Structurally informative prosodic cues in center-embedded and right-branching sentences

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Traditionally, difficulty of center-embedded sentences (CES) is attributed to syntactic complexity [3,6]. In such frameworks, effects of acoustic information are neglected [4]. However, acoustic information helps the parser disambiguate attachment ambiguities (e.g., high vs. low relative clause (RC) attachment) or "chunk" linear input into relevant constituents [1,5]. Therefore, it is plausible that acoustic cues also help the parser accurately analyze the complex structure of CES. Through sentence production, self-paced reading, and offline rating experiments, we attempt to describe and explain acoustic cues differentiating CES from right-branching sentences (RBS), which allows future studies to accommodate these acoustic cues into the model of processing overload.

Singly-embedded sentences are our current focus, since *multiply-embedded* sentences are often judged as unacceptable, thus are risky production stimuli for revealing optimal prosodic structure. In Experiment 1, native English speakers (N=12) read sentences aloud after presentation of short familiarizing contexts, making production more naturalistic and inducing a restrictive reading of each RC (#1). Example #1 also illustrates which locations syntactic models predict to be pre-boundary (PB) and non-boundary (NB), relative to intonational phrases. We compare relative word duration in CES and RBS in these locations (taken as evidence of prosodic breaks), in addition to comparing overall pitch contours [1,2]. By comparing relative durations of second nouns and first verbs (within part of speech, across PB/NB), we confirm the existence of strong prosodic breaks after the embedded RC in CES ($p<0.05$) and before the RC in RBS ($p<0.001$). There is no evidence for differing prosodic features between CES/RBS conditions in the NP1 region ($p>0.05$), likely due to the option for a VP intonational phrase in RBS. However, N2 in CES is significantly shorter than all other nouns ($p<0.01$), suggesting that the RC in CES is acoustically reduced compared to the matrix clause. Additionally, f0 analysis shows RBS and CES follow strikingly similar pitch contours, except for a medial relative pitch maximum in CES without a corresponding RBS maximum ($p<0.05$), indicating an additional pitch accent in CES.

In Experiment 2, native English speakers (N=20) read stimuli from Experiment 1 in a self-paced reading task and subsequent offline rating task. The only difference found between CES and RBS is a significant reading time slowdown at the second verb location in CES ($p<0.05$), reflecting the complexity of the embedded structure and the parser's attempt to resolve the embedding. However, this complexity is not reflected in the acceptability rating, where RBS and CES do not significantly differ ($p>0.05$).

In sum, although multiply-embedded CES are notoriously less acceptable due to processing overload, singly-embedded CES do not suffer from the same overload. They do, however, have an extra pitch accent in the embedded clause and a reading-time slowdown after the embedded clause boundary. These findings are consistent with traditional syntactic processing theories (assuming the slowdown reflects complexity), but the additional accent indicates a difference in prosodic chunking that existing theories do not address. Thus, our study forms the foundation for future investigations into prosodic contributions to processing by defining the variables to be manipulated.

(#1) Context: A family-owned bowling alley was located next door to a barber shop
The owner of the barber shop got to be friends with the regular bowlers

CES:[The jolly [barber$_{N1}$]$_{NP1}$] that [the nimble [bowler$_{N2,\mathbf{NB}}$]$_{NP2}$] [greeted$_{V1,\mathbf{PB}}$] || said good morning
CES:[The nimble [bowler$_{N1}$]$_{NP1}$] that [the jolly [barber$_{N2,\mathbf{NB}}$]$_{NP2}$] [greeted$_{V1,\mathbf{PB}}$] || said good morning
RBS:[The nimble [bowler$_{N1}$]$_{NP1}$] [greeted$_{V1,\mathbf{NB}}$] [the jolly [barber$_{N2,\mathbf{PB}}$]$_{NP2}$] || that said good morning
RBS:[The jolly [barber$_{N1}$]$_{NP1}$] [greeted$_{V1,\mathbf{NB}}$] [the nimble [bowler$_{N2,\mathbf{PB}}$]$_{NP2}$] || that said good morning

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