PROSODIC INFLUENCES ON THE RESOLUTION OF LEXICAL AMBIGUITY

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1 INTRODUCTION

A classic finding in research on prosody is that of Lehiste (1973), who showed that prosody could reliably disambiguate surface structure ambiguities, but not lexical ambiguities. Numerous studies have confirmed the syntactic effects of prosodic phrasing information. We will present results from two experiments, using cross-modal naming and end-of-sentence tasks, which show that prosodic phrasing can also affect lexical disambiguation, including cases of within-category lexical ambiguity. We will further show that phonological phrase (PPh) and intonational phrase (IPh) boundaries have separable effects on processing, with IPh boundaries leading to further interpretive processing than PPh boundaries. Specifically, we will argue in support of the Interpretive Domain Hypothesis, given in (1).

> (1) The Interpretive Domain Hypothesis (IDH) (Schafer, 1997):
> An intonational phrase boundary, but not a phonological phrase boundary, defines a point at which the processor performs any as yet outstanding semantic/pragmatic evaluation and integration of material within the intonational phrase.

2 THEORETICAL ASSUMPTIONS

2.1 THE PROSODIC HIERARCHY (e.g., Beckman & Pierrehumbert, 1986; Nespor & Vogel, 1986)

- Utterances are composed of one or more intonational phrases (IPhs).
- Intonational phrases are composed of one or more phonological phrases (PPhs).
- Each phonological phrase must contain at least one pitch accent (e.g., H*).
- Each IPh ends with either a high boundary tone (H%) or a low boundary tone (L%).
- Each PPh ends with either a high phrase accent (H-) or a low phrase accent (L-).
- Pitch accents can be high (H*), low (L*), or a combination of high and low (e.g., L+H*).

2.2 THE GARDEN PATH MODEL (e.g., Frazier, 1987; Frazier & Clifton, 1996)

- One structure is built at a time, using structure-based principles such as Minimal Attachment and Late Closure.
- There are separate processing modules, each using a specialized computational vocabulary. There is limited overlap in the vocabularies, allowing limited interaction between the modules.
- The prosodic representation is part of the computational vocabulary of the syntactic and semantic processing modules.

3 EXPERIMENT 1: END-OF-SENTENCE MAKES-SENSE JUDGMENTS SHOW LEVEL OF PROSODIC PHRASING AFFECTS SEMANTIC INTEGRATION

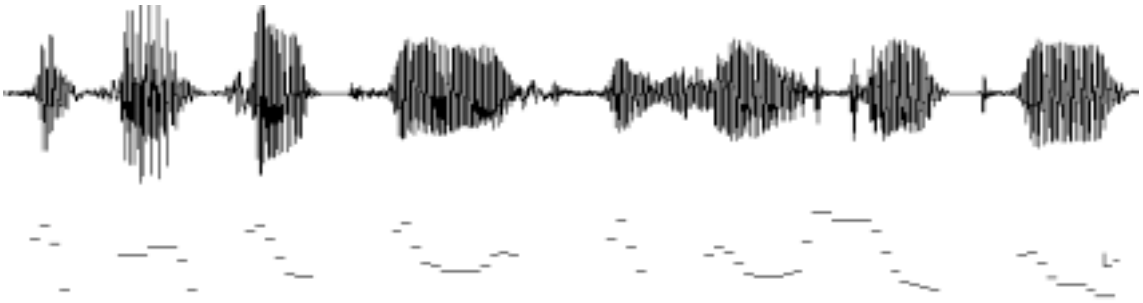
3.1 PRETESTING

Sixteen strongly-biased polysemous words were selected through a written sentence completion task. Twenty subjects completed neutral sentence fragments (e.g., *Although the glasses were ugly...*) and then answered a disambiguating question about the fragment (e.g., *Why were the glasses ugly?*). A second pretest of visually-presented full sentences confirmed that the sentences were sensible with either a continuation instantiating the dominant meaning of the ambiguous word (e.g., *...Stacey wore them anyway.*) or a continuation instantiating the subordinate meaning (e.g., *...they held a lot of juice.*).

3.2 MATERIALS

Sixteen sets of sentences as in (2), produced by a ToBI-trained native speaker of English.

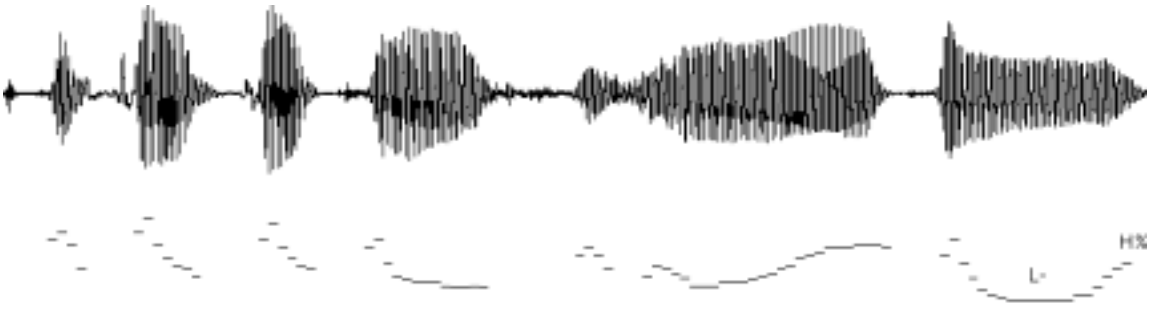
(2a) PHONOLOGICAL PHRASE BOUNDARIES



Although the glasses were ugly L-)$_{PPh}$

...Stacey wore them anyway. DOMINANT
...they held a lot of juice. SUBORDINATE

(2b) INTONATIONAL PHRASE BOUNDARIES



Although the glasses were ugly L-)$_{PPh}$ H%)$_{IPh}$

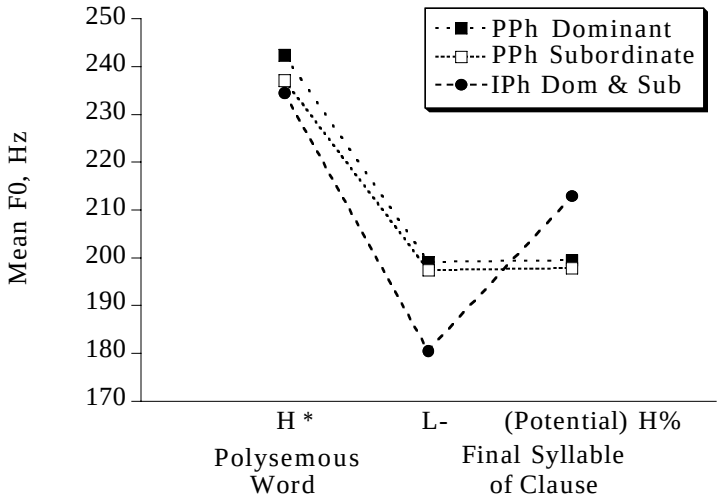
...Stacey wore them anyway. DOMINANT
...they held a lot of juice. SUBORDINATE

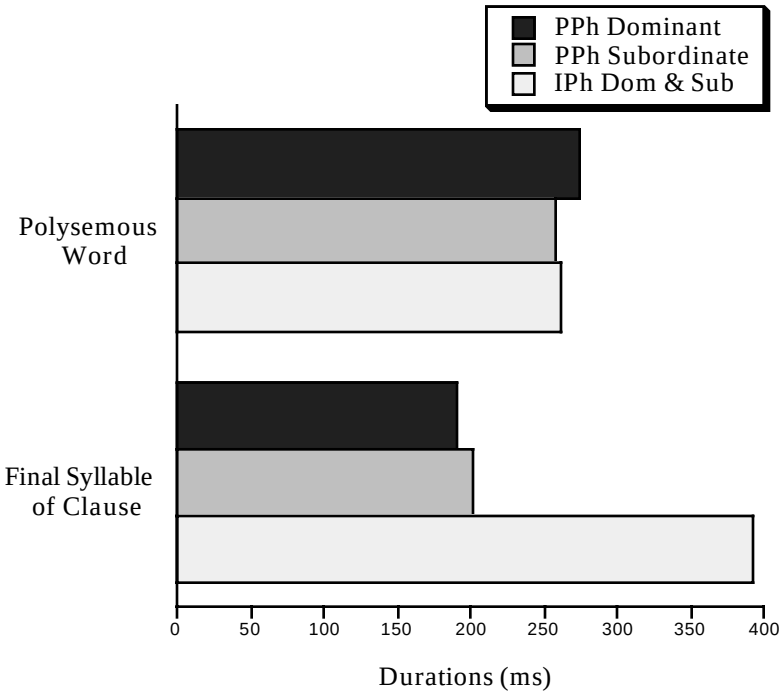
3.3 DURATIONAL CONTROLS

The region from the end of the polysemous word to the beginning of the disambiguating material contained sufficient lexical material to be at least 500 ms for each token (averaging over 1 second across tokens), ensuring that lexical selection occurred well before the point of disambiguation. The initial IPh of the IPh-Dominant condition sentences was replaced with the corresponding initial IPh of from the IPh-Subordinate condition to ensure that differences in the production of the polysemous word or initial IPh did not confound the results. The silent interval at the medial IPh boundary was digitally trimmed to 40 ms to minimize durational differences between the PPh and IPh boundaries while still providing a natural-sounding utterance in the IPh conditions.

3.4 PHONETIC ANALYSIS

- The prosody did not differ on the polysemous words.
- The final syllable of the initial clause was significantly longer with IPh prosody than with PPh prosody.
- There was a significant final rise in F0 with IPh prosody, but not with PPh prosody.





3.5 TASK

End-of-sentence “makes-sense” judgments. Latin-square design. Experimental sentences were randomized, by subject, with 52 control sentences with various prosodic and syntactic structures.

3.6 SUBJECTS

52 University of Massachusetts undergraduates, all native speakers of English, in exchange for course credit.

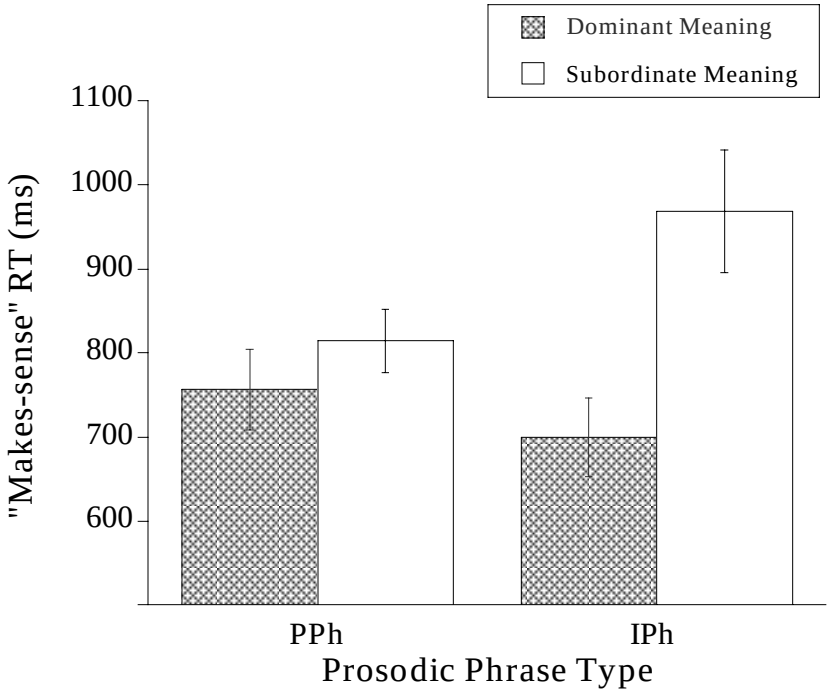
3.7 PREDICTIONS

- Sentences which instantiate the subordinate meaning of the polysemous word will have longer comprehension times than sentences which instantiate the dominant meaning.
- Sentence requiring reanalysis of material in a previous IPh will have longer comprehension times than sentences requiring reanalysis of material in a previous PPh.

3.8 RESULTS

Comprehension times from the end of sentence for makes-sense judgments:

PPH & IPH EFFECTS ON INTERPRETING POLYSEMOUS WORDS (EOS)



- Main effect of meaning: Longer makes-sense judgment times for sentences that ended in a clause that instantiated the subordinate meaning ($F_{(1,51)} = 15.4$, $p<.01$, $F_{(1,14)} = 10.6$, $p< .01$).
- Interaction of prosody and meaning: The main effect of meaning is due to the IPh condition ($F_{(1,51)} = 2.5$, $p<.13$, $F_{(1,14)} = 5.7$, $p< .04$; planned comparison of PPh-subordinate to IPh-subordinate conditions: $F_{(1,51)} = 3.6$, $p<.07$, $F_{(1,14)} = 6.1$, $p< .03$)
- No correlation between duration of ambiguous region and makes-sense judgment times ($r^2_{Sub.} = .03$, $p>.3$).

3.9 Discussion

- In a neutral context, the dominant meaning of a polysemous word is selected. Disambiguation to the subordinate meaning results in longer makes-sense judgment times.
- Further integration takes place at an IPh boundary than at a PPh boundary. A medial IPh boundary results in longer makes-sense judgment times than a PPh boundary in the subordinate conditions, when reanalysis is generally required, but not in the dominant conditions.
- Pragmatic differences between a falling contour vs. fall-rise contour do not account for the results.
- The Interpretive Domain Hypothesis is supported.
- Is the effect due to durational differences or a phonological distinction?
    - The silent interval of the medial IPh boundary was trimmed to 40 ms.
    - The duration of the ambiguous region averaged over 1 second.
    - No evidence of a correlation between the duration of the ambiguous region and makes-sense judgment times.

4 Experiment 2: Cross-Modal Naming Shows Immediate Effects of Prosodic Phrasing on Semantic Integration

4.1 Pretesting

- Polysemous words were strongly biased toward one meaning.
- Polysemous words were presented in a subordinate-biased context in a sentence completion task (*Since the anchor is more attractive now...*) with follow-up questions (*Why is the anchor more attractive now?*). The results verified that the context biased interpretation toward the subordinate meaning of the polysemous word, but did not exclude an interpretation with the dominant meaning of the polysemous word.
- Visual targets (*NEWS, BOAT*) were verified to be strong semantic associates of either the subordinate or dominant meaning of the polysemous word (*anchor*) but not of the primary context word (*attractive*).
- Full sentences were pretested to ensure that continuations which went against the bias of the initial clause were acceptable and both prosodic contours were acceptable.

4.2 Materials

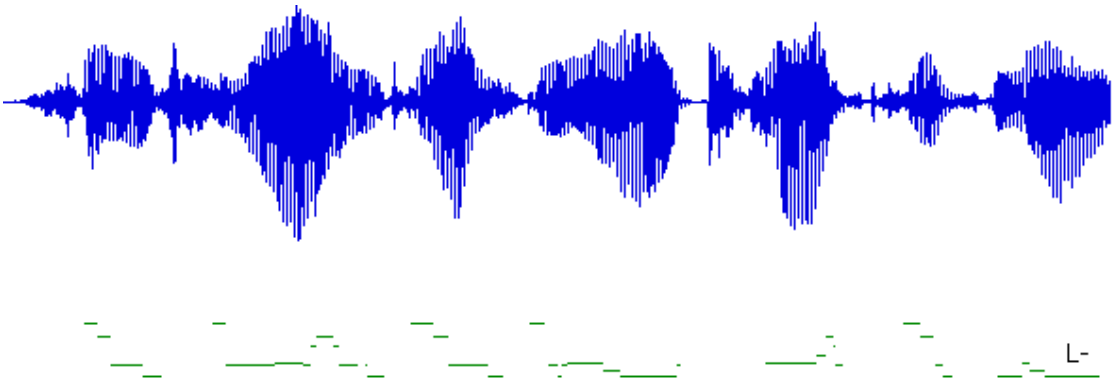
Twenty-four sets of sentences as in (3) were produced by a ToBI-trained native speaker of English. Each sentence contained a strongly-biased polysemous word in a weakly subordinate-biased context. Experimental sentences were truncated approximately one syllable after the key context information, at the end of an initial clause. Thirty-six additional control sentences were truncated at various points in the sentence.

4.3 Procedure

The 24 experimental sentence fragments were pseudorandomized with the 36 control sentence fragments in four lists, following a Latin-square design, and presented in a non-integrative cross-modal naming task, as illustrated in (4). Subjects were seated in front of a computer monitor in a sound-attenuated booth or small room. Sentence fragments were presented over headphones (4a). At the offset of each fragment, a visual target appeared on the monitor (4b). Subjects were instructed to name the visual target as quickly as possible (4c), and then complete the sentence (4d). Sentence completions were noted down by an experimenter. Naming times were measured from the onset of the visual word. Subjects were not told to relate the visual and auditory stimuli, and control trials contained fragment/visual word combinations that were unrelated.

Corrected Naming Times At the end of the experiment, subjects named each visual word token four times following a neutral fragment ("Now say..."). Individual reaction times were corrected for each subject for each item by subtracting the mean of these times from the item's response time.

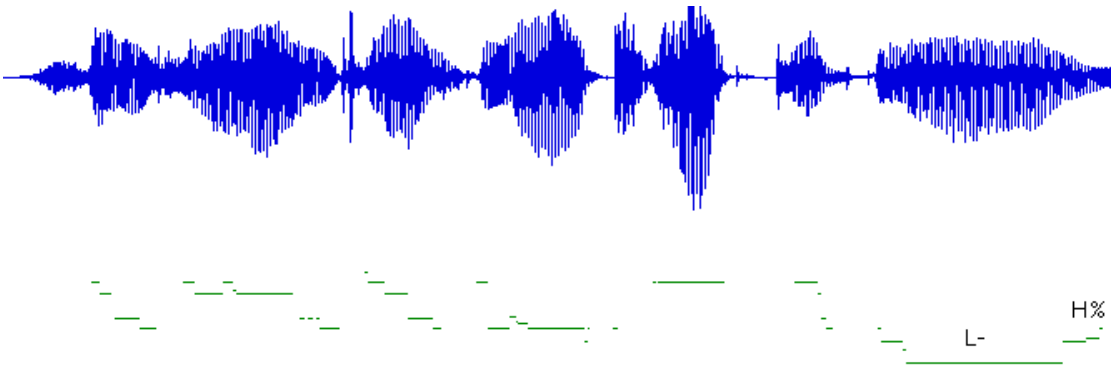
(3a) PHONOLOGICAL PHRASE BOUNDARIES



Since the anchor is more attractive now L-)$_{PPh}$

SUBORDINATE VISUAL TARGET: NEWS
DOMINANT VISUAL TARGET: BOAT

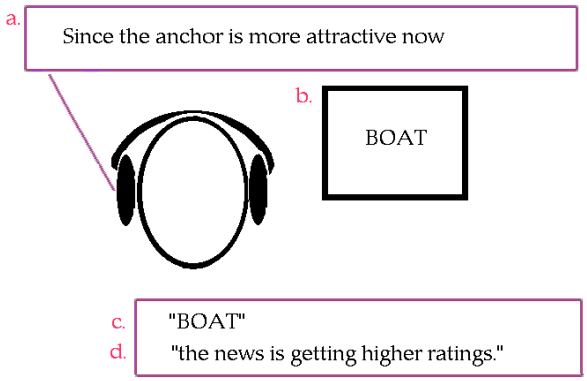
(3b) INTONATIONAL PHRASE BOUNDARIES



Since the anchor is more attractive now L-)$_{PPh}$ H%)$_{IPh}$

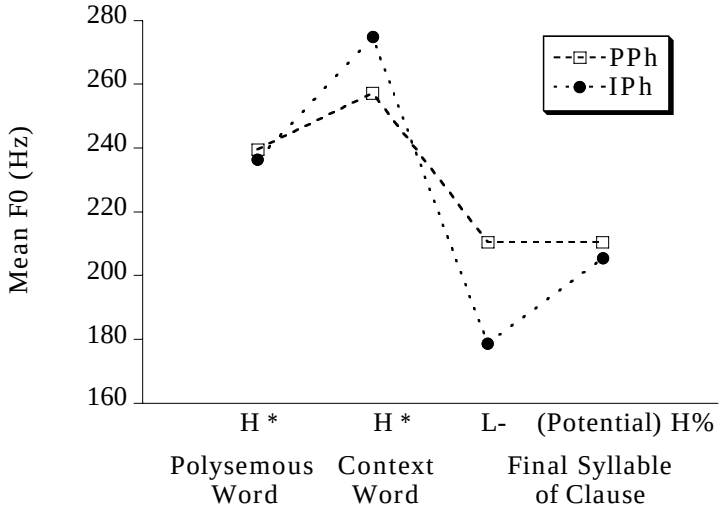
SUBORDINATE VISUAL TARGET: NEWS
DOMINANT VISUAL TARGET: BOAT

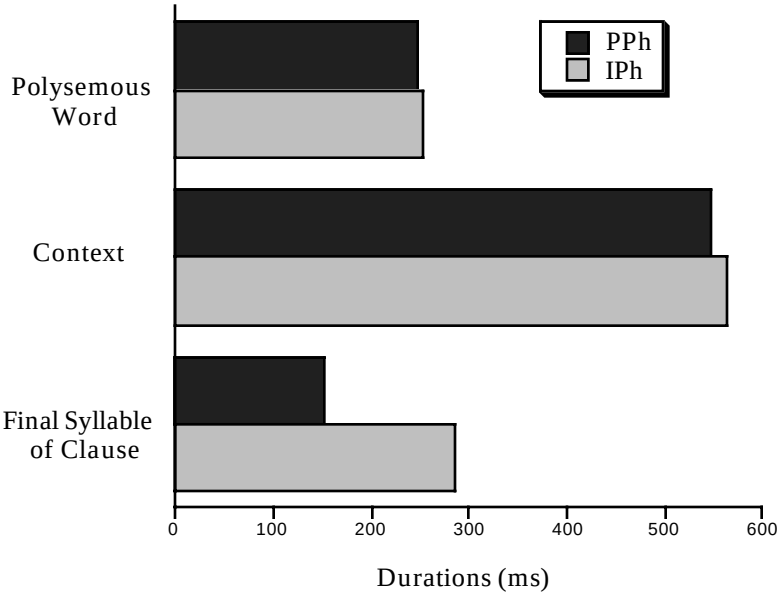
(4) NON-INTEGRATIVE CROSS-MODAL NAMING TASK:



4.4 PHONETIC ANALYSIS

- The prosody did not differ on the polysemous words.
- The accented word of the context region had a higher F0 with IPh prosody than with PPh prosody.
- The duration of the context region (the end of the polysemous word to the beginning of the final syllable) did not differ.
- The final syllable of the fragment was significantly longer with IPh prosody than with PPh prosody.
- There was a significant final rise in F0 with IPh prosody, but not with PPh prosody.





4.5 SUBJECTS

44 University of Kansas students participated in exchange for course credit.

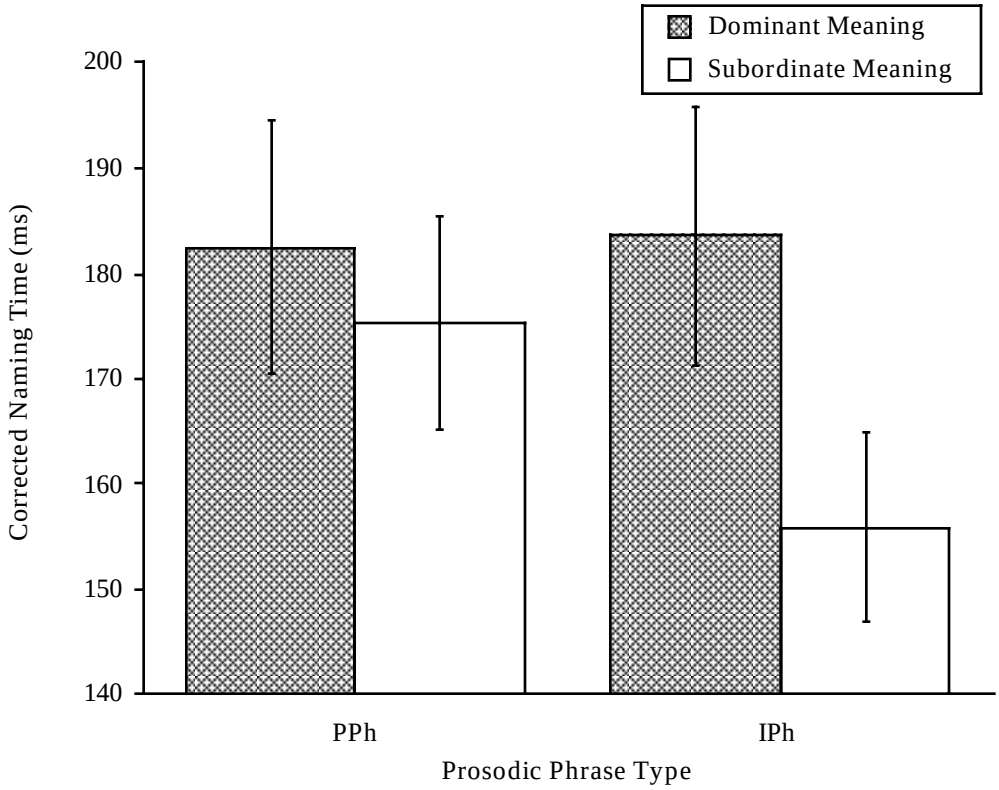
4.6 PREDICTIONS

- Visual targets which are semantic associates of the subordinate meaning of the polysemous word will have shorter naming times than those which are associates of the dominant meaning.
- For subordinate conditions, shorter naming times in the IPh condition than in the PPh condition.

4.7 RESULTS

Corrected cross-modal naming times:

PPH & IPH EFFECTS ON THE IMMEDIATE INTERPRETATION OF POLYSEMOUS WORDS (NAMING)



- Main effect of meaning: Shorter naming times for visual words related to the subordinate meaning of the polysemous word, the meaning that was more congruent with sentence context ($F_{(1, 43)} = 5.03$, $p = .03$, $F_{(1, 23)} = 3.97$, $p = .052$).
- Planned comparisons show no effect of meaning for the PPh conditions ($F<1$), but in the IPh conditions, show shorter naming times for subordinate associates than dominant associates ($F_{(1, 43)} = 8.87$, $p = .005$, $F_{(1, 23)} = 5.47$, $p = .029$). Planned comparisons also show shorter naming times for subordinate associates in the IPh condition than in the PPh condition, but this effect was not significant by items ($F_{(1, 43)} = 4.53$, $p = .039$, $F_{(1, 23)} = 2.79$, $p = .10$).

4.8 DISCUSSION

- In a subordinate-biased context, semantic associates of the subordinate meaning are primed over dominant associates.
- There is an immediate effect of further integration at IPh boundaries.
- The Interpretive Domain Hypothesis is supported.

5 CONCLUSIONS

- Prosodic phrasing affects the processing of polysemous words.
- IPh boundaries, but not PPh boundaries, affect higher-level interpretive and integrative processing, as predicted by the Interpretive Domain Hypothesis.
    - IPh boundaries following strongly-biased polysemous words in a neutral context lead to longer makes-sense judgment times with disambiguation toward the subordinate meaning.
    - IPh boundaries following strongly-biased polysemous words in a subordinate-biased context lead to shorter cross-modal naming times for visual associates of the subordinate meaning.
- Prosodic phrasing defines the relevant context for a given linguistic level of processing:
    - IPhs delimit the important context for semantic/pragmatic processing.
    - Previous work (e.g. Kjelgaard, 1995; Speer et al, 1996; Schafer, 1997) indicates that PPhs delimit the important nodes for syntactic processing.
- These results support the phonological theory of the prosodic hierarchy and give evidence for the early use of this prosodic representation by the human sentence comprehension mechanism, at multiple levels of linguistic analysis.

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