Prosody of classic garden path sentences: The horse raced faster when embedded

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Abstract

Prosody, it is assumed, does not always disambiguate syntax. We investigate one classic case at point from the psycholinguistics literature: garden paths sentences involving the main-verb vs. reduced relative clause contrast (\textit{the horse raced past the barn (and) fell}). Despite their centrality in shaping theories of sentence processing, no experimental work to date has investigated the prosody of these sentences. We show that, contrary to previous assumptions \cite{1, 2}, this contrast is prosodically disambiguated, but that this disambiguation can only be observed when the relevant clauses are embedded within a matrix clause which provides a baseline pace. Prosodic disambiguation obtains through pace modulation, with faster pace associated with the embedded/reduced relative reading and regular pace (no change) with main verb analysis. The essential contribution of the matrix sentence is to provide a baseline pace without which it is impossible to establish whether a change took place. Importantly, duration is solely determined by prosody and independent from complexity: faster pace is associated with the more complex structure.

**Index Terms:** Prosodic disambiguation, pace, complexity, garden-path sentences, embedding vs. sisterhood

1. Introduction

In current psychological models, and our everyday intuition, a simple correlation exists between relative task complexity and completion duration (when successful). Since Donders experiments in 1867, (reaction/response) time measures have been correlated with complexity and, in combination with other behavioural measures (i.e., accuracy), have consistently provided key insights into processes and mechanisms of the mind. We argue that, while generally sound, in the domain of language, and in particular when prosodic effects on duration are taken into account, this simple correlation can lead to dangerous oversimplifications. Recent psycholinguistics research shows that (Explicit and Implicit) prosodic properties, including phrasing, accentuation and rhythm, play a central role in sentence processing \cite{3}. This work shows that prosody modulate durational properties of words and phrases to reflect their structural and interpretive properties. We claim that these effects can lead to apparently paradoxical cases of shorter durations for more complex structures. Prosody, it is assumed, does not always disambiguate syntax, the contrast between Main verb and Reduced-Relative Clause (RC) analysis in (1-a,b), is one classic case of such mapping failure:

(1) a. The horse raced past the barn and fell.  
b. The horse raced past the barn fell.

We present evidence from a production study, that the classic garden path sentences in (1) are prosodically distinct and more generally that there exists a well-defined environmental contrast in which higher complexity co-occurs with shorter production/reading durations: a verb-phrase in a sisterhood vs embedded relation to a DP.

2. Background

Since the seminal work of Bever 1970, the contrast in (1), a case of local ambiguity between the Main Verb/Reduced RC parse, constitutes possibly the most well-known and one of the best studied examples of syntactic ambiguity in the literature and has provided one of the main testing grounds for different theories of sentence processing and of the relative contribution and timing of its subcomponents. The higher complexity of the reduced-RC analysis is not under discussion, rather the debate has focused on the underlying causes of this complexity and their relevance for sentence processing models. A variety of factors (including lexical, semantic, pragmatic and contextual) has been shown to modulate the strength of the garden path effect \cite{4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15}.

Since the seminal work of Bever 1970, Despite this wealth of data, no study, to our knowledge, has investigated experimentally whether and how the reduced-RC vs. Main Verb ambiguity is prosodically disambiguated, although the general assumption has been that the relevant structural and interpretive differences are not prosodically encoded \cite{16, 2}. While there are no a priori reasons to assume that prosody \textit{always} disambiguates syntax, lack of prosodic disambiguation between the two readings is somewhat surprising, as previous results on similar structural contrasts from different languages clearly show a correlation between attachment height and intonational phrasing (see \cite{17, 18, 19} a.o.).

The crucial distinction between Main Verb and the reduced RC in (1) lies in the relation between the DP (\textit{the horse}) and VP (\textit{raced past the barn}). The verb (the whole VP in fact) is embedded within the DP it modifies in (figure \texttt{1[B]}) but stands in a sisterhood relation with the same DP in (figure \texttt{1[A]}).

Similar differences in attachment height have previously been shown to be prosodically encoded, with higher attachment site correlating with separate phrasing \cite{18}, for example, provided further support to the common claim that Appositives
tachment height [17, 18, 25]. Higher attachment site correlates with separate phrasing, this is often observable in terms of durational differences between the two readings, with shorter durations for more deeply embedded strings and longer durations for high attachment of the same string.

Our first question, therefore, is whether and, if so, how the syntactic and semantic difference between the two readings of classic garden path sentences of the Main Verb/Reduced-RC variety are encoded at a prosodic level. More specifically, we ask whether the structural differences (i.e. differences in attachment height) between the position of the verb (raced) with respect to the subject DP (horse) results in prosodic differences.

We show that, contrary to previous assumptions [16, 2], the contrast in (1) is prosodically disambiguated, as early as the subject DP (the horse), aligning the Main Verb/Reduced RCs with other cases of attachment height disambiguation. This disambiguation, however, is best observed when the ambiguous string is embedded within a matrix clause which provides a baseline pace. Prosodic disambiguation obtains through pace modulation, with faster pace associated with the embedded/reduced relative reading and regular pace (no change) with main verb analysis. The essential contribution of the matrix sentence is to provide a baseline pace without which it is impossible to establish whether a change took place. Importantly, duration is solely determined by prosody and independent from complexity: faster pace is associated with the more complex structure.

3. The study

3.1. Methods

In a planned production study we compared the prosodic properties of utterances evoking a Main Verb reading with phonetically similar utterances evoking a reduced-RC reading only. These sentences were embedded in short introductory sentences containing declarative verbs. The short introduction was neutral with respect to the relevant disambiguation and was present solely to provide a baseline tempo. Notice that, for convenience, we still refer to “Main Verb” parse, even though in the materials used the relevant verb is part of the embedded declarative clause.

3.2. Materials

The material comprised 16 experimental utterances per condition adapted from previous experiments in the relevant garden path literature [7, 11]. Each experimental sentence was structured as follows: Noun Phrase (NP) matrix subject + matrix-
verb + that + ROI (DP + VP, in *italics* in (4)) + disambiguating coda (and got badly hurt).

(4) **MAIN VERB CONDITION:**
Jason claims that \[TP_{DP}\,the\,subject\,\,VP_{pulled\,into\,the\,row\,of\,traffic}\,and\,VP_{got\,badly\,hurt}\].

(5) **REDUCED-RC CONDITION:**
Jason claims that \[TP_{CP}\,the\,\,VP_{student\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,\,
reduced-RC condition, a result which comes with the important implication that listeners necessarily have less time to process the more complex reduced-RC. In other words, the domain of syntax-prosody interface presents an interesting case in which more complex structures have to be processed faster than simpler ones.

The preliminary analyses of the production study suggest that, contrary to previous assumptions [1, 2] on the whole English speakers make use of both temporal cues to disambiguate between Main Verb and reduced-RC readings and that this disambiguation is observable already at the head of the subject DP (the horse). To the best of our knowledge, previous claims that the two structures are not prosodically disambiguated are based on impressionistic judgments of the sentences in isolation. We have argued that indeed the temporal dimension of this disambiguation might go unnoticed when the sentences are presented in isolation and presented the relevant sentences as complement clauses of verba dicendi (John said that . . .). The durational differences that constitute the main source of disambiguation of the two readings are not absolute, but relative to a baseline pace set by e.g. a matrix sentence (or alternatively by the preceding discourse). This is because shorter/longer duration of a string produced in isolation is not informative per se, as it might simply be taken to reflect aspect of speech rate irrelevant to syntax-prosody mapping. Just as previously observed with the Pseudo Relative/Relative Clause contrast, the longer duration of the head of the embedded subject in the Main Verb analysis may signal the presence of a major prosodic boundary. The temporal differences of the combined measures (duration of the DP plus the VP, i.e. the whole ROI) may be taken to reflect the different structural relation between the DP and the VP in the sentences under considerations. The DP and the VP form a single constituent in the reduced-RC analysis, with the VP (raced past the barn) embedded within, acting as a modifier of, the DP (the horse). Together, they form a modified subject of the embedded clause (the horse fell). In the Main Verb analysis, on the other hand, the DP (the horse) is the subject of an embedded clause which contains two conjoined VPs (raced past the barn and fell). In other words, while with reduced-RCs the relation between the VP and the DP is one of embedding, in the case of the Main Verb analysis it is one of sisterhood. To the extent that these duration differences can be interpreted in terms of intonational phrasing differences, the current preliminary results are in line with previous work showing a similar interaction between prosody and syntax [19, 17, 18, 25]. As mentioned in the introduction, in this study we chose to be faithful to original research on garden path effects by using sentences from previous studies which had been shown to derive strong complexity effects in the reduced-RC condition. This was important since we set to investigate the potential independence of duration from complexity. This choice, however, proved problematic for the analysis of tonal differences across conditions. The materials, while kept constant across conditions, varied greatly across items. The VPs of the embedded sentences varied in length (both in terms of number of words, syllables and characters), but also in terms of argument and event structure. We are currently working on follow up study with carefully controlled prosody across items.

5. Conclusions and Outlook

We tested the hypothesis that structural embedding is associated with shorter duration (faster speech rate with respect to a baseline set by the matrix clause) at the prosodic level, while longer duration (regular pace) is associated with higher attachment site (sisterhood). This proposal, based on previous results from a comparable contrast in Italian [19, 21], makes an important prediction: the more complex reduced RC (1)[b] should be associated with shorter duration than the easier Main Verb analysis (1)[a]. Preliminary results from a production study support this prediction. An important implication of these results is that listeners necessarily have less time to process the more complex reduced RC. In other words, the domain of syntax-prosody interface presents an interesting case in which more complex structures have to be processed faster than simpler ones. Future work is required to test the extent of this mapping across languages and structures and of its implications for psycholinguistics.
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7. References


