

Testing the P-map hypothesis I: Coda devoicing

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The problem

- Languages resolve voiced obstruents in codas by devoicing but not by any other phonological means.
- The underlying /ab/ can become [ap], but not *[am], *[aba] or *[a].
- The absence of some strategies is an example of a “too-many-solutions” problem (Lombardi, 2001; Steriade, 2001/2008).
- Steriade (2001/2008) claims that (i) speakers maximize the similarity between inputs and outputs, assuming that (ii) devoicing yields an outcome that is most similar to the original form.

The aim of this talk

- Previously I have attempted to support the premise of this hypothesis using verbal art pattern data (Kawahara, 2007; Kawahara & Shinohara, 2009), and also by paper-based and auditory-based similarity judgement experiments (Kawahara, 2009).
- But these works only compare devoicing and nasalization.
- This talk more directly supports the premise by several types of similarity judgment experiments.
- Four online-based similarity judgment tasks show that English speakers do judge devoiced form as more similar to the original form than outcomes of other phonological resolutions.

Experiment I: Introduction

- A multiple-choice similarity judgment experiment.
- The target stimuli contained coda voiced stops, and for each target, the participants were presented with four options that each represent the output of devoicing, nasalization, deletion and epenthesis.
- For example, for [ab], the four options were [ap], [am], [apa], and [a].

Experiment I: Method, stimuli

- The target stimuli were [ab], [ad], [ag], [itab], [ikad], and [itag].
- Disyllabic stimuli were added because speakers may disfavor deletion in monosyllabic stimuli because of the minimal word requirement in English (Hammond, 1999).
- Since all target items involve coda voiced stops, 6 fillers were added: [am], [an], [na], [ma], [da], and [ga].

Experiment I: Method, procedure

- The experiment was administered online through Sakai (<https://sakai.rutgers.edu/portal>) using English orthography.
- For each target word, four choices were presented, and the participants were asked which of the option sounds most similar to the target word.
- The order of these choices and the presentation of the 12 stimuli were randomized by Sakai.

Experiment I: Method, procedure

- The nasalization of [g] was represented by [ng] with a note that these letters represent the last sound in “sang”.
- Although the experiment was based on English orthography, the participants were asked to read the stimuli before they answer the questions and base their judgments on their auditory quality.
- 32 native speakers of English completed the survey.

Experiment I: Results

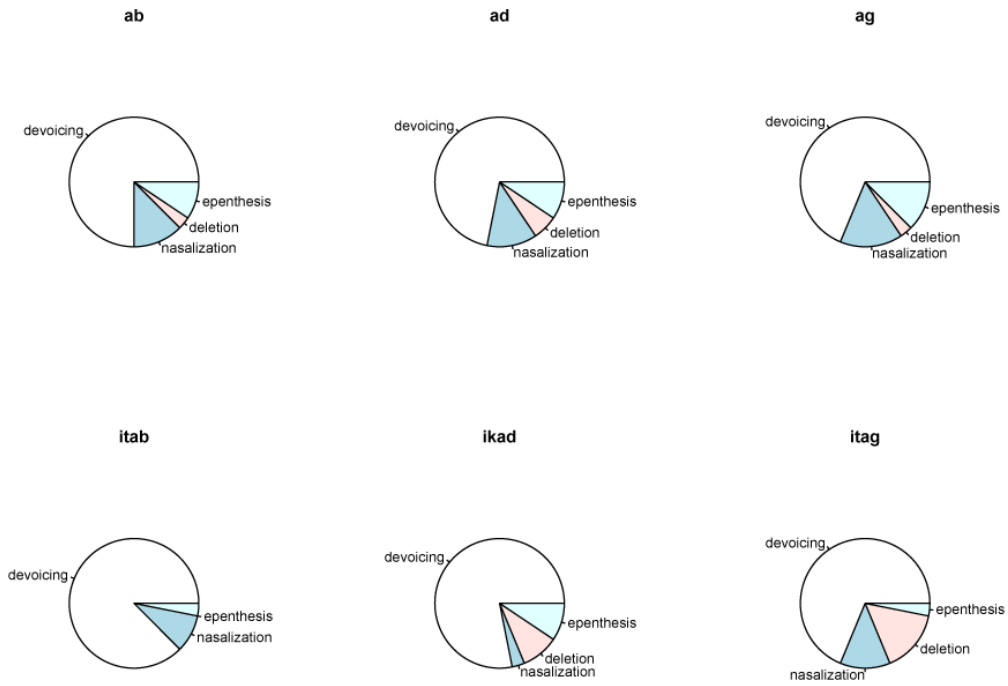


Figure: The percentages of forms that were judged to be most similar to the target items with coda voiced stops.

Experiment I: Results

- For all targets, the speakers most often chose the devoiced outcome as most similar to the original forms.
- The null hypothesis: each speaker would choose devoicing 1.5 (=6/4) times out of 6 items.
- A non-parametric Wilcoxon test shows that the preferences toward devoicing did not arise by chance ($V = 526, p < .001$).

Experiment II: Introduction

- To further verify the results of Experiment I and to compare the similarity differences caused by each phonological process, a follow-up similarity judgment task was conducted with binary comparisons.
- The design involved all binary comparisons of four phonological processes (devoicing, nasalization, deletion, and epenthesis) ($4 \times 3 / 2 = 6$ comparisons).

Experiment II: Method, stimuli

- The stimuli included [ab], [ad], [itab], and [ikad].
- Dorsal stimuli were excluded because the binary comparison design in Experiment II involves more comparisons than Experiment I.
- There is a psychological limit on how many questions speakers can focus on in an online test (Hayes, Zuraw, Siptár, & Londe, to appear).
- Dorsal stimuli were excluded because English does not offer an orthography to represent nasalized [g].

Experiment II: Method, procedure

- The procedure was almost identical to Experiment I.
- Given binary choices, the participants were asked which of the option sounds most similar to the target word.
- For example, which one of [ap] and [aba] is more similar to [ab]?
- The order of these choices was randomized by Sakai.

Experiment II: Method, procedure

- The overall experiment was organized into two smaller blocks.
- The first block contained all 12 monosyllabic stimuli (6 comparisons * 2 target stems) followed by a break sign where they were encouraged to take a break. After the break, the second block contained all 12 disyllabic stimuli.
- The order of the stimuli within a block was randomized by Sakai.
- 35 speakers of English participated in the survey.

Experiment II: Results

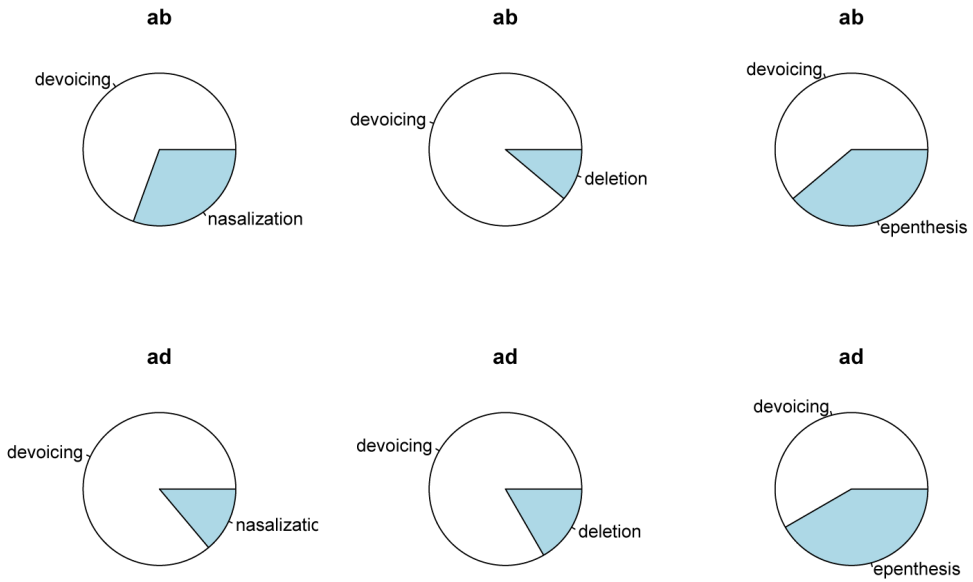


Figure: Comparisons involving devoicing: monosyllabic stimuli.

Experiment II: Results

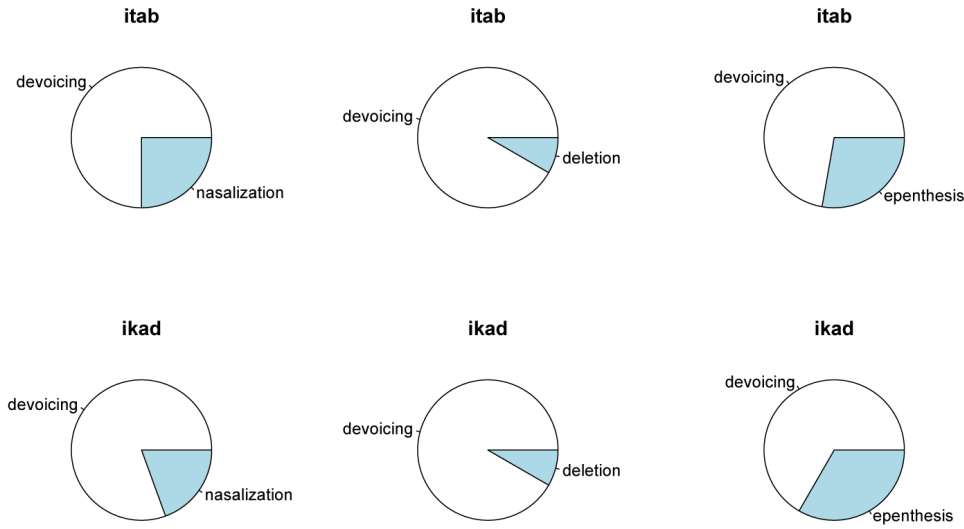


Figure: Comparisons involving devoicing: disyllabic stimuli.

Experiment II: Results

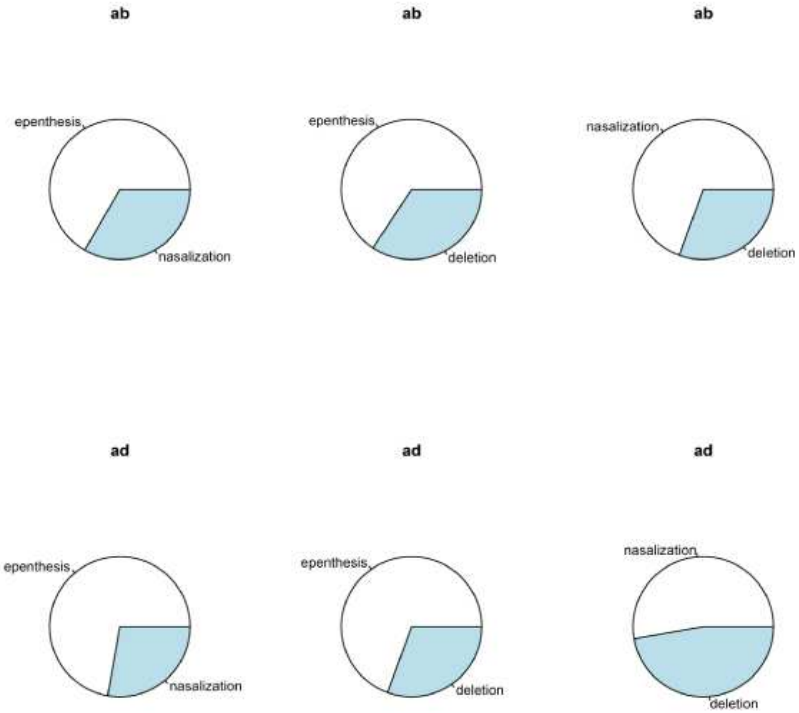


Figure: Comparisons involving non-devoicing processes: monosyllabic stimuli.

Experiment II: Results

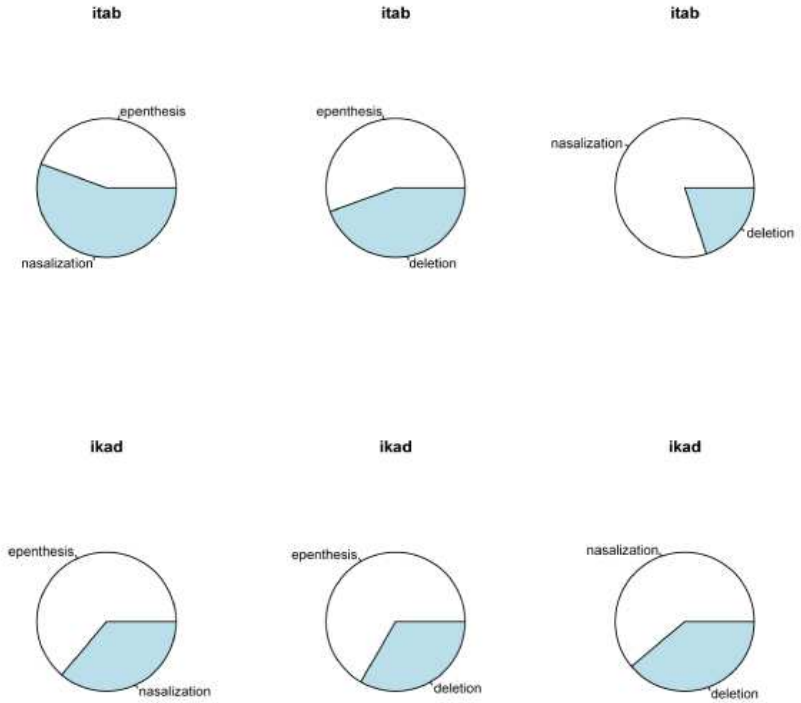


Figure: Comparisons involving non-devoicing processes: disyllabic stimuli.

Experiment II: Discussion

- Speakers judged the devoiced form as more similar to the target words than any other forms.
- Epenthesis seems to yield a form that is more similar than nasalization and deletion.
- Nasalized forms were judged to be more similar to the original form than forms with deletion.
- Three post-hoc analyses with Bonferroni correction ($\alpha = .05/3 = .016$):
dev vs. others ($V = 459.5, p < .001$); ep vs. nas/del ($V = 294.5, n.s.$); nas vs. del ($V = 324.5, n.s.$)

Experiment III: Introduction

- To confirm that the results obtained in Experiment I and II are not an artifact of task design, a magnitude estimation task was run (Johnson, 2008; Lodge, 1981; Winter, 2003).
- In this task, speakers judged the perceptual differences between stimuli in a given scale.

Experiment III: Method, stimuli

- The stimuli were [ab], [ad], [itab], [ikad].
- These four stems were each compared to the outcome of four phonological operations (e.g. [ab]-[ap], [ab]-[am],[ab]-[a], and [ab]-[aba]).
- The stimuli with coda [g] were not included because 16 test items would have been sufficient for an online test (Hayes et al., to appear).

Experiment III: Method, procedure

- The scale was a 5-point scale:
 - 1 almost identical
 - 2 very similar
 - 3 similar
 - 4 not so similar
 - 5 completely different.
- As with Experiment I and II, the test was administered using Sakai.

Experiment III: Method, procedure

- The entire experiment was organized into two smaller blocks, preceded by a practice session with 3 items.
- The design included a practice session so as to allow participants to establish their subjective scale of similarity before preceding to the main session.
- The first block contained monosyllabic stimuli with 8 items (2 stems * 4 comparisons) followed by a break sign.
- After the break, the second block contained all disyllabic stimuli. The order of the stimuli within a block but not the order of the options was randomized by Sakai.
- 27 native speakers of English participated in the study.

Experiment III: Results

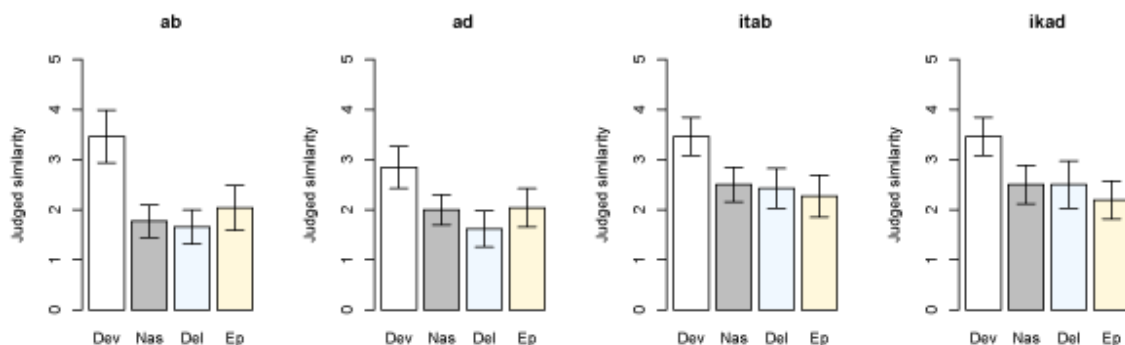


Figure: The average similarity ratings of four forms with respect to the original forms with coda voiced stops. The error bars represent 95% confidence intervals.

Experiment III: Results

- The participants judged the devoiced forms (the leftmost bars) to be more similar to the original forms than other forms.
- A Wilcoxon contrast test compared the judged similarity scores between the devoiced form and the average of the other three forms and revealed a statistically significant difference ($V = 349, p < .001$).

Experiment IV: Introduction

- The concern: in the preceding experiments, the epenthetic candidate was created with an epenthetic [a]. However, [a] is in general longer in duration than other vowels (Lehiste, 1970; Lindblom, 1968).
- Therefore, this experiment included the epenthetic target in which the epenthetic vowel is [i]
- [i] is the shortest vowel (besides schwa) in English (Parker, 2002; Peterson & Lehiste, 1960; Strange, Bohn, Trent, & Nishi, 2004) and is arguably used for epenthesis in English (Yip, 1987) and other languages (Howe & Pulleyblank, 2004).

Experiment IV: Method, stimuli

- The details of the experimental design are identical to Experiment I, except for a few aspects.
- The task was a three-way forced choice similarity test, the options including the devoiced candidate, a candidate with an epenthetic [a], and a candidate with an epenthetic [i].
- The participants were gathered primarily thorough “Psychological Research on the Net” maintained by Dr. John H. Krantz.
- <http://psych.hanover.edu/research/exponnet.html>
- 35 native speakers completed the survey.

Experiment IV: Results

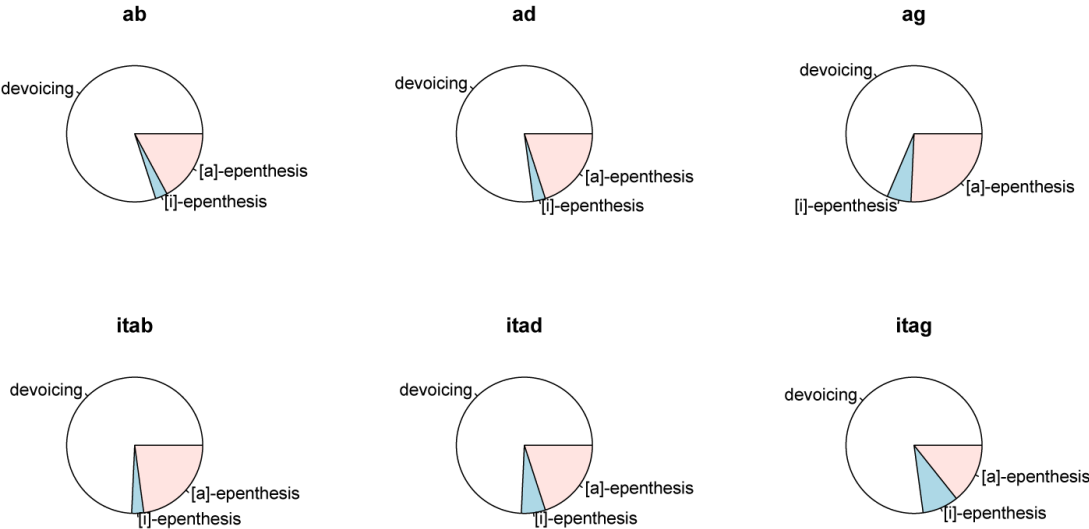


Figure: The results of the three-way similarity judgment task comparing devoiced forms, forms with [i]-epenthesis, and forms with [a]-epenthesis.

Experiment IV: Discussion

- Speakers still considered the devoiced forms as the most similar to the target forms ($V = 480, p < .001$).
- Speakers did not even consider forms with [i]-epenthesis more similar than the forms with [a]-epenthesis.
- It may be because copy epenthesis involves less of “perceptual addition” (Shinohara & Kawahara, 2009).

Summary

- English speakers find the devoiced outcome as most similar to the original forms than the outcomes of other phonological forms.
- This finding supports the premise of Steriade (2001/2008).
- The phonological strategy that speakers chose as yielding the most similar form to the original form is actually the phonological strategy observed in natural language.

Remaining questions, future developments and other remarks

- Question I: Why is devoicing special? It may be due to semi-devoicing of coda voiced stops in English (and other languages) (Myers, to appear, and references cited therein).
- Question II: Would the results be language-specific? Extending the experiments to speakers of other languages is warranted.
- Question III: Effects of orthography? Auditory-based experiments (currently on-going).
- Question IV: Other tasks? Discrimination experiments under noise.
- Final remarks: The usefulness of online-based experiments: I got responses from more than 130 speakers within a month.

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