EXPERIMENTALLY COMPARING THE LEARNABILITY OF TRANSPARENT AND OPAQUE RULE INTERACTIONS

Yuxuan (Melody) Wang

Harvard University & University College London | yuxuan_wang@fas.harvard.edu

Background

Question: transparent vs. opaque rule interactions, which is easier?

Past Findings

Project	Results	Limitations
Ettlinger (2008)	surface opacity is learnable	no comparison with a transparent interaction
Kim (2012)	opacity preferred	small sample size (*N*=12); no inferential stats
Brooks et al. (2013)	faithful relation preferred	faithful rule relation had no interacting potential
Prickett (2019)	transparency preferred	participants were directly told how rules interact; not a natural simulation

This experiment …

- Method: artificial language learning
- Paradigm: 'poverty of stimulus'
  - participants were introduced two rules separately
  - the rules could either Feed (transparent) or Counterfeed (opaque)
  - no instructions about how to interact were given
  - participants chose how rules should interact themselves
- Hypothesis: Transparent rule interactions are easier than opaque ones, following Kiparsky (1973).
- Expectation: more participants choose Feeding than Counterfeeding.

Materials

Rules used were …

1) Vowel Harmony: (/e/→[i], /o/→[u] within a word)
2) Palatalisation: (/t, d/→[tʃ, dʒ] / _i)

How did participants learn them?

- Rules were introduced in two suffixation scenarios:
  - suffixes were /-i/ (test item) and /-a/ (control item)
  - they were plural and dimunitive markers
  - meanings of the suffixes were counterbalanced across participants
- Participants were presented a picture of an object and the corresponding word stem.
- Then, they saw another picture consisting of either two or a smaller version of that object.
- Two button appeared on the screen for participants to click on and listen to the suffixed form.
- They should choose the form they deemed correct.
- Feedback was provided immediately after each choice.
- So, participants could learn the rules using the feedback.

About the stimuli …

- All stems were $C_1VC_2VC_3$ in form.
- Recorded by a female native English speaker at UCL beforehand.

Procedures

The experiment had **3** phases …

	Training	Verification	Test
Block	4 in total: • 2 for Vowel Harmony • 2 for Palatalisation	2 in total: • 1 for Vowel Harmony • 1 for Palatalisation	4 in total: • Critical test items • Harmony fillers • PalC1C2 fillers • PalC3 fillers
Stimuli	20 stimuli / block: • 10 suffixed with /-i/ • 10 suffixed with /-a/	20 stimuli / block: • 10 suffixed with /-i/ • 10 suffixed with /-a/	8 stimuli / block: • all suffixed with /-i/

Notes:

- Only participants with a 75%+ accuracy in the Verification phase entered Test phase.
- PalC1C2: fillers for Palatalisation at C1 and C2 positions, to ensure participants do not randomly palatalise even when environments do not allow.
- PalC3: fillers for Palatalisation at C3 position, to ensure the participants know how to palatalise.
- The order in which the blocks appeared in each phase was counterbalanced between participants.

Feeding		Counterfeeding	
UR	/petek-i/	UR	/petek-i/
Harmony	pitiki	Palatalisation	------
Palatalisation	pitʃiki	Harmony	pitiki
SF	[pitʃiki]	SF	[pitiki]

Table 1. Expected surface forms assuming Feeding vs. Counterfeeding rule orderings

	Affixed form	Option1	Option2	'Correct' form
Critical	petek-i	pitʃiki (Feeding)	pitiki (Counterfeeding)	pitʃiki (Feeding)
Harmony	komop-i	kumupi	komopi	kumupi
PalC1C2	kutug-i	kutʃugi	kutugi	kutugi
PalC3	bimit-i	bimitʃi	bimiti	bimitʃi

Table 2. Examples of choices in the Test phase. The word in the bracket is the ordering that would create this option in Critical trials. The 'correct' forms for Critical trials were set to be those created by Feeding (i.e., what the transparency bias theory would predict).

Participants: 30 native American English speakers participated in this online study in 2020.

Results

Analysis: analysed with mixed-effects logistic regression models in *R* using the *lme4* package.

Factors: Stimulus Block vs. Accuracy in Test phase.

Findings: Hypothesis disproven → participants did NOT prefer Feeding, the transparent interaction!

- Only 28.0% ($z = -4.509$, $p < 0.001$) of participants chose the Feeding option for Critical trials
  → significantly lower than chance.
- The accuracy rates in PalC3 (53.6%, $z = 4.904$, $p < 0.001$) and Harmony Fillers (60.1%, $z = 6.037$, $p < 0.001$) were significantly different from that of Critical trials.
  → participants did significantly better for separate rules but did not choose to let them feed.

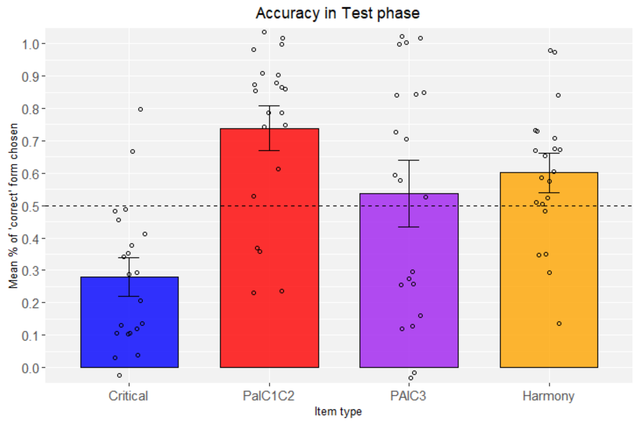

Figure 1. Mean % accuracy in Test phase by block (in Critical, 'accurate' = Feeding option chosen).

Conclusion: Feeding order is NOT necessarily preferred or the easier order to learn.

Discussion

Why did all this happen … ?

Guess 1: Participants just preferred 'no change'.

- **Evidence:** Higher accuracies when the correct option required no change from the UR in Training blocks Har2 and Pal2:

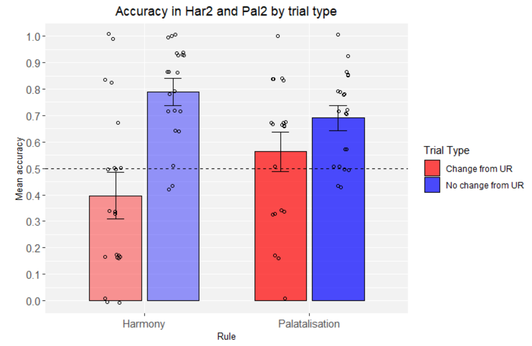

Figure 2. Mean % accuracy in Har2 and Pal2 blocks by trial type and change nature

- In other words, fewer changes (i.e. more faithful to UR) → higher accuracies.
- Following earlier researchers, I summarise this as a 'faithfulness bias':
  → Participants prefer the form that is more faithful to UR.
- Agrees with Kim (2012), Ettlinger (2008) and Brooks et al. (2013)'s findings.
- Possible explanation: structural complexity (Pater & Moreton, 2012).
  - 'The fewer things (e.g. restrictions, features) the grammar considers, the easier it is to learn.'
  - ∵ Feeding grammar = (1) restrictions on alveolar stops/affricates + (2) vowel co-occurrence
    Counterfeeding grammar = only vowel co-occurring restrictions
    ∴ Counterfeeding is easier / preferred.

Guess 2: Participants just resisted Palatalisation.

- The Palatalisation rule in this experiment required participants to generalise from C3 (the original position at which they learned the rule) to C1/C2 positions (which they did not see in training).
- But participants could have …
  - employed a more conservative learning strategy (e.g. Hayes, 2004); or
  - believed C1/C2 positions had intrinsic differences from C3 positions.
  → They could have thought that Palatalisation just should not happen in C1/C2 positions.
- **What made them think C3 would be different, though?**
  - Proposal: C3 was at the morpheme concatenation boundary, but C1 and C2 were not.
  - Similar example: Finnish Assibilation (Baković, 2011), where assibilation only happens when (1) the environment description is met after the application of another phonological rule, or (2) at morpheme concatenation boundaries:

		a. /tilat+i/	b. /äiti/	c. /vete/
Raising:	e → i / __ #			i
Assibilation:	t → s / __ i	t s	t	s
		[tilasi]	[äiti]	[vesi]

  - This could be a potential future direction of research!
- **Potential revisions:**
  - training stimuli: more evidence that C1/C2 can also undergo changes should be added; or
  - rule design: use rules with only local changes

Acknowledgements

I would like to thank Dr. Jamie White at UCL, who was the supervisor of this project, my three classmates who also participated in this project, and the lovely volunteer who recorded the stimuli. A massive thank you also goes to Prof. Katie Franich and my fellow lab members at Harvard University who reviewed my abstract.

Selected References: Baković, E. (2011). Opacity and Ordering. In *The Handbook of Phonological Theory*. · Brooks, K. M., Pajak, B., & Baković, E. (2013). Learning biases for phonological interactions. · Ettlinger, M. (2008). *Input-driven Opacity* [PhD dissertation, UCB]. · Hayes, B. (2004). Phonological acquisition in optimality theory: The early stages. In *Fixing Priorities: Constraints in Phonological Acquisition*. · Kim, Y. J. (2012). Do learners prefer transparent rule ordering? An artificial language learning study. *CLS*. · Kiparsky, P. (1973). Abstractness, opacity, and global rules. In *Three dimensions in linguistic theory*. · Pater, J., & Moreton, E. (2012). *Structurally biased phonology: Complexity in learning and typology*.