Exploring the relationship between static and dynamic generalizations in learning

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Background: One strategy that has been suggested to aid in learning phonological alternations is the prior learning of static phonotactic generalizations. The hypothesis is not only that phonotactic learning facilitates the learning of phonological alternations, but that both sources of knowledge are derived by a shared mechanism (see Hayes 2004, Tesar & Prince 2007, Pater & Tessier 2005, Hayes & Wilson 2008). In this study, we investigate these claims using an artificial language experiment where learners are taught a language in which a static phonotactic pattern and the dynamic generalization are either matched or mismatched when a morphological decomposition is available. If learners are biased to encode these generalizations with the same mechanism, we expect to see impeded performance in alternation learning when these generalizations do not match.

Methods: American English listeners were trained on one of two artificial languages: derived-environment (DEE) and across-the-board (ATB) modeled on /t/-palatalization in Korean (e.g., Kiparsky 1993). Both artificial languages contained singular and plural words where plurality was indicated by suffixing /-i/. In both languages, stem-final [t] and [d] became [ʧ] and [ʤ] respectively before [i] at the morpheme boundary. While [ti]/[di] sequences were unattested within the singulars in the ATB language, they were attested in the DEE language. That is, in the ATB language, the dynamic generalization (ti/di→ʧi/ʤi) matches the static generalization (*ti/di), but in the DEE language, there is a mismatch (ti/di→ʧi/ʤi, but ti/di is legal).

The artificial languages were constructed using consonants [p, t, ʧ, b, d, ʤ] and vowels [a, i, u]. In the DEE language, 36 non-words, either of the form CVC (e.g., [bap]) or CVCVC (e.g., [batup]), were created as singulars. Two thirds of the items ended in the filler sounds {p, b, ʧ, ʤ} with 10 each of {p, b} and 2 each of {ʧ, ʤ}. The remaining 1/3 of the items ended in the target sounds {t, d}. Each possible CV combination, including [ti] and [di], appeared equally across all singulars. For each singular, a plural was also created. For non-words ending in {p, b, ʧ, ʤ}, plurals were created by simply suffixing the vowel [i] to the singular stem (e.g., singular [batup], plural [batupi]). For non-words ending in {t, d}, plurals were created in the same way, except that the final consonant of the stem changed to the corresponding palatoalveolar affricate [ʧ] or [ʤ] (e.g., singular [baput], plural [bapuʧi]). Non-words were randomly paired with one of 36 digital images showing singular objects and another 36 showing plural objects. The ATB language consisted of the same stimuli except that the four stems with [ti] or [di] sequences were excluded from training, resulting in a total of 32 non-words instead. All other properties of the language were kept as similar as possible to the DEE language.

Participants (currently - ATB: n=14; DEE: n=17) were recruited via the UCLA Psychology Subject Pool and tested online using Experigen (Becker & Levine, 2014). The training phase consisted of two self-paced blocks. In each block, participants heard singular and plural pairs with their respective images. Trials were randomized within each block. In the verification phase, participants performed a well-formedness judgment on both familiar and novel singulars to probe what static generalizations about stems they learned. Novel singulars were created in a similar manner as the training items. Participants were presented a singular non-word and had to decide whether what they were hearing was a possible word from the language they had just learned (two-alternative forced choice). Non-words were not paired with images in this phase. Finally, in the generalization phase, participants first saw a singular image paired with a singular non-word. When the plural image appeared on the screen, participants heard two plural options:

one changing and one non-changing plural option, the order of which was counterbalanced such that each option appeared first equally often. Participants were asked to choose the correct plural form for the image for both familiar and novel singulars.

Results: In the verification phase, participants' rate of endorsement of singulars differed by trained language (Fig.1L). In the DEE language, participants endorsed words with both [ti] and [ʧi] equally, regardless of whether the item was familiar or novel, consistent with the stem-internal static generalization in training (62% vs. 67%: β=-.42, z=-1.42, p=0.33). In contrast, in the ATB language, participants endorsed items with [ti] significantly less frequently than those with [ʧi] (64% vs. 79%: β=-1.0, z=-4.46, p<0.001). Together, this indicates that participants successfully learned the static distribution of sound sequences within stems in each language. In the generalization phase, participants in both languages chose the changed plural significantly more often with {t, d}-final singulars than {p, b, ʧ, ʤ}-final singulars, indicating that they successfully learned the phonological alternation (DEE – 55%: $\chi^2(1)$=32.55, p<0.001; ATB – 60%: $\chi^2(1)$=11.55, p<0.001; Fig.1R). Interestingly, participants in the ATB language, incorrectly chose the changed plurals for {p, b, ʧ, ʤ}-final singulars more often than in the DEE language (24% vs. 12%). This suggests that participants in the ATB language were more likely to make a product-oriented generalization (e.g. Bybee, 2001) that plurals should end with [ʧi/ʤi], regardless of the source consonant.

Discussion: Our results show that learners are able to learn the alternation pattern in both languages equally well, despite learning different static phonotactic generalizations. In fact, learners in the DEE language successfully learned both the static and dynamic generalizations despite the mismatch, keeping the domains of static and dynamic generalizations separate. This suggests that a learner need not use the same mechanism to encode both static and dynamic generalizations once they have a morphological parse of the artificial language. We are currently investigating whether learners are biased to use the same mechanism to encode both static and dynamic generalizations when morphological information is not available and phonotactic learning has to occur over unparsed forms. Together, the results from these two experiments will tell us whether learners are initially biased to maintain symmetry between static and dynamic generalizations.

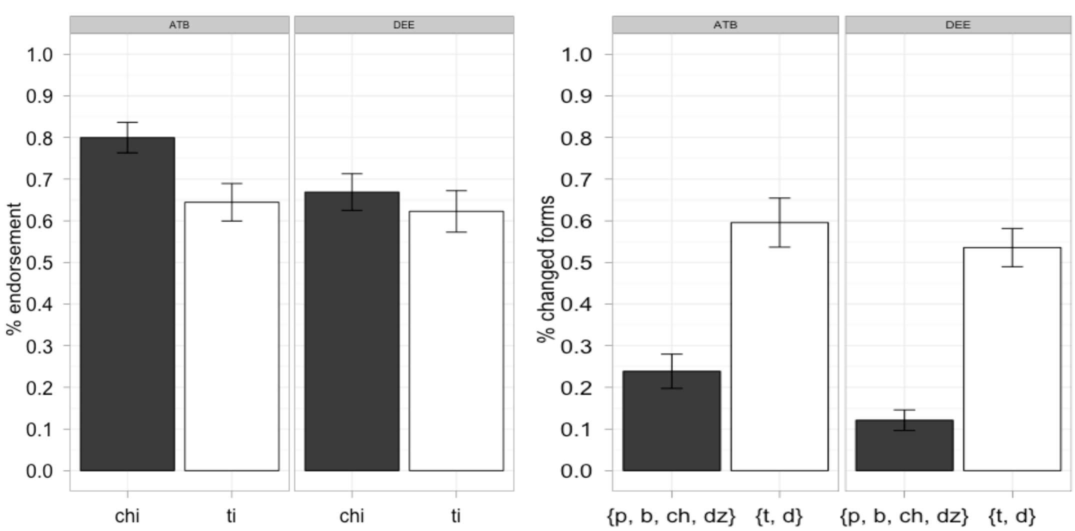

Figure 1 (L): Endorsement rate by word-type by language (Verif. phase)
(R): Proportion of changed forms selected by final consonant by language (Gen. phase).
'ch' = [ʧ] ; 'dz' = [ʤ]