicon) that a trisyllabic word will usually have penultimate stress, then they may assume (in the absence of evidence to the contrary) that this is the stress pattern of any trisyllabic word they hear. This assumption that there is a default stress pattern may apply both when Italians are recognizing known Italian words, and when they are recognizing newly-learnt words. We tested both these possibilities in the present experiments.

Prior research has already indicated that Italian listeners are sensitive to lexical stress information (Tagliapietra & Tabossi, 2005). In a cross-modal priming paradigm, listeners performed a lexical decision task on visual targets preceded by spoken bi-syllabic primes. Responses were facilitated when the target (e.g., GOmito, 'elbow') was preceded by a fragment-prime with the same stress pattern (e.g., GOmi), in line with previous findings for Dutch (Cutler & Van Donselaar, 2001; van Donselaar, Koster, & Cutler, 2005) and Spanish (Soto-Faraco, Sebastian-Galles, & Cutler, 2001). Italian listeners thus appear to use lexical stress cues to recognize spoken words. It is not clear, however, how early in the recognition process knowledge and information about stress in Italian are brought to bear. Dutch listeners use stress information very early (i.e., in words that are segmentally identical in their initial syllables, such as OCtopus, 'octopus', and okTOber, 'October', stress information is used prior to the segmental disambiguation point; Reinisch, Jesse, & McQueen, 2010). Since in Italian, as in Dutch, the difference between stressed and unstressed syllables is at the suprasegmental rather than the segmental level, we expect that Italian listeners can also take advantage of stress cues early in the recognition process. An open question, however, is whether the distributional bias toward the penultimate stress pattern in Italian can affect the earliest stages of word recognition.

Furthermore, although Tagliapietra and Tabossi's (2005) findings suggest that the word-recognition process in Italian benefits from stress information, it remains unclear what exactly that information is. Which acoustic cues specify the stress patterns of Italian words? In general, stressed vowels differ acoustically from unstressed vowels in pitch, duration, and intensity (Albano Leoni & Maturi, 1998). But it is not clear which of these acoustic cues Italian listeners pick up on. Some authors consider amplitude to be the main stress correlate (Albano Leoni & Maturi, 1998). Others argue that duration plays the main role (Alfano, 2006; Alfano, Savy, & Llisterri, 2009). An additional aim of the present study was therefore to establish which stress cues Italian listeners use during word recognition. We were especially interested in whether the bias toward the penultimate syllable stress pattern modulates the way the acoustic information that signals stress is processed. In fact, if Italian listeners have stored knowledge about the acoustic correlates of stress and about the asymmetrical distribution of the two stress patterns, then it is possible that their use of acoustic information about stress may also be asymmetric. In particular, they should be more sensitive to the acoustic cues specifying an antepenultimate stress pattern than to those specifying the penultimate pattern – because the latter pattern can be assumed to occur by default.

In summary, the present study investigated three related questions. First, when do Italians use knowledge and information about lexical stress in spoken-word recognition? Second, how does the distributional bias favoring penultimate stress in Italian affect the recognition process? Third, which acoustic cues are picked up by Italians as they detect stress position, and how do these cues interact with the distributional bias? Answers to these questions should inform the debate on the nature of lexical representation. Is lexical stress knowledge stored in an abstract way (i.e., are there generalizations made across the Italian lexicon), and is that knowledge available to assist in word recognition?

To address these questions, we examined how Italian listeners use lexical stress to recognize known and newly-learnt words. In Experiment 2, an artificial-lexicon study, we examined recognition of newly-learnt words. This allowed us to control for the amount of exposure to specific episodes of those words and test whether prior knowledge about prosodic structure (abstracted from earlier experience with real Italian words) can nonetheless be brought to bear during word recognition. Shatzman and McQueen (2006) used the same paradigm to test whether