Paradigm uniformity inhibits regularization during phonological learning

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Previous research suggests that learning biases can play a role in constraining language change and explaining typological patterns (e.g. Moreton 2008, White 2013). In the current study, we focus on the question of whether learners are biased to avoid alternations, which can be considered a type of paradigm uniformity bias. Previous work on children's acquisition of Korean inflection indicates that they prefer unified paradigms and that they disfavor alternations in the early stages of learning (Do 2013). Likewise, artificial language experiments with adults and children have suggested that learners have a baseline preference to avoid alternations (Tessier 2012, White 2013).

We take a novel approach to looking at paradigm uniformity by examining how it interacts with another bias that has been demonstrated during learning: the learner's tendency to regularize when faced with variable input (Hudson Kam & Newport 2005, Culbertson et al. 2012). In the general case, learners faced with unpredictable variability in their input tend to regularize the system in favor of the more frequent variant, but this tendency can be inhibited if the more frequent variant is otherwise disfavored (Culbertson et al. 2012). In the current experiment, we exposed learners to an artificial language in which the plural was variably marked by one of two prefix forms (*ba-* or *ni-*), one of which was frequent and one of which was infrequent; we manipulated which form was frequent. Crucially, the *ni-* form also triggered palatalization of stem-initial velar stops whereas the *ba-* form triggered no alternations. If learners are biased to avoid alternations, then we expected regularization to be greater when *ba-* was the frequent form than when *ni-* was the frequent form.

Method: Seventy-five native English speakers completed the study. The experiment consisted of four phases: stem exposure, stem test, affixed exposure, and affixed test. Participants were told that an alien instructor (who appeared on the screen) would be teaching them an alien language. In the stem exposure phase, participants heard 10 nonce CVCV noun stems (e.g. *gapi*) paired with images of objects. Each stem was repeated 10 times (100 total trials). The stem test phase was a production task; participants were asked to produce the correct word after seeing the image. The alien instructor provided feedback by producing the correct word after each response. Each stem was presented 5 times in the test (50 total trials). Participants were given two chances to pass the test; those who failed to reach 70% accuracy on the second test were excluded.

In the affixed exposure phase, participants heard the CV-CVCV plural forms for the stems they had learned (paired with plural pictures). Each stem was presented 6 times (60 total trials). Participants were randomly assigned into one of three conditions (25 participants each). In the *Ba*-Frequent condition, the prefix form *ba-* occurred in two-thirds of trials (4/6 times for each stem) while *ni-* occurred in one-third of trials. The *Ni*-Frequent condition had the opposite distribution. In the 50-50 condition, the two prefixes occurred with equal frequency. The prefix *ni-* triggered palatalization in velar-initial stems, changing [k, g] to [tʃ, dʒ]. Four of ten stems were affected by the palatalization, two [k]-initial and two [g]-initial.

In the affixed test phase, participants were asked to produce the correct word after seeing the plural picture. After participants responded, the alien instructor produced the correct stem with either a *ba-* or *ni-* prefix, where the prefix selection followed the same proportion as in the exposure phase. Participants were instructed that there was more than one correct way to say words in the language. Following Culbertson et al. 2012, we took two steps to encourage participants to respond probabilistically. First, we told participants that the goal was to try to fit in with the alien community. Second, we tracked a score on the screen and encouraged them to get as high a score as possible; they received 10 points if a response matched what the alien

said exactly, and 5 points if the response was correct but did not match the alien.

Results: Figure 1 shows how often participants chose the frequent prefix according to input condition. The results were analyzed using mixed logit models. Participants in the 50-50 group chose the two prefixes equally at test; participants in the *Ba*-Frequent group (β=1.22, z=6.82, p<.001) and the *Ni*-Frequent group (β=.71, z=3.99, p<.001) were significantly more likely to choose the frequent prefix compared to the 50-50 group, indicating that both groups learned the frequency asymmetry. Recoding the model to compare the *Ba*-Frequent group to the *Ni*-Frequent group, we found that the *Ba*-Frequent group was significantly more likely than the *Ni*-Frequent group to choose the frequent prefix (β=.52, z=2.84, p<.01).
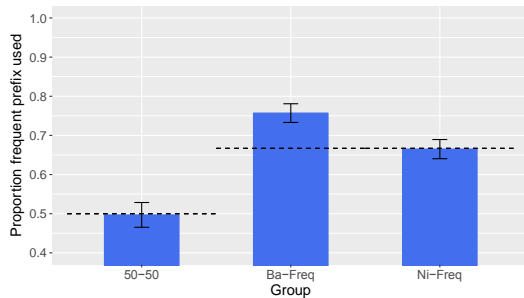

Figure 1. Proportion frequent prefix chosen at test according to Group (*ba*- was arbitrarily chosen as the 'frequent' form for the 50-50 group). Dashed lines show the input frequency of the frequent prefix.

Numerically, it appears (Fig. 1) that participants regularized the frequent prefix in the *Ba*-Frequent group (76% *ba*- vs. 67% in the input) but not in the *Ni*-Frequent group (67% *ni*- vs. 67% in the input). Following Culbertson et al. (2012), we used one-sample sign tests to further investigate whether participants tended to regularize the frequent form. In the *Ba*-Frequent group, 21/25 participants used the frequent prefix (*ba*-) more often than 66.7%, which is significant according to the sign test (p<.001). In the *Ni*-Frequent group, only 12/25 participants used the frequent prefix more than 66.7%, which was non-significant (p=1). These results further suggest that participants regularized in the *Ba*-Frequent group, but not in the *Ni*-Frequent group. Finally, there was no significant difference in how often participants applied the palatalization rule when using *ni*- across the three conditions (*Ba*-Frequent: 74%; *Ni*-Frequent: 72%; *50-50*: 71%), suggesting that they learned the palatalization rule equally well in all conditions.

Discussion: Participants were sensitive to the frequency of the variants that they encountered in their input, largely replicating the input frequencies in their productions at test. The crucial finding, however, was that learners regularized the frequent prefix form only when it did not trigger alternations. The results are consistent with the view that learners have a bias in favor of paradigm uniformity (particularly alternation avoidance), which interacts with the tendency to regularize variable patterns in the input. The findings raise a potential mechanism by which paradigm uniformity could influence language change, namely by reducing the likelihood that variable alternations become regularized over time.

References:
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