Learning generalisations in the face of ambiguous data

Karthik Durvasula Adam Liter
Department of Linguistics and Languages, Michigan State University, East Lansing, MI

Background There is little experimental work probing how learners extract phonological generalisations from input that is ambiguous between multiple generalisations. It is unclear if they learn: (i) the most specific generalisation that accounts for the data - *Subset Principle* (**SP**; Berwick 1985; Hale and Reiss 2003), (ii) the simplest (most general) generalisation that accounts for the data - *Simplest Generalisation* (**SG**; Chomsky and Halle 1968), (iii) multiple (simple) generalisations, all of which are consistent with the data - *Multiple Simple Generalisations* (**MSG**; Hayes and Wilson 2008). The little experimental work there is on the issue suggests that learners use SP (Gerken 2006). We provide evidence that learners use SP when there is a smaller set of environments, and MSG with more variegated environments.

Experiment 1 The experiment had two phases: *training* and *test*. In the training phase, participants listened to and silently mouthed 100 CVCV nonce words [C=/p,b,t,d,f,v,s,z/, V=/a,i,u/], where the consonants obeyed both voicing and stop harmony simultaneously (e.g., ✓[tipa, bida, fisa], *[tisa,bipa,fida]). In the test phase, participants heard CVCV nonce words of the following types: (a) 12 words they heard during training (OldStims), (b) 12 words they did not hear during training but that obeyed exactly the same pattern (NewStims), (c) 12 words that had only a voicing harmony pattern (OnlyVoicing), (d) 12 words that had only a stop harmony pattern (OnlyStop), and (e) 12 words that did not have either a stop or voicing harmony pattern (NoPattern). The participants were asked if the the word they heard was possible in the "language" they had learned during training. 14 English-speaking undergraduates participated in the experiment for extra-credit.

Hypotheses SP predicts that learners will prefer NewStims and OldStims over the other three, which should be undifferentiated. This is because NewStims have exactly the same pattern as OldStims (stop and voicing harmony). SG predicts that some learners will prefer OnlyVoicing stimuli, while others will prefer the OnlyStop stimuli, and that they will find NewStims as acceptable as either. Thus, they might be equally good with all three. Finally, MSG predicts that learners will prefer both OnlyVoicing and OnlyStop equally, and this would potentially have an additive effect on the NewStims, which would be accepted at a higher rate since they are consistent with both generalisations.

Results A logistic mixed-effects model was fitted to the Yes-No responses with random intercepts for participants and stimuli. The independent variable was the generalisation type of each stimulus (Type). The NoPattern stimuli were the baseline. Results indicate that all of the test types were recognised as possible more so than the NoPattern stimuli; however, the Yes-responses for the NewStims were as high as for OldStims (Table 1 left, Fig. 1 left). The results are most consistent with MSG.

Experiment 2 There was a potential confound in Exp. 1: the NewStims had consonantal sequences that learners heard during training. Therefore, learners might have performed so well on them simply because they kept track of the consonantal sequences. So, in Exp. 2, during training, participants heard a list of nonce words similar to Exp. 1, except that a particular combination of consonants (in both orders) was withheld for testing (e.g., no words with the patterns dVbV or bVdV were presented to the participant). The excluded consonant pair was randomised for each subject. The combinations that were withheld

were used exclusively for the NewStims in the test phase of Exp. 2. 20 English-speaking undergraduates participated in the experiment for extra-credit.

Hypotheses Same as in Exp. 1.

Results A logistic mixed-effects model (similar to Exp. 1) indicated that *only* the NewStims and the OldStims were significantly different from the NoPattern responses (Table 1 right, Fig. 1 right). The results suggest that only the NewStims were acceptable beyond the NoPattern levels, thereby supporting SP.

Overall Discussion The only difference between Exp. 1 and Exp. 2 was that the test set for NewStims of the latter contained new consonantal sequences not observed during training. As a consequence, there were fewer different consonantal combinations (environments) in Exp. 2 during training, than in Exp. 1. Overall, the results suggest that, initially, learners learn generalisations according to the SP, and as more evidence from different environments gathers, listeners attempt to move towards accounting for the patterns using simpler generalisations (MSG).

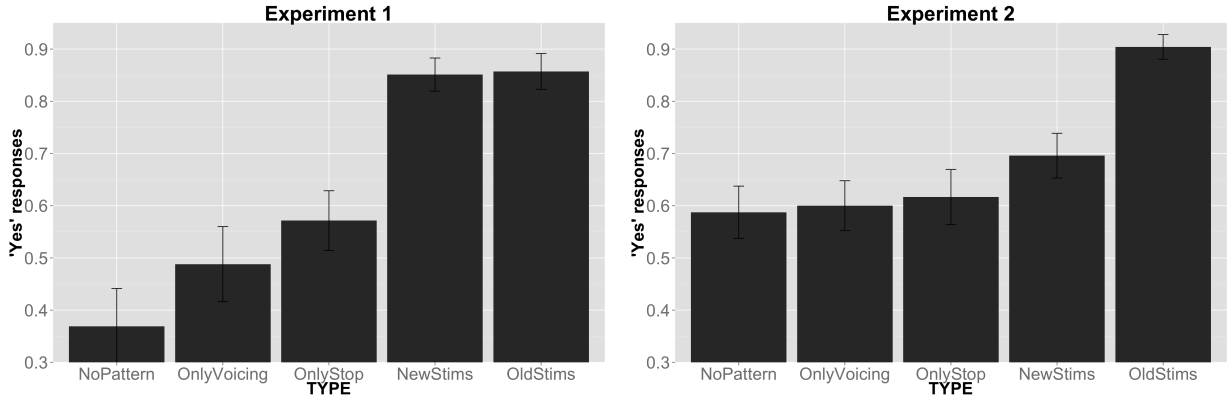

Figure 1: 'Yes' responses for Experiment 1 (left) & Experiment 2 (right).

	Experiment 1			Experiment 2		
Fixed Effect	Estimate	z value	Pr(>|z|)	Estimate	z value	Pr(>|z|)
(Intercept)	-0.60	-1.76	0.078	0.43	1.87	0.06
Type: OldStims	2.77	8.09	**<0.001**	2.06	7.63	**<0.001**
Type: OnlyVoicing	0.62	2.33	**0.02**	0.06	0.28	0.78
Type: OnlyStop	1.04	3.81	**<0.001**	0.14	0.67	0.5
Type: NewStims	2.73	7.95	**<0.001**	0.53	2.55	**0.01**

Table 1: Logistic mixed-effects models for Experiment 1 (left) & Experiment 2 (right).

References

Berwick, R. C. (1985). *The Acquisition of Syntactic Knowledge*. MIT Press. **Chomsky, N. and M. Halle (1968)**. *The Sound Pattern of English*. Harper and Row. **Gerken, L. (2006)**. "Decisions, decisions: infant language learning when multiple generalizations are possible." *Cognition* 98, B67–B74. **Hale, M. and C. Reiss (2003)**. "The Subset Principle in phonology: why the tabula can't be rasa." *Journal of Linguistics* 39.02, pp. 219–244. **Hayes, B. and C. Wilson (2008)**. "A maximum entropy model of phonotactics and phonotactic learning." *Linguistic Inquiry* 39, pp. 379–440.