The Role of Anti-Harmony in Learning Neutral Vowels
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Introduction: Vowel harmony is one of the most widely studied phonological processes. Productive across a wide variety of language families, it has the potential to expand our understanding of speakers' representations of vowels, and how these representations interact at a distance (Walker 2012; Nevins 2010). Any account of vowel harmony must explain the representation of neutral vowels, which are generally classified as either opaque (creating a new harmonic domain), or transparent (invisible to the harmony process). One insight that may help explain why some vowel harmony languages have opaque neutral vowels and other languages have transparent neutral vowels is the typology of anti-harmony. In Hungarian, a language with transparent vowels, anti-harmony occurs when a stem containing only front neutral vowels triggers a back vowel suffix (Krämer 2003; Rebrus and Törkenczy 2015). Rebrus and Törkenczy (2015) argue that anti-harmony is unattested in languages with opaque vowels. This result is predicted under a theory of monotonicity, where front-back vowel features fall on a single continuum. In this theory, the featural representation of transparent vowels is intermediate between front and back (in a back vowel harmony language), while opaque vowels are represented as clearly front (or back). The intermediate representation for transparent vowels allows the potential for neutral vowels to trigger disharmonic suffixes, creating anti-harmony.

If anti-harmony is unlikely to occur in a language with opaque vowels, exposure to anti-harmony could provide the learner with clues about the status of the neutral vowel. This could help reduce the difficulty of learning transparent vowels that has been shown in previous studies (Finley 2015). The present experiment tests the hypothesis that exposure to anti-harmony may reduce biases against transparent vowels. Using an artificial language learning experiment, participants were exposed to neutral vowels with either anti-harmony or no anti-harmony. Participants were then tested on their generalization to neutral vowels in front or back vowel contexts. Exposure to anti-harmony had a significant effect on generalization to novel items containing neutral vowels, supporting the role of anti-harmony in the learnability of neutral vowels in vowel harmony.

Method: Forty-five adult, English speaking participants were presented with a front/back vowel harmony system based on 18 stem-suffix pairs (e.g., /notup/-/notupo/). Crucially, the stems did not provide evidence that the neutral vowel was transparent or opaque. This allowed the experimenters to isolate learners' inferences about the representation of the neutral vowel following exposure to anti-harmony. Participants heard six of three types of stems, repeated 10 times in a random order (see Table 1 for examples). Front vowel stems containing /i/ and /e/ triggered /-e/; back/round stems containing /o/ and /u/ triggered /-o/; neutral vowel stems contained only /a/. In the Anti-Harmony Condition, three neutral vowel stems triggered /-o/, and three neutral vowel stems triggered /-e/. In the Non-Anti-Harmony Condition, all six neutral vowel stems triggered /-o/. While /a/ is not typically a neutral vowel in front/back harmony, /a/ was chosen in this study because previous vowel harmony learning experiments showed that English speakers treat /a/ as a neutral or non-participating vowel (Finley and Badecker 2009), and /a/ is a regular non-participating vowel in round harmony.

	Stem	**Stem+Affix Anti-Harmony**	**Stem+Affix Non-Anti-Harmony**
Front Vowel	pideg mebit	pidege mebite	pidege mebite
Back Vowel	buton gopub	butono gopubo	butono gopubo
Neutral Vowel	banam dakag	bana**me** dakag**o**	banam**o** dakag**o**

Table 1. Examples of Training Items

Following training, participants were given four sets of ten two-alternative forced choice items presented in a random order (see Table 2 for examples). Old items were taken from the training set; New Harmonic items were novel items, with stems that did not contain the neutral vowel (e.g., /ei/ and /ou/). Front Neutral items contained a front vowel /i, e/ followed by the vowel /a/, while Back Neutral items contained a back vowel followed by the vowel /a/. Participants were always asked to select between two forms that were identical except the final vowel, which was either /e/ or /o/. Presentation of choices was counter-balanced.

Test Condition	Front Vowel Affix	Back Vowel Affix
Old	baname mebite	banamo mebito
New Harmonic	bipene kupuge	bipeno kupugo
Front Neutral	bitame mepane	bitamo mepano
Back Neutral	bopane nubade	bopano nubado

Table 2. Examples of Test Items.

Results: Means and standard errors can be found in Figure 1. A linear mixed effects logistic regression (lme4 package in R (R Development Core Team 2018)) was used to compare responses between the Anti-Harmony and Non-Anti-Harmony conditions for each type of test item. The model included random intercepts for subjects and items, the maximal model for this experimental design (Barr et al. 2013). While there were no significant differences between Old (β = 0.031, SE = 0.023, z = 1.34, p = 0.18) and New Harmonic (β = 0.15, SE = 0.23, z = 0.66, p = 0.51) items, there were statistically significant differences between Front Neutral (β = 0.48, SE = 0.23, z = 2.09, p = 0.037) and Back Neutral items (β = 0.66, SE = 0.24, z = 2.78, p = 0.0054), supporting the role of anti-harmonic neutral vowels in learning the role of the neutral vowel.

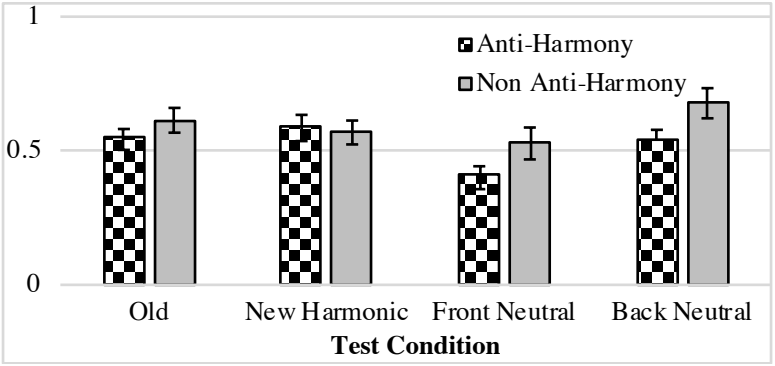

Figure 1. Means and standard errors for all participants. Values for Old/New Harmonic items represent proportion of harmonic response; values for Front and Back Neutral items represent proportion of /o/ responses

Discussion: Exposure to anti-harmony lead to learners to be more likely to accept transparent Front-Back-Front vowel sequences, suggesting that anti-harmony may help learners to form representations of transparent vowels. These results support the theory of a monotonic function between front and back vowel features, where transparent vowels are 'in between' front and back, and can thus trigger either front or back vowel suffixes when isolated in stems. The present research helps to bridge connections between linguistic theories and the cognitive processes that underlie linguistic representations, providing an example of how learning experiments can be used to complement theoretical findings.