The time-course of recognition of reduced Japanese words: Evidence from pupillometry with a Go-NoGo task

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1. Introduction

Background:

- Variability in spoken language, especially in casual speech, largely due to phonetic reduction [1]
- Incomplete articulation and deletion of speech sounds and segments in reduced forms [2]:

  e.g., /daigaku/→[daiɣakɯ]→[daiakɯ] [3]
- Inhibitory effect in the recognition of spoken language [4]
- Fewer studies have investigated the inhibitory effect over time

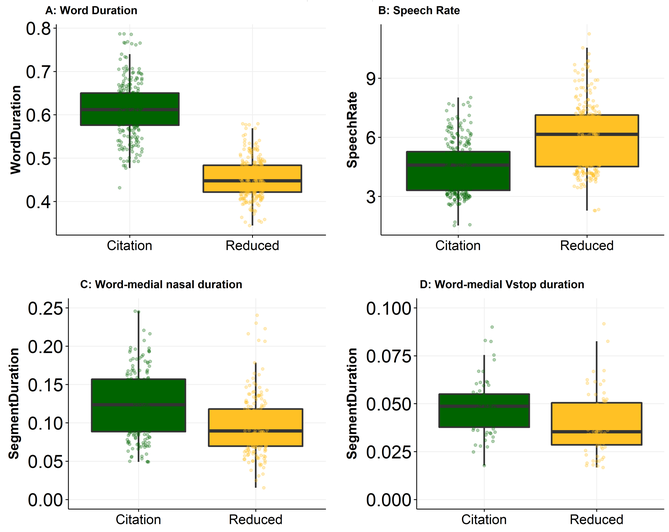
Research objective:

- Compare the time-course of the recognition of reduced and citation forms of Japanese words as indicated by pupil dilation

Pupillometry:

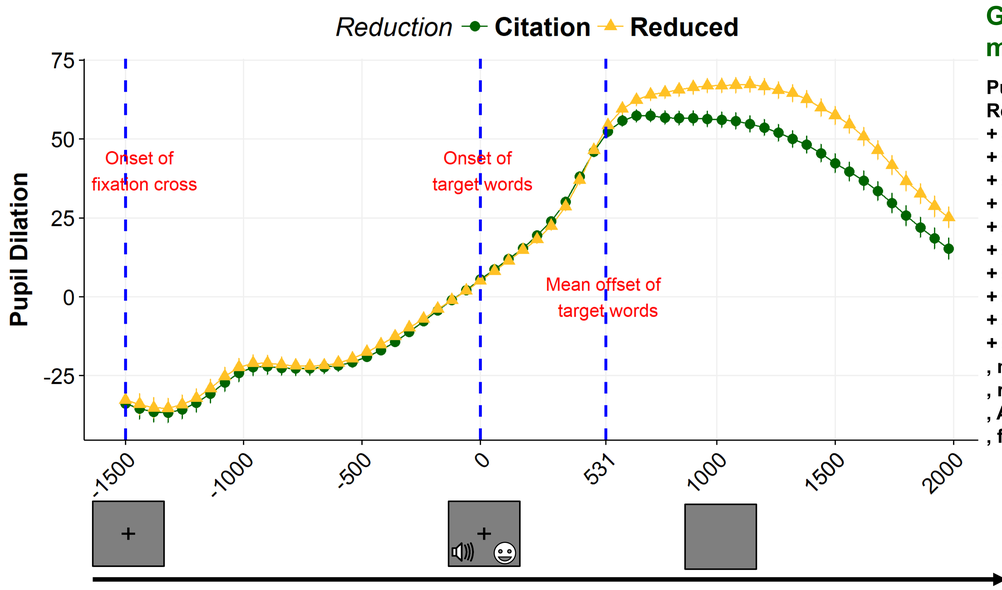
- Reflects the allocations of cognitive resources imposed by different variables in speech comprehension in the absence of voluntary and conscious processes [5]
- Harder to process, greater the pupil dilates

Fig. 1: Acoustic properties of reduced and citation forms of Japanese words, all of which contain word-medial nasals or voiced stops



2. Method

Participants: 38 Japanese speakers (female, *n* = 16)
Stimuli: 226 four-mora Japanese words (452 total items: 226 reduced and 226 citation forms)
{V, CV} - {V, CV, N, H} - {V, CV, N, H} - {V, CV, N, H}
Go-NoGo task: Participants respond to pure tones (non-target) by pressing a button and do not respond to Japanese words (target), while fixating on a cross on the computer screen
Preprocessing pupil size data: Remove and interpolate blinks and their artifacts; downsample and smooth the data; calculate the baseline pupil size for each trial



Generalized additive modeling:

```
PupilDilation ~
Reduction
+ SegmentType
+ s(Time, by=Reduction)
+ s(logfreq, by=Reduction)
+ ti(Time, logfreq, by=Reduction)
+ s(baseline)
+ s(WordDuration)
+ s(TRIAL_INDEX)
+ s(GAZE_X, GAZE_Y)
+ s(TIME, Participant, bs='fs', m=1)
+ s(TIME, Item, bs='fs', m=1)
, method='fREML'
, rho = 0.98
, AR.start = data$start.event
, family = "scat"))
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Fig. 2: The aggregated raw pupil dilation over time and schematic outline of a single experimental trial

3. Results & Discussion

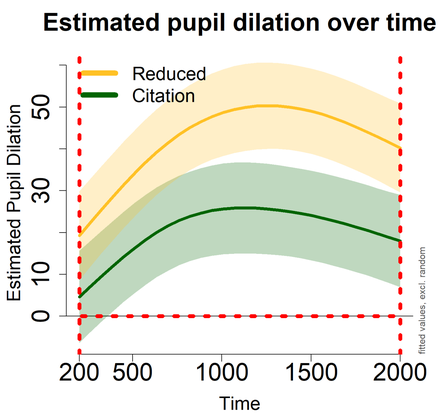

Fig. 3: The time-course of pupil dilation for reduced and citation forms (Take-home message 1)

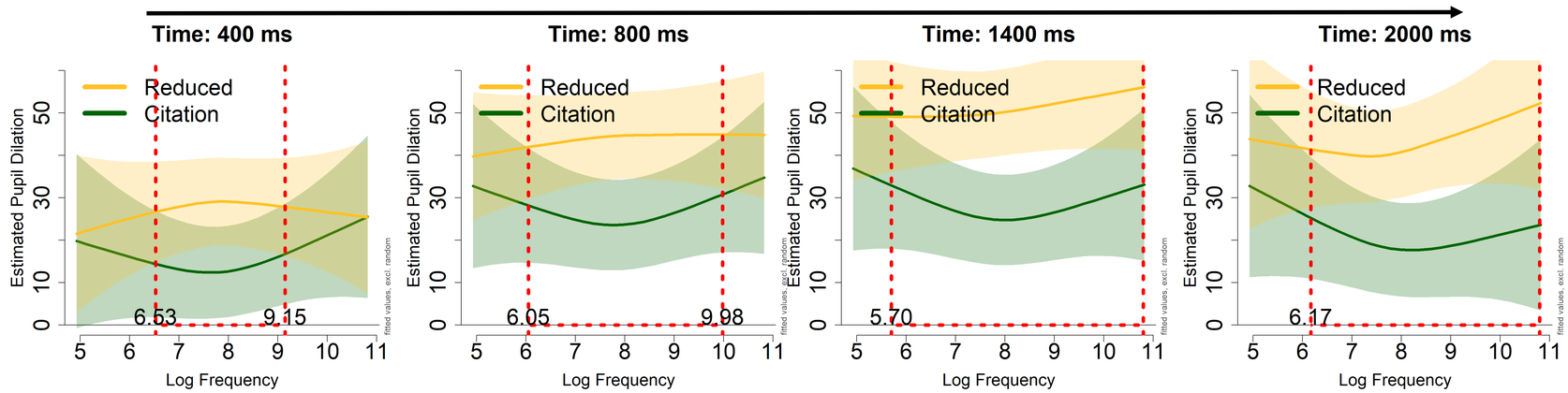

Fig. 4: The pupil dilation across Log Frequency at 400 ms, 800 ms, 1400 ms, and 2000 ms for reduced and citation forms (Take-home message 2, 3 & 4)

Take-home message:

1. The effect of reduction comes as early as 200 ms after the onset of the stimulus; greater pupil dilation for reduced forms; the trend of pupil dilation over time differs between the two forms (**Fig. 3**)
2. Both forms seem to show a similar frequency effect, but the effect seems to appear later in reduced forms (**Fig. 4**)
3. No effect of reduction for very low frequency words (**Fig. 4**)
4. The U-shaped frequency effect [4] (**Fig. 4**)

References:
[1] Ernestus, M., & Warner, N. (2011). An introduction to reduced pronunciation variants. Journal of Phonetics, 39(3), 253–260.
[2] Warner, N., & Tucker, B. V. (2011). Phonetic variability of stops and flaps in spontaneous and careful speech. The Journal of the Acoustical Society of America, 130(3), 1606.
[3] Arai, T., Warner, N., & Greenberg, S. (2007). Analysis of spontaneous Japanese in a multi-language telephone-speech corpus. *Acoustical Science and Technology*, *28*(1), 46–48.
[4] Tucker, B. V. (2011). The effect of reduction on the processing of flaps and /g/ in isolated words. Journal of Phonetics, 39(3), 312–318.
[5] Laeng, B., Sirois, S., & Gredebäck, G. (2012). Pupillometry: A Window to the Preconscious? Perspectives on Psychological Science, 7(1), 18–27.

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