Neutralization avoidance and naturalness in the learning of palatalization

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Learning bias

- Learners exhibit a variety of learning biases when learning phonological alternations. (see Moreton & Pater, 2012a/b for a summary)
- Most previous studies looking at learning biases focused on non-neutralizing alternations. (e.g., Wilson, 2006; Peperkamp & Dupoux, 2007; White, 2014)
- **Neutralizing alternations**?

Neutralization avoidance (contrast preservation)

- Previous studies have appealed to neutralization avoidance in analyses of phonological patterns:
  - Diachronic perspective: selection process against neutralizing patterns, especially those resulting in ambiguous speech; functional load hypothesis (e.g., Wedel, 2006; Silverman, 2010; Wedel et al., 2013)
  - Synchronic perspective:
    - MAXIMIZE CONTRASTS (Flemming, 1996, 2004)
    - *NEUT (Bolognesi, 1998)
    - *MERGE (Padgett, 2003, 2009)
    - PRESERVECONTRAST (Lubowicz 2007)

Some neutralization avoidance effects

- Preservation of contrasts with phonetic shifts. (Flemming, 1996)
  - English: Difficult to maintain voicing in initial stops, so /b/ → [p], /p/ → [p^h].
- Rules applying to an isolated sound rather than a natural class of sounds.
  - E.g. stop nasalisation in traditional Tokyo dialect of Japanese: (Labrune 2012)

    [g] → [ŋ]

    *[d] → [n], *[b] → [m]

    /n/ and /m/ are phonemes in Japanese while [ŋ] is not.
- Exceptional allomorph selection just in case it would avoid neutralization.
  - Polish (Lubowicz, 2007)
- Optional rules less likely to apply if they might neutralize.
  - Japanese nasal contraction (Kaplan & Muratani, 2015)

Research question

- A lot of work discussing the role of the speaker and listener in neutralization avoidance. (see Silverman 2012 for an overview)
  - But not much work looking at the role of the learner.

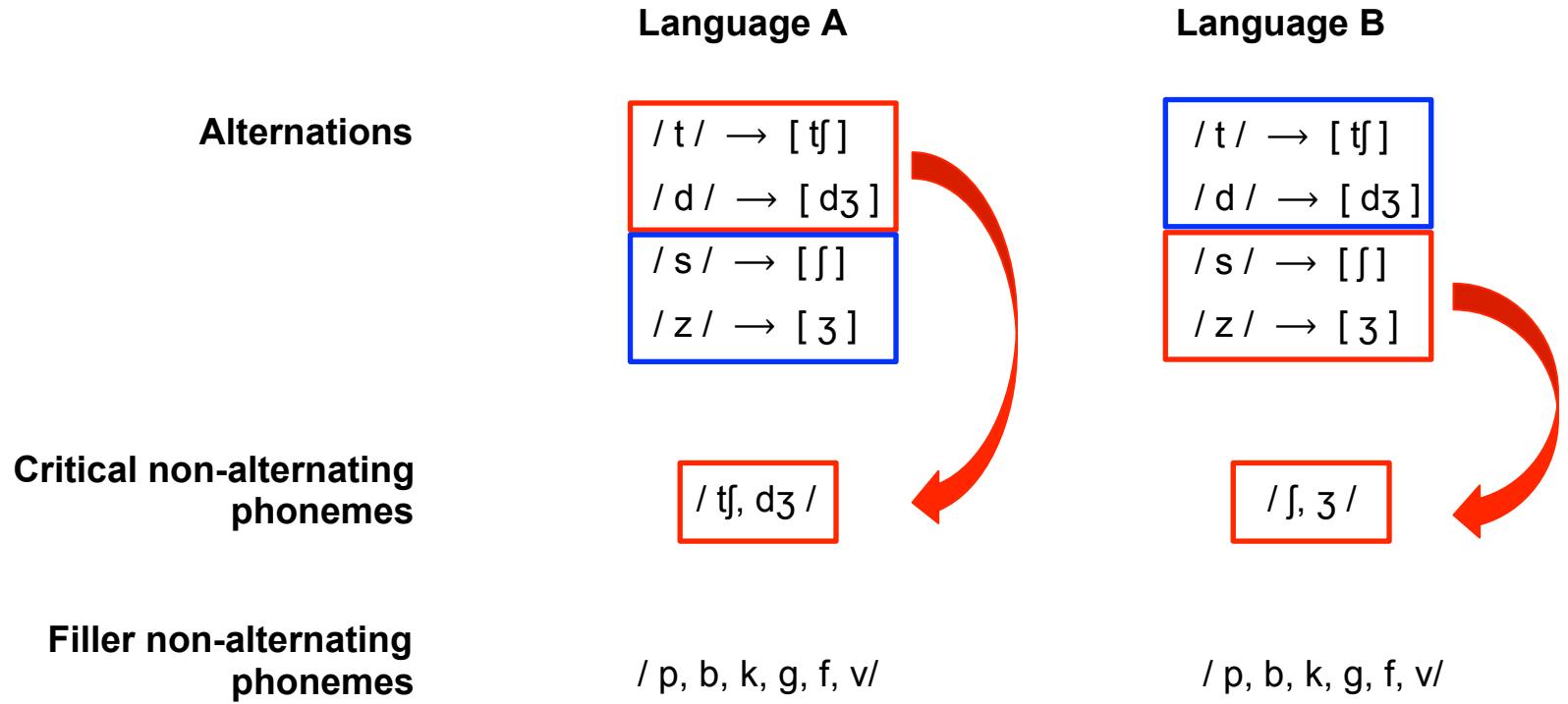
- Question: Are learners biased against neutralizing alternations in comparison with non-neutralizing ones?

- Artificial language approach:
  - Present equal input for neutralizing and non-neutralizing alternations.
  - Test how well learners acquire the two types of alternation.

Experiment 1: method

- Participants: native English speakers (n=30)
- 3 phases:
  - Exposure phase
  - Test phase 1: trained items
  - Test phase 2: novel items
- 4 novel alternations involving palatalisation [t, d, s, z] ~ [tʃ, dʒ, ʃ, ʒ]
- 2 counterbalancing groups: Language A vs. Language B

Experiment 1: design



Experiment 1: stimuli

- Exposure stimuli: 48 CVCVC singular nonwords with CVCVC-i plural forms:
  - 8 alternating [t ~ tʃ] and [d ~ dʒ] (Neutralizing in Language A)
    [tusut] ⟶ [tusutʃi]
  - 8 alternating [s ~ ʃ] and [z ~ ʒ] (Neutralizing in Language B)
    [duvis] ⟶ [duviʃi]
  - 8 critical non-alternating trials ending in [tʃ, dʒ] (Language A) or [ʃ, ʒ] (Language B)
    [buvatʃ] ⟶ [buvatʃi]
  - 24 non-alternating filler trials ending in [p, b, k, g, f, v].
    [vatuk] ⟶ [vatuki]

Experiment 1: stimuli

- ‘Illegal’ sequences never presented.
  - *[ti, di] in Language A.
  - *[si, zi] in Language B.
- Otherwise, consonant and vowel distribution roughly balanced across positions.

Experiment 1: exposure phase

Experiment 1: test phases

- 2 test phases: 24 trained items, then 48 untrained items.
- Forced-choice task: choose the correct plural form between an alternating option and a non-alternating option.

Experiment 1: test phase options

- Incorrect changing options for non-alternating phonemes:

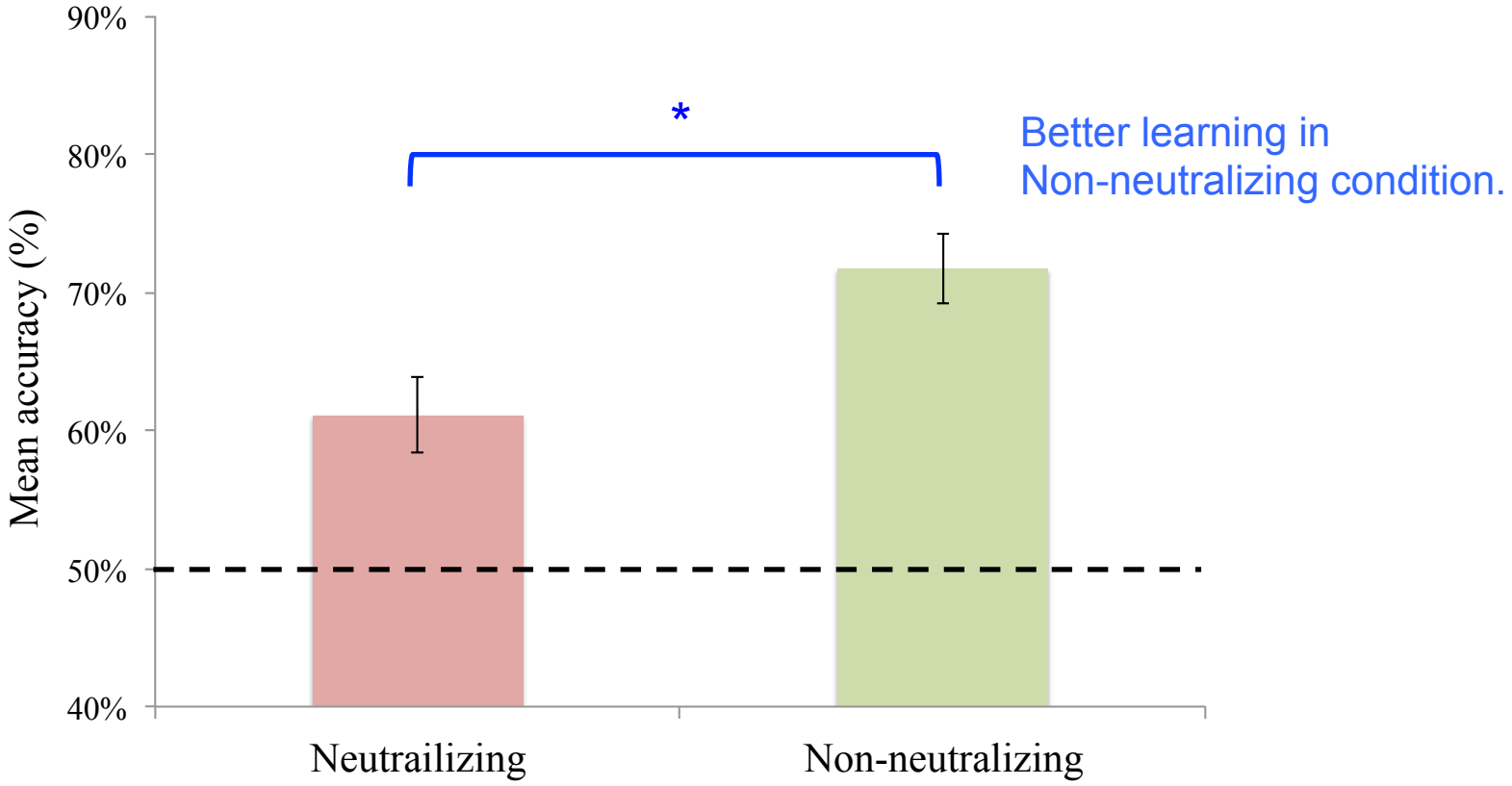
/ tʃ / → [ʃ]
/ dʒ / → [ʒ]
/ ʃ / → [tʃ]
/ ʒ / → [dʒ]

/ p / → [tʃ]
/ b / → [dʒ]

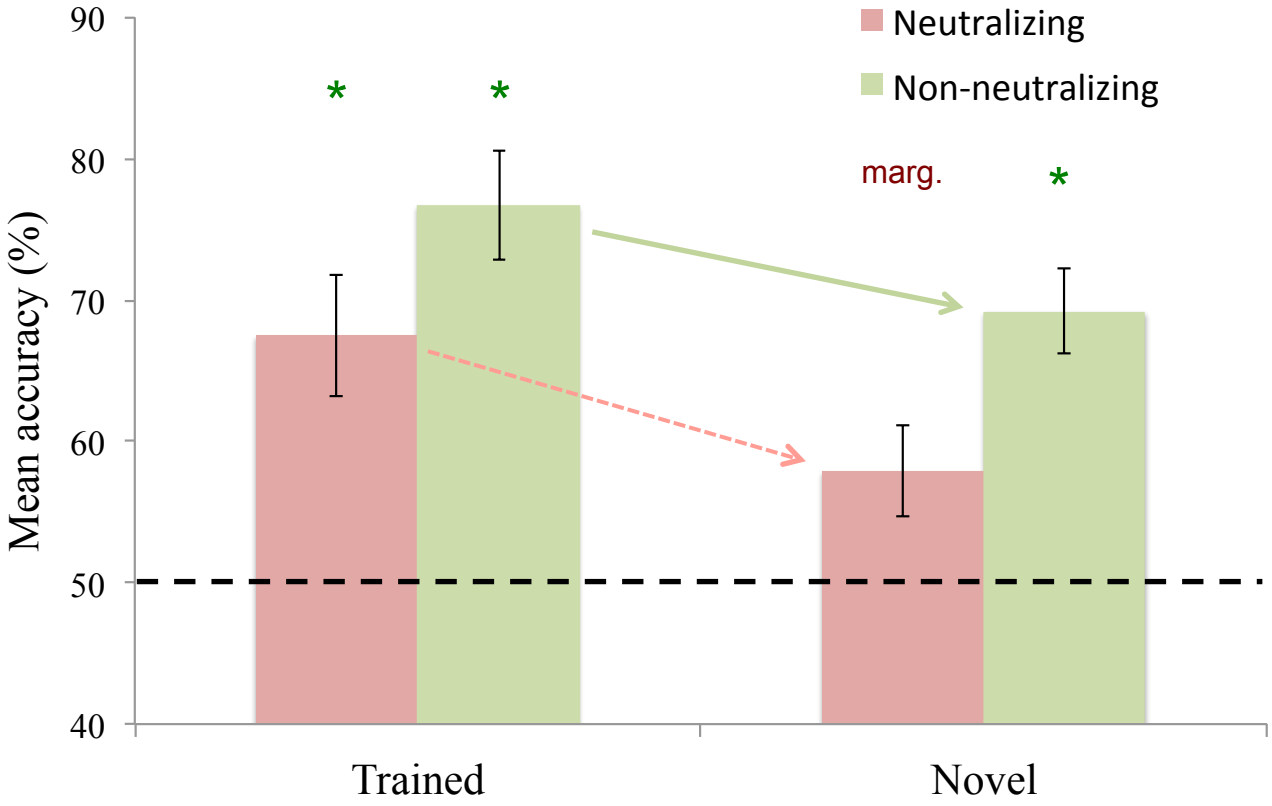
/ k / → [tʃ]
/ g / → [dʒ]

/ f / → [ʃ]
/ v / → [ʒ]

Experiment 1: results (Neut. vs. Non-neut. overall)



Experiment 1: results (trained and new items)



Main effect of training.
Trained > New

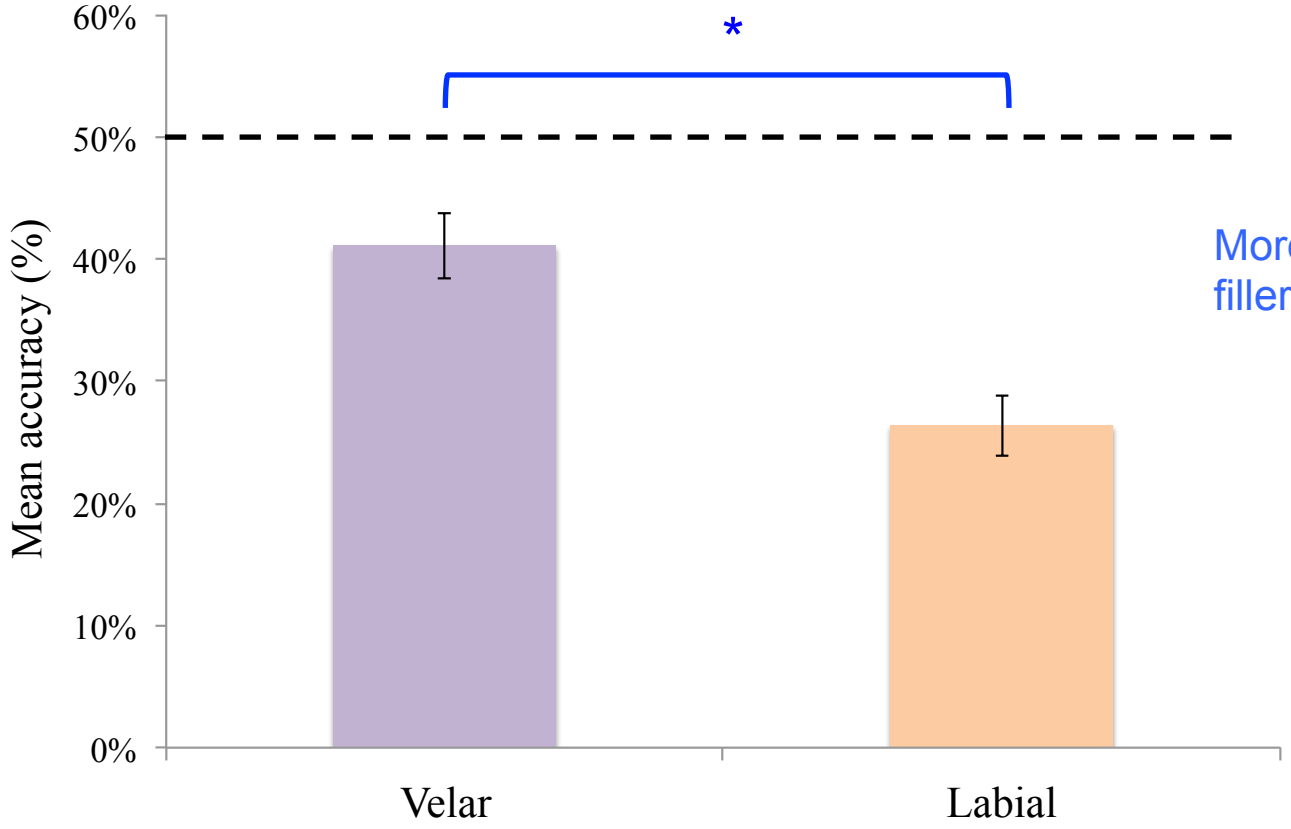
Main effect of Trial Type.
Non-neut. > neut.

No interaction.

Summary

1. Neutralizing alternations dispreferred relative to Non-neutralizing alternations, despite equal evidence for both.
   - Independent of which alternations were being learned.

A second interesting result: velar vs. labial fillers



More errors on velar fillers than labial fillers!

Summary

1. Neutralizing alternations dispreferred relative to Non-neutralizing alternations, despite equal evidence for both.
   - Independent of which alternations were being learned.

2. Participants spontaneously palatalized velar stops more often than labial stops.
   - Even though neither was palatalized in exposure.

Why velars more than labials?

- Substantive naturalness bias?
  - Typologically, palatalization of velars more common than labials. (Kochetov 2011)
  - [ki] and [tʃi] are more phonetically similar than [pi] and [tʃi], and thus considered a more likely alternation by learners. (e.g. Steriade, 2001)
  - Consistent with previous studies (Wilson, 2006; Skoruppa et al., 2011; White, 2014; White & Sundara, 2014)

- L1 influence?
  - English has alternations involving velar palatalization ('velar softening').
    - *opaque* [oʊˈpeɪk], *opacity* [oʊˈpæsɪɾi]; *esophagus* [əˈsɑfəgəs], *esophageal* [əˌsɑfəˈdʒiəl] (Halle 2005)
  - Cross-linguistic study would be useful.

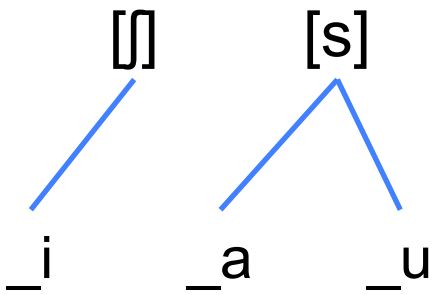
Accounting for the anti-neutralization effect

- Why are neutralizing rules more difficult to learn?

- We consider two possibilities:
  - pure statistical learning
  - learning bias

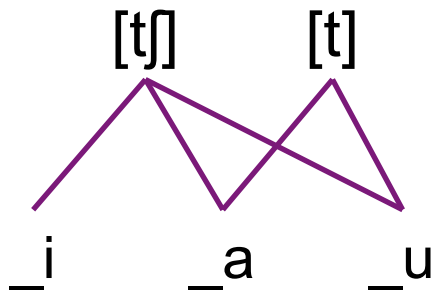
Just distributional learning?

Non-neutralizing alternation



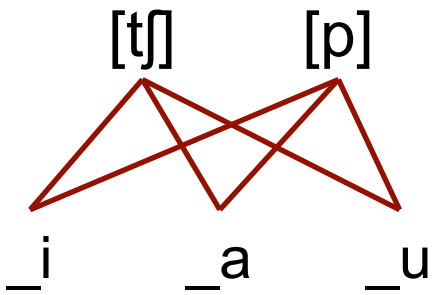
Fully complementary distribution

Neutralizing alternation



Partially overlapping distribution

Non-alternating fillers



Fully overlapping distribution

Discussion: distributional learning

- A distributional learning model must be able to recognise both fully complementary distributions and partially overlapping distributions as cues for alternation. (Calamaro & Jarosz, 2015)

- But perhaps identifying partially overlapping distribution requires more input or computation, resulting in reduced learnability.

- Potential limitation: Is there more than just phonological distributions involved? Lexical, semantic, and/or pragmatic influences?
  - If so, this is unlikely to be the full story.

Anti-neutralization learning bias

- Learners have a neutralization avoidance bias when learning alternations.

- Could be formalized in a learning model with weighted constraints (e.g. MaxEnt).
  - A prior could initially assign the ANTI-NEUTRALIZATION constraint a high weight.
    - Would block alternations resulting in neutralization.
  - Exposure to neutralizing alternations would gradually lower the constraint's weight.
    - Would make neutralizing alternations learnable, but at a slower rate.

What type of constraint/bias?

- Phonological
  - Does it consider all possible forms (e.g., Lubowicz, 2007; Padgett, 2009) or only existing forms in the lexicon?
  - Is it restricted to paradigms, or can it consider any pair of forms? (see Kaplan & Muratani, 2015 for discussion)

- General/functional
  - How do we integrate the neutralization avoidance pressure with models of the grammar (assuming we want to do that)? (e.g. Flemming 1996, 2004)
  - What roles does homophony (actual or potential) or frequency play? (Wedel et al. 2013)

- Upshot: If we see neutralization avoidance effects in learning, learning experiments could provide us with a new way of looking at these questions.

Is neutralization avoidance driven by homophony avoidance?

- Phonologically neutralizing alternations tolerated when they result in little lexical neutralization. (e.g. Silverman 2010 on Korean)
- Diachronically, mergers less likely when they would result in high amounts of homophony. (Wedel et al. 2013)
- Synchronically, stochastic processes may occur less frequently when they result in potential homophones. (e.g. Kaplan & Muratani, 2015 on Japanese nasal contraction)

Does homophony affect the learnability of neutralizing alternations?

- Currently running Experiment 2 to address this question.

Exp. 1: Half lexical neutralization

t-final	tusut	tusutʃi
	buvat	buvatʃi
	tʃuzat	tʃuzatʃi
	faput	faputʃi
tʃ-final	tusutʃ	tusutʃi
	buvatʃ	buvatʃi
	pifitʃ	pifitʃi
	gizutʃ	gizutʃi

Exp. 2: Homophony Condition

t-final	tusut	tusutʃi
	buvat	buvatʃi
	tʃuzat	tʃuzatʃi
	faput	faputʃi
tʃ-final	tusutʃ	tusutʃi
	buvatʃ	buvatʃi
	tʃuzatʃ	tʃuzatʃi
	faputʃ	faputʃi

Exp. 2: No Homophony Condition

t-final	tusut	tusutʃi
	buvat	buvatʃi
	tʃuzat	tʃuzatʃi
	faput	faputʃi
tʃ-final	busutʃ	busutʃi
	tavutʃ	tavutʃi
	pifitʃ	pifitʃi
	gizutʃ	gizutʃi

Product-oriented learning?

- Product-oriented learning (e.g. Bybee & Slobin, 1982) and neutralization avoidance predict different results in our experiment:
  - Product-oriented learning: Adding /tʃ/ ⟶ [tʃ] should boost /t/ ⟶ [tʃ] due to more cases of plural *-tʃi.*
  - Neutralization avoidance: Adding /tʃ/ ⟶ [tʃ] should reduce /t/ ⟶ [tʃ].
- We found neutralization avoidance, not product-oriented learning.
  - Fillers further suggest that product-oriented generalization was not a major factor in our study.
- Results diverge from Kapatsinski 2013.
  - He found that adding /tʃ/ ⟶ [tʃ] had no impact on (trained) /k/ ⟶ [tʃ]. (no neutralization avoidance)
  - But it did increase (untrained) /t/ ⟶ [tʃ]. (product-oriented learning)

Conclusions

- Learners are biased against neutralizing alternations.
  - Use of neutralization avoidance in synchronic accounts is potentially warranted.
  - Learner could play a role in diachronic neutralization avoidance effects.

- Learners favor palatalization of velar stops over that of labial stops.
  - Suggests a substantive bias, though a L1 bias cannot be ruled out at in this experiment.

Future directions

- Running the study with different L1 backgrounds.

- Would we see the same effect with infants?
  - Perhaps related to the Mutual Exclusivity Bias in pragmatic development? (Merriman, Bowman, & MacWhinney, 1989)
  - Infants disfavour the learning of homophones.
  - Neutralization avoidance could be a realization of mutual exclusivity at a phonological level.
  - Infants have 'proto-lexical' knowledge (Ngon et al., 2013) and phonotactic generalizations (Mattys et al.1999) at an early age.

- L2 acquisition of natural languages.
  - L2 learners care more about semantic information than ALL participants.
  - More explicit training on phonological system.

Acknowledgements:

- Help with experiment: Andrew Clark.
- Helpful discussion: Wing Yee Chow, Richard Breheny.
- London Phonology Seminar audience.

References:

Bolognesi, R. (1998). *The phonology of Campidanian Sardinian: A unitary account of a self-organizing structure*. NOR.

Bybee, J. L., & Slobin, D. I. (1982). Rules and schemas in the development and use of the English past tense. *Language*, 265-289.

Calamaro, S., & Jarosz, G. (2015). Learning General Phonological Rules From Distributional Information: A Computational Model. *Cognitive science*, *39*(3), 647-666.

Flemming, E. (1996). Evidence for constraints on contrast: The dispersion theory of contrast. *UCLA Working Papers in Phonology*, *1* (pp. 86-106).

Flemming, E. (2004). Contrast and perceptual distinctiveness. In B. Hayes, R. Kirchner, and D. Steriade (Eds.) *Phonetically-Based Phonology* (pp. 232-276).

Halle, M. (2005). Palatalization/velar softening: What it is and what it tells us about the nature of language. *Linguistic Inquiry*, *36*(1), 23-41.

Kapatsinski, V. (2013). Conspiring to mean: Experimental and computational evidence for a usage-based harmonic approach to morphophonology. *Language*, *89*(1), 110-148.

Kaplan, A., & Muratani, Y. (2015). Categorical and gradient homophony avoidance: Evidence from Japanese. *Laboratory Phonology*, *6*(2), 167-195.

Kochetov, A. (2011). Palatalisation. In M. Oostendrop, C. Ewen, B. Hume, & K. Rice (Eds.). *Companion to Phonology*. (pp.1666-1690). Oxford: Wiley Blackwell.

Labrune, L. (2012). *The phonology of Japanese*. Oxford: Oxford University Press.

Łubowicz, A. (2007). Paradigmatic contrast in Polish. *Journal of Slavic linguistics*, *15*(2).

Mattys, S. L., Jusczyk, P. W., Luce, P. A., & Morgan, J. L. (1999). Phonotactic and prosodic effects on word segmentation in infants. *Cognitive psychology*, *38*(4), 465-494.

References:

Merriman, W., Bowman, L., & MacWhinney, B. (1989). The Mutual Exclusivity Bias in Children's Word Learning. *Monographs Of The Society For Research In Child Development*, *54*(3/4), i.

Moreton, E., & Pater, J. (2012a). Structure and Substance in Artificial-phonology Learning, Part I: Structure. *Language And Linguistics Compass*, *6*(11), 686-701.

Moreton, E., & Pater, J. (2012b). Structure and Substance in Artificial-Phonology Learning, Part II: Substance. *Language And Linguistics Compass*, *6*(11), 702-718.

Ngon, C., Martin, A., Dupoux, E., Cabrol, D., Dutat, M., & Peperkamp, S. (2013). (Non) words,(non) words,(non) words: evidence for a protolexicon during the first year of life. *Developmental Science*, *16*(1), 24-34.

Padgett, J. (2003). Contrast and post-velar fronting in Russian. *Natural Language & Linguistic Theory*, *21*(1), 39-87.

Padgett, J. (2009). Systemic contrast and Catalan rhotics. *The Linguistic Review,* 26(4), 431-463.

Peperkamp, S. & Dupoux, E. (2007). Learning the mapping from surface to underlying representations in an artificial language. In J. Cole & J. Hualde (Eds.). *Laboratory phonology* (Vol. 9, pp. 315-338). Berlin: Mouton de Gruyter.

Silverman, D. (2010). Neutralization and anti-homophony in Korean. *J. Ling.*, *46*(02), 453-482.

Silverman, D. (2012). *Neutralization*. Cambridge: Cambridge University Press.

Skoruppa, K., & Peperkamp, S. (2011). Adaptation to novel accents: Feature-based learning of context-sensitive phonological regularities. *Cognitive Science*. 35, 348-366.

Steriade, D. (2001). Directional asymmetries in place assimilation: a perceptual account. *The role of speech perception in phonology*, 219-250.

Wedel, A. (2006). Exemplar models, evolution and language change. *The Linguistic Review*, *23*(3).

References:

Wedel, A., Jackson, S., & Kaplan, A. (2013). Functional load and the lexicon: Evidence that syntactic category and frequency relationships in minimal lemma pairs predict the loss of phoneme contrasts in language change. *Language and speech*, 0023830913489096.

White, J. (2014). Evidence for a learning bias against saltatory phonological alternations. *Cognition*, *130*(1), 96-115.

White, J., & Sundara, M. (2014). Biased generalization of newly learned phonological alternations by 12-month-old infants. *Cognition*, *133*(1), 85-90.

Wilson, C. (2006). Learning phonology with substantive bias: An experimental and computational study of velar palatalization. *Cognitive Science*, *30*(5), 945-982.