Cross-linguistic survey of intonation planning: a cognitive approach

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The study explores the relationship between utterance-initial pitch raising and the cognitive demands of language processing for speech production. Existing research suggests that dialectal, contextual, and individual factors influence whether utterance-initial intonation peaks occur higher in longer than shorter utterances (e.g. [1-3]). Moreover, literature indicates that intonation is responsive to the amount of available cognitive capacity, with the average fundamental frequency (F0), an acoustic approximation of sentence intonation, rising when speakers divide their attention between two simultaneous tasks (e.g. [4-7]). The aim of this study was to contribute to the understanding of the relationship between the utterance-initial pitch raising and cognitive demands in language processing for speech production. For this, the experiment comparatively investigates whether sentence planning and the length-dependent scaling of utterance-initial pitch peaks in German and Estonian are affected by a shortage of cognitive capacity.

To modulate cognitive resources available for linguistic processing in a visual world speech production task, the study implemented a dual-task paradigm. Native speakers of Estonian (84 in total) and German (71 in total) were tasked with describing 64 pictures depicting complex events involving multiple actors (see Fig. 1). The pictures were designed to elicit utterances differing in length at the sentence-initial position (e.g., Santas vs. Santa and the elf decorating the Christmas tree) or at the sentence-final position (i.e. Santa decorating the Christmas trees vs. the Christmas tree and the window). In half of these picture descriptions (32 in total), participants were assigned the task of memorizing three nouns before describing the pictures. Subsequently, they were instructed to audibly recall the memorized nouns and answer a question related to these nouns (see Fig. 1). The pictorial design (see Fig. 1) controlled for cognitive processes of sentence planning which were then approximated by the measures of eye movement.

The results show that in both German and Estonian, the utterance-initial intonation peaks are sensitive to the length of utterances (in terms of the number of mentioned nouns; Santas are decorating the Christmas tree vs. Santa and the elf are decorating the Christmas tree), regardless of the load manipulation (Fig. 2c). This finding underscores the cross-linguistic planning of sentence intonation. Furthermore, the length effect does not depend on the sentential position of the lengthened constituent (Fig. 2d). Thus, the preview of the length of an emerging utterance effectively encompasses also sentence-final constituents and suggests a wide planning scope of sentences in Estonian and German. Interestingly, the rising effect of load is confirmed in German but it does not occur in Estonian. The measures of ongoing sentence planning (onset of the naming gaze) suggest that independent of language, an interference effect of high load occurs in conceptual planning stage (Fig. 2a). However, sentence length did not interact with the extent of conceptual planning, indicating that length and cognitive load constitute independent influences on sentence intonation. The relatively long speech onset latencies across two languages and especially in Estonian (Fig. 2b) suggest that the working memory load declined rapidly towards initiation of speech and interfered with planning of intonation only minimally.

The observed effects on intonation peaks provide valuable insights into the intricate cognitive processes involved in intonation planning. Firstly, they suggest that intonation planning relies on the comprehensive scope of linguistic organization at the conceptual level and possibly at other linguistic levels. Secondly, intonation is sensitive to cognitive resources but not contingent upon them, as high cognitive load did not interrupt intonation planning. In conclusion, these results deepen our understanding of how cognitive processes influence planning of sentences and sentence intonation across languages. By demonstrating cross-linguistic similarities in sentence planning strategies and highlighting the impact of cognitive load on speech production, these findings offer insights into theories of language processing and cognitive psychology.

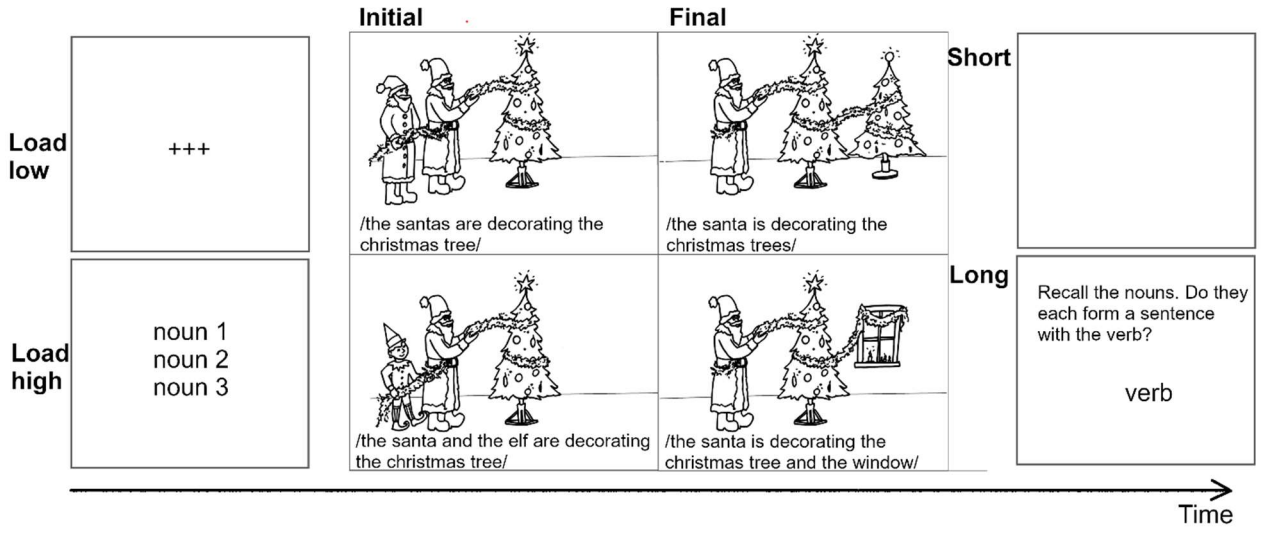

Fig. 1. Design and procedure of the visual world speech production experiment within a dual-task paradigm. Participants were instructed to describe a picture under one of four conditions (Agent of a SVO sentence Short, Agent Long, Patient Short, Patient Long) by mentioning all relevant actors and objects. The first block featured pictures preceded by three crosses, representing low cognitive load. In the second block, pictures were introduced after participants memorized three nouns, leading to high cognitive load. Subsequently, participants audibly recalled the memorized words and determined whether each could form a sentence with a verb displayed on the screen.

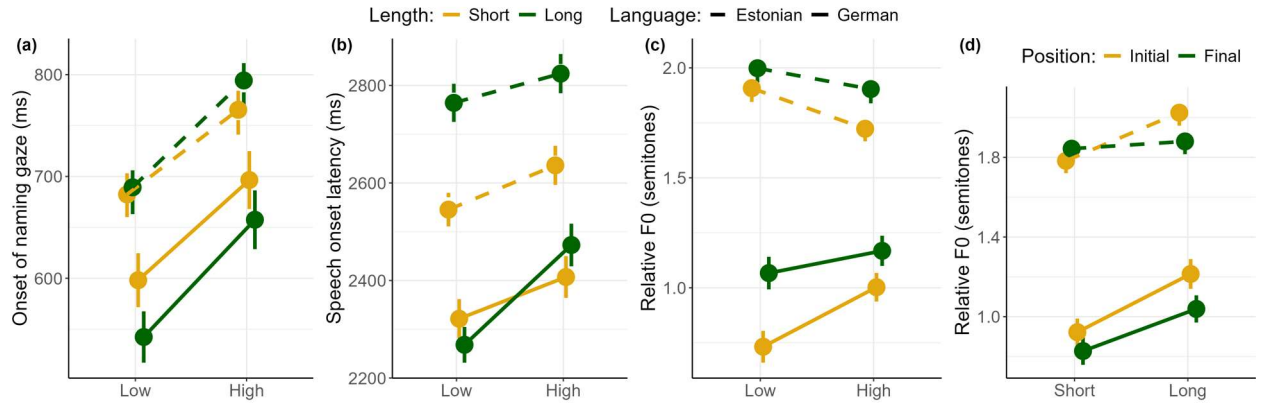

Fig. 2. Results of the visual world speech production experiment: (a) Onset of the naming gaze (longest gaze occurring before speech onset; approximates the start of linguistic encoding processes), (b) Speech onset latency, (c) mean intonation peaks (semitones) with 95% confidence intervals, illustrating the effects of load, utterance length, and language, and (d) Intonation peaks (semitones) with 95% confidence intervals depicting the impact of load, utterance length, and the sentential position of the lengthened constituent. Dashed and solid lines represent effects in Estonian and German, respectively.

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