Experimentally comparing the learnability of rule interactions

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Abstract

This paper aims to test the claim that opaque interactions are harder to learn than transparent ones with artificial grammar learning (AGL) experiments and the 'poverty-of-stimulus' paradigm. The participants were first taught Vowel Harmony and Palatalisation separately and then tested on whether they preferred to let them feed or counterfeed in ambiguous environments. If transparent interactions are indeed preferred, significantly more subjects should choose the Feeding option. Result indicated that significantly more participants preferred the opaque interaction instead, contrary to predictions. Preference for opacity might be attributed to structural simplicity or a dispreference for the application of the Palatalisation rule.

Keywords: opacity, AGL, learnability, natural bias

Introduction

Opacity has attracted phonologists' attention since first defined by Kiparsky (1976). A central question concerns whether opacity is indeed less preferred or harder to learn than transparent rule interactions. The two main arguments for opacity's relative difficulty are: (1) It is harder to deduce the processes responsible for turning the underlying representation (UR) to the opaque surface form (SF); and (2) Historically opaque interactions tend to become transparent over time.

Many AGL experiments appeared to test this claim but none provided convincing evidence for the relative difficulty of opacity, and many had methodological or statistical deficiencies. This project directly compares Feeding with Counterfeeding and tests if opacity is less learnable, without teaching participants specific orderings but rather letting them choose the default order under a 'poverty-of-stimulus' paradigm. If transparency is preferred, significantly more participants should be disposed to learning SFs resulting from Feeding.

Method

The two interacting rules were Vowel Harmony (/e/→[i], /o/→[u] within a word) and Palatalisation (/t, d/→[tʃ, dʒ] / _ i). Participants learned them by observing how the plural and diminutive suffixes (*-i* and *-a*, counterbalanced) worked in an artificial language. Participants saw a picture of an object and the corresponding word stem, followed by another picture with either two or a smaller version of that object. Subjects then listened to two suffixed forms, and chose the one they deemed correct. Feedback was provided immediately. Participants were expected to learn the phonological rules using the feedback, especially how the stem changed when *-i* was attached. Table 1 shows what the participants saw for different trials in the Test phase.

Table 1. Examples of choices in the Test phase. The 'correct' forms for Critical trials were set to be those created by Feeding (i.e., what the transparency bias theory would predict).

	Affixed form	Option1	Option2	'Correct' form
Critical	petek-i	pitʃ iki (Feeding)	Pitiki (Counterfeeding)	pitʃ iki (Feeding)
Harmony	komop-i	kumupi	komopi	kumupi
PalC1C2	kutug-i	kutʃ ugi	kutugi	kutugi
PalC3	bimit-i	bimitʃ i	bimiti	bimitʃ i

The experiment had three phases: Training, Verification, and Test. Training had two blocks for learning Harmony and two for Palatalisation. Verification was a two-block version of Training to confirm participants grasped the rule. Only participants with an accuracy of 75%+ entered the Test phase. The Test phase included Critical trials and three kinds of fillers: Harmony, PalC1C2 and PalC3. Critical trials created environments where participants could apply either rule first. Filler blocks were designed to check the participants' understanding of each rule. All stimuli were in a $C_1VC_2VC_3$ format and recorded with a female native speaker of English at UCL. Thirty native American English speakers took part.

Results

Results were analysed with mixed-effects logistic regression models in *R* using *lme4*. There were two major findings. First, the percentage (28.0%, z=–4.509, p<0.001) of participants choosing the Feeding option for Critical trials was significantly lower than chance, and significantly different from the accuracy in PalC3 (53.6%, z=4.904, p<0.001) and Harmony Fillers (60.1%, z=6.037, p<0.001), as in Figure 1. That is, participants successfully learned these two rules separately but refused to let them feed. So, it can be concluded that Feeding is *not* necessarily preferred or easier to learn. Second, participants showed a faithfulness bias. They achieved higher accuracy when the correct option required no change from the UR in Training blocks Har2 and Pal2 (see Figure 2).

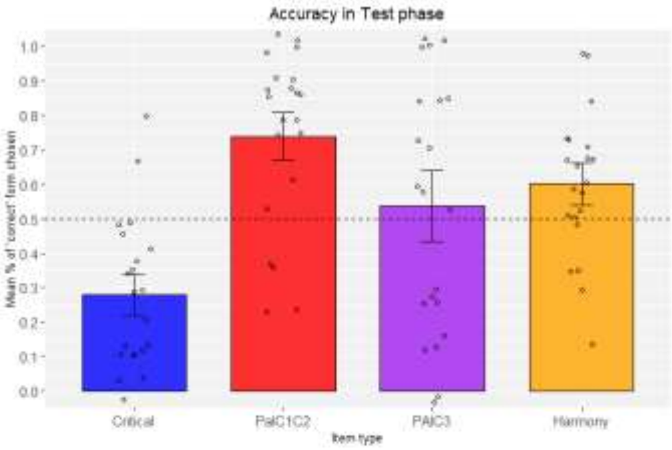

Figure 1. Mean % accuracy in the Test phase by block. For Critical trials, accuracy = the percentage of the Feeding option chosen.

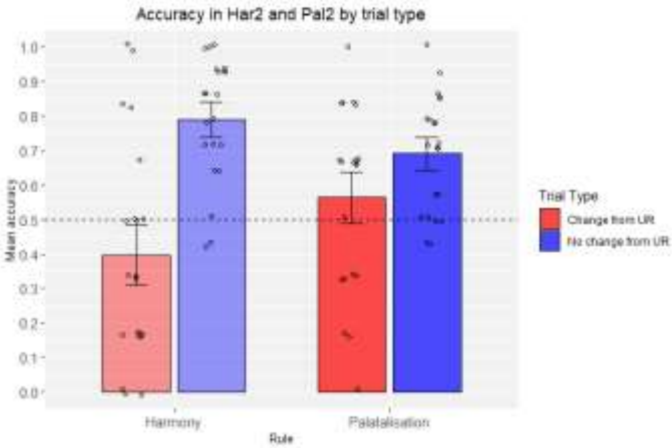

Figure 2. Mean % accuracy in Har2 and Pal2 blocks by trial type and nature.

Discussion and conclusion

Participants' preference for options requiring no changes from UR could be interpreted as a faithfulness bias, which coincided with Kim (2014), Ettlinger (2008) and Brooks et al.'s (2013) findings. A potential explanation concerns structural complexity: the more features are involved in a pattern, the harder it is to learn (Pater, Moreton 2012). In this project, the grammar deriving Counterfeeding requires the learning of only vowel height co-occurrence restrictions, but deriving Feeding requires knowing the constraints on alveolar stops/affricates (i.e., only affricates before [i]) besides vowel height agreement. However, earlier experiments on structural complexity only tested stable patterns but not dynamic derivations, which could be investigated by future research.

Participants' rejection to apply Palatalisation in Critical trials is also worth discussion. Since Palatalisation here required participants to generalise the rule from C_3 to C_1/C_2 positions, which they did not see in Training, they could either have employed a more conservative learning strategy (e.g., Hayes 2004), or believed C_1/C_2 positions are intrinsically different from C_3. One piece of evidence for the latter comes from Finnish (see Baković 2011) where Assibilation happens only when the environment description is met by the application of another phonological rule, or at morpheme concatenation boundaries. Here, since C_3 was at a morpheme boundary, it is natural for participants to think that only C_3 could undergo Palatalisation. This not only suggests a future research direction i.e., the effects of morpheme boundaries on opacity learning, but also potential revisions of the current Palatalisation training stimuli or rule design.

To conclude, this project provides laboratory evidence that transparent rule order is *not* necessarily easier to learn or the order that people are naturally biased towards, and calls for more research in confirming the faithfulness bias.

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