Prominence effects on pre-lexical processing
time-course evidence from vowel perception

I. Introduction

Two important components of spoken language processing:
• determining segments, lexical contrasts -> segmental processing
• determining phrasal grouping and prominence -> prosodic processing

These two processes usually assumed to operate fairly independently [1]
• however, acoustic info which specifies segment/prosody overlap – prosody shapes segment cues [2,3] – how should listeners contend with this?

Proposed non-independence of prosodic and segmental processing [3,4]
• prosodic structure as a mediating influence in segmental processing

“Prosody Analyzer” [4]: integration of prosody + segment via lexical competition:
• (1) segmental information activates lexical hypothesis
• (2) prosodic context modulates lexical activation/competition

Prediction: prosodic contextual effects should occur later in time – esp. following the uptake of segment cues – some evidence for this from binned data [5,6]

Goals of the project:
• Test if/when phrasal prominence influences perception of spectral cues (Exp. 1)
• previous work focuses on phrasal boundaries, and durational cues
• Two accounts tested by observing the time-course of prominence effects:
  (a) Prosody Analyzer as a mechanism of integration – delayed time-course
  (b) Prominence as a standard acoustic pattern – no delay in integration [6]

II. Experiment 1 - methods

The test case: prominence driven “sonority expansion” – phrasally prominent vowel articulations show:
• more jaw movement, lowered/backed lingual articulations [7,8]
• this modulates the acoustic structure of vowels: formants
  • (= resonance frequencies that characterize different vowels)
• raised first formant (F1) & lowered second formant (F2) [9,10]

F1 and F2 are crucial for making vowel category distinctions -
• lexical contrasts: e.g. “head” / head / “head” / head /
• F1 & F2 are thus shaped by both prosody and segment

Task: 2AFC categorization task (n = 30)
Target: 10-step F1-F2 phonetic continuum from “ebb” to “ab” (Fig.1)

Prominence manipulation:
• two carrier phrase conditions
  Nuclear pitch accent (NPA): I’ll say [target] now
  Post-Target:
  • target is prominent L+H+
  • I’ll say [target] now

Predictions: in prominent contexts: attribution of F1 raising + F2 lowering to prominence marking (not segmental contrast) would lead to more /d/ percepts – i.e. “this is prominent /d/, not /l/”
• In other words - /d/ becomes acoustically more like /l/ when prominent – will listeners account for this?

III. Experiment 1 - results

Main effect of prominence confirms predictions – increased “ebb” responses when the target is prominent

Evidence for phrasal prominence effects in vowel contrast perception:
• aligns with previous prosodic boundary findings [5,6]

With this finding in hand, we can test how this information is processed online

(i) Click responses show prominence increases clicks on “ebb” (Fig. 3 )
• replicates categorization responses in Exp. 1

(ii) Eye movement data: both manipulations show effects online (Fig. 4)
• graded preference for “ebb” along the continuum (panel A) – sanity check, showing listener sensitivity to fine-grained F1-F2 differences
• clear online influence of prominence manipulation (panel B) – though relatively small

(iii) Time course assessment (Fig. 5 at right)
• formant information is used relatively early in time –standard time course for intrinsic spectral cues [11] (panel C)
• The observed prominence effect is asynchronous, following formant cues by 300ms (panel D)

IV. Experiment 2 - method

2AFC visual word eyetracking task, following [10, 11] (n = 32)

• listeners look to and click on orthographic target word representations
• same stimuli as Exp. 1, using the 6 most ambiguous continuum steps [12]
  • full parametric terms, smooths for prominence, time and continuum - b) tensor product
  • used to model continuum effects over time, random smooths

Time course predictions:
• Following (a) Prosodic Analysis – formant cues activate lexical hypotheses – prosodic structure mediates lexical competition
  • Prediction: asynchrony in the use of formant cues and prominence
  • Spectral cues are used rapidly [11] – a benchmark for what counts as “fast”
• Following (b) prominence as a contextual use of formant cues – synchronous use of formant and prominence cues, standard for context effects (e.g. speech rate, spectral context [11])
• compatible with models where contextual information recodes cue values [13] – or cue integration [6] – no explicit prosodic analysis on the part of the comprehension system

V. Experiment 2 - results

Take home messages:
1. Listeners incorporate prosodic prominence in sequential processing
   • Prominence effects are delayed – consistent with recent proposals - later stage integration of prosody in lexical competition

Further questions:
1. Does signal-extrinsic prominence (e.g. information structural cues from context) also show this effect? cf. [14]
2. What perception/modeling best accounts for these findings?

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