The role of phonetic detail in associating phonological units

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A large part of phonological competence is usually assumed to consist of the knowledge of co-occurrence relations between phonological units. Native speakers know which phoneme combinations and phoneme-morpheme sequences are legal in their language, and which are not, as well as the frequencies with which particular sequences occur (e.g., Pierrehumbert 1994). A speaker can be said to possess knowledge of the co-occurrence relation that holds between two phonological units if s/he can generalize to instances of the relevant phonological units in unfamiliar contexts. For instance, if an English speaker possesses a rule that prohibits labial codas following /au/ (but not any other vowel), s/he should judge monosyllabic words with labial codas to be unacceptable iff they contain the phoneme /au/. Thus, to be said to know the rule, the subject must extract [au] from the novel acoustic signal and recognize it an instance of /au/.

In the present paper, we show that the likelihood with which a newly-learned rule involving a particular phoneme is extended to a novel instance of the phoneme depends on how easy it is to classify the novel instance as belonging to the phoneme in question, indicating that the process of even unconscious phonemic categorization is not completely automatic. Yet, the rule is applied to novel syllables as accurately as to syllables presented during training, indicating that subjects do form a generalization at the phonemic level as opposed to simply memorizing exemplars of whole stimuli presented during training. The results suggest that learners generalize to the phonemic level of abstraction but the process of phonemic categorization is not error-free, hence the likelihood that a phoneme’s associations will be accessed (and strengthened) depends in part on whether the phoneme’s identity will be detected in time.

In the first study, native English speakers were exposed to an artificial language in which CVC stems sharing a particular rime (VC) or body (CV) also shared an affix. One group of participants learned that /CQS/ stems take the affix /mI/ while /C√g/ stems take the affix /num/. Thus, participants assigned to this group were exposed to rime-affix co-occurrences. The other group was exposed to body-affix co-occurrences where /C√C/ stems took /min/ while /gAC/ stems took /num/. Knowledge of the co-occurrence relations was tested by presenting the participants with novel syllables containing familiar rimes or bodies and asking for the affix. Whether the affix came after or before the stem had no significant effect. However, as Figure 1 shows, rime-affix associations were much easier to form than body-affix associations (by subjects: t=5.401, df=66, p<.0001, by items: t=13.445, df=42, p<.0001). The subjects’ accuracy with novel syllables was as high as with familiar syllables (F(1,66)=.002, p=.98), indicating that the subjects did not simply memorize the tokens presented to them but rather formed rime-affix associations. However, there was significant within-category variability: rule application was more accurate with some novel stems containing a given familiar string than with other novel stems containing the same familiar string.

To explain this between-item variability, we presented a new group of native English speakers with the stem syllables used in the first study and asked them to decide whether the vowel they are hearing is /a/ or /æ/. Examples of minimal pairs containing /a/ and /æ/ were provided (e.g., /kæt/~/kɑt/). Like in the original study, syllables were presented over headphones in the absence of noise. While accuracy in the task was at ceiling, syllables differed in how fast the identity of the syllable’s vowel was detected. We then examined vowel categorization reaction times in response to syllables that served as generalization stimuli in the first study and correlated reaction time in vowel categorization with generalization accuracy. As Figure 1 shows, there was a strong linear correlation. Generalization accuracy is low when the generalization stimulus is difficult to categorize into the same phonemic category as the training stimuli.
Figure 1: Reaction time in vowel categorization correlates with accuracy in generalizing CV-affix or VC-affix associations to the syllable.

This finding provides a potential account for recent findings that associations between vowels are more difficult to learn than associations between consonants (Bonatti et al. 2005, Creel et al. 2006). Since instances of a vowel phoneme are both acoustically and perceptually more variable than instances of a consonant phoneme, generalization to a novel instance of a vowel phoneme is predicted to be more difficult than generalization to a novel instance of a consonant phoneme. The same explanation could also be offered for the difference in associability between bodies and rimes. If listeners do not categorize incoming speech into phonemic categories automatically, and variations in the coda have a greater impact on vowel quality than variations in the onset, the equivalence of different tokens of the same rime may be easier to detect than the equivalence of different tokens of the same body, making rime-affix associations easier to acquire and generalize than body-affix associations. However, Figure 1 shows that variation in phonemic categorization does not account for all the variation in associability that the rime/body distinction accounts for (R²=62% vs. 50+39=89%). We propose that a phoneme string A is easy to associate with something else when its instances are perceptually similar and when an instance of A present in the acoustic signal is likely to be extracted from the signal due to instantiating a constituent in the learner’s language. Together these two factors account for most of the between-item variability in the present study (89%).

References: