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Constraints on Immediate Memory for Prosody: Evidence of a Correspondence with the Prosodic Organization of Speech

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Abstract

This study investigates the correspondence between memory of stress rhythms in the context of a serial recall task and the organization of stress patterns in meaningful utterances. French speakers' ($n = 40$) reproduction of stress patterns in recalling series of syllables with stress groups of differing size shows a floor effect for groups that exceed four syllables. A second experiment where the Ss ($n = 39$) produced utterances with phrases of differing length indicates a strong tendency to insert stress marks in phrases that exceed four syllables. Taken together, the findings provide an initial demonstration that memory for prosodic patterns can be an organizational factor of prosody in speech.

Keywords: speech prosody; memory

Introduction

Learning a language, as an adult or as a child, implies memory for series of speech sounds that are prosodically organized. Prosody can induce grouping effects on serial recall (Frankish, 1995; Reeves, Schmauder, & Morris, 2000), and thus appears to provide frameworks that facilitate the learning of novel series of speech sounds constituting new words and expressions. This is supported by a number of studies showing that children's ability to imitate prosody correlates with vocabulary growth (see Baddeley, Gathercole, & Papagno, 1998). That prosody can become engrained in the process of recalling novel series may account for the common behavior of producing prosody in remembering lists of digits such as phone numbers. A significant aspect of this behavior is that series of numbers bear no syntactic structure. In this case, it is the memorization process as such that appears to be the source of prosodic grouping. Yet the role of memory processes on the organization of speech prosody has not been explored, and may appear to lack relevance. How, in fact, would imitation of prosody in the context of recalling novel speech material relate to prosodic structure in meaningful speech? There is a rationale for supposing such link in that any restriction on the imitation or reproduction of prosody could, potentially, contribute to reinforce a given set of patterns in speech. By this principle, limited reproducibility of stress rhythms and intonation contours in recalling meaningless speech may well correspond to limits on

prosodic patterns in meaningful speech. The present report addresses this hypothesized correspondence by focusing on stress. Both experiments in this summary refer to French, where stress is not determined by the lexical code (as in English) and defines the endpoints of stress groups that vary in size (equivalent to *phonological words*, in this case).

Experiments 1: memory for stress groups

Subjects Forty native speakers of French served as subjects. All reported no history of speech or hearing problems.

Stimuli and procedure The stimuli consisted of assembled series of seven, monotone nonsense syllables (e.g. /pido'gatube'ky/). There were two sets of stimuli. The first set comprised series where one stressed syllable was placed at varying points within the list so as to create groups of one to six syllables (rhythms of 1:6, 2:5, 3:4, 4:3 etc.). The duration ratio of stressed to non-stressed syllables was 1.7, which is representative of French speech. A second set of stimuli included series with no stress marks (i.e., "ungrouped" series). To ensure the perception of stress rhythms, stressed and non-stressed syllables were arranged in terms of P-Center intervals (Marcus, 1981). Three ungrouped series were presented before 12, randomized, grouped series. These series were delivered over a loudspeaker (73 dBA at the subjects' ears). Though the test requested that the subjects ($n = 40$) recall the heard series, stress patterns were also recalled.

Results

Acoustic analyses of duration increases marking stress showed that reproduction of list-initial groups reached a floor level for units exceeding four syllables (see Figure 1). Moreover, by comparison to serial recall of ungrouped series (baseline), it was found that stress-groupings of more than four syllables had no beneficial effect on serial recall.

Experiment 2: stress groups in speech

Studies have reported a cross-language tendency to limit stress intervals in speech to four syllables (Dauer, 1983). The aim of Experiment 2 was to verify whether this tendency could predict stress marks in test utterances.

Subjects All but one of the 40 participants in Experiment 1 served as subjects in Experiment 2.

Stimuli and procedure. A set of 10 French sentences was used containing noun and verb-complement phrases of varying length (2 to 5 syllables). All phrases had an internal word boundary allowing for optional group stress. These sentences were presented in large characters on a computer monitor. Subjects were asked to first read a presented sentence out loud and then say the sentences by humming the syllables.

Results

Analyses of the durational changes in the hummed utterances indicated a strong tendency to produce a phrase-internal stress when the phrase exceeded four syllables. For instance, the proper noun *Marie* was most often non-stressed in:

“*Marie-Paul part mecredi matin*”

but was generally stressed in:

“*Marie-Antoinette part mecredi matin*”

so as to create a stress-group that does not exceed four syllables.

Figure 1 is an overlay of the results of subjects’ recall of stress groups (Experiment 1) and production of stress groups in meaningful phrases (Experiment 2) as a function of number of syllables in the groups. The similar relationship, as illustrated, suggests that both memory for stress groups and the production of stress groups in speech tend to be limited by the same syllable-count.

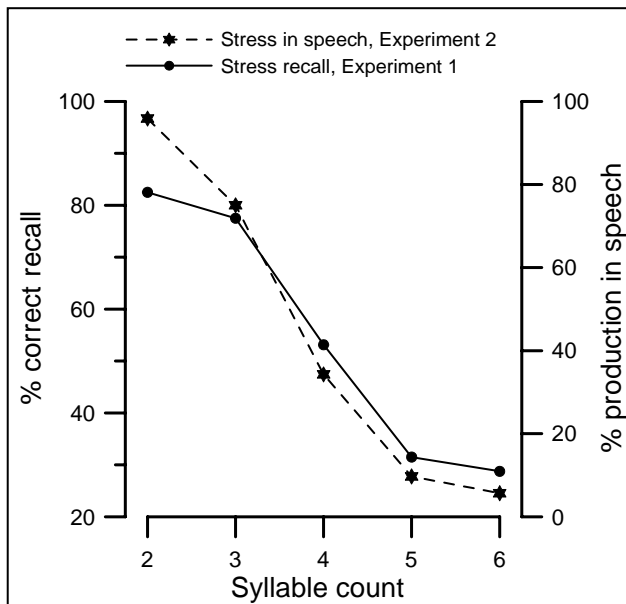


Figure 1: Combined results, Experiments 1 and 2

Discussion and conclusion

Investigations of grouping effects induced by such aspects as pauses inserted in lists of digits or letters has led to speculations on the role of prosody in language learning.

However, the paradigms used in such investigations (typically involving written recall of series containing repetitive groups of three) provide no basis for extrapolation to speech. In this respect, critics have, justifiably, questioned the relevance of list-recall tasks in understanding speech processes (Van der Linden & Poncelet, 1998). The above results provide an initial demonstration of the relevance of memory processes in understanding the organization of speech prosody and its role. It should also be noted that, while the above results refer to a tendency to restrict stress patterns in French to units of four, similar tendencies have been reported for other languages including English (Dauer, 1983 among others). There are theoretical implications for psychological and linguistic models that do not consider that memory processes bearing on the reproducibility of tonal and rhythmic frameworks can contribute to the prosodic organization of utterances and issues bearing on a *language learning device*. For instance, linguistic models assume that syntax underlies the organization of prosody. However, prosodic patterns appear in child speech before syntax and constitute the most easily learned and generalizing aspects of speech. It is also clear in the literature that these patterns assist serial memory that is required in learning new words and expressions.

Prospective

Prosody presents a hierarchical organization: intonational (pitch) contours can encompass a number of stress groups or intervals, which in turn can subsume a number of syllables. Research by the present authors shows that different constraints apply on the reproducibility of stress rhythms and pitch contours: whereas reproduction of stress rhythms reaches an average upper-limit of four syllables, results suggest that the reproduction of pitch contours has a mean upper-limit of 7-8 syllables (Gilbert & Boucher, 2005). These constraints on reproducibility are reflected in meaningful speech and determine prosodic patterns regardless of morpho-syntactic boundaries. For instance, subject noun phrases (NP) before a verb phrase (VP) are only marked by a complete pitch contour when they are long. Length (or syllable count) thus constitutes a dominant factor. Such findings suggest that constraints on the reproducibility of prosodic patterns can underlie prosodic structure of meaningful speech.

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