

Table 13: Linear mixed-effects model for response variable RELPITCHDIFF (WOMEN) by CONDITION

Analysis of Deviance Table (Type II Wald chisquare tests)			
Response: RELPITCHDIFF (WOMEN) ~ CONDITION*PREDICTABILITY * GROUP * ORDER + (1 SUBJECT) + (1 WORD)			
	Chisq	Df	Pr(> Chisq)
condition	0.0938	1	0.75943
condition:predictability	4.5828	1	0.03229 *
condition:order	0.5148	1	0.47306
condition:order:predictability	0.0049	1	0.94417
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1			

The results of the mixed-effects models confirm that subjects are influenced by PREDICTABILITY, ORDER, and to some degree, the PREDICTABILITY by ORDER interaction in different ways in the two instructional conditions. PREDICTABILITY has a significantly stronger effect on the degree of imitation when given no instruction to imitate, while ORDER is more influential when told to imitate. The PREDICTABILITY by ORDER interaction only emerges when told to imitate, although is only marginally significantly different in the two conditions for the VOTDIFF response variable.

4. Discussion

Experiment #1 considered whether stronger imitation would occur when listening to isolated speech as opposed to sentences. The results were marginally significant in suggesting this was the case, however there were several confounding variables (syntax, semantics, total length of sentences vs. isolated phrases) making it unclear what was causing the difference in the two groups. The second experiment considered only the effect of the contextual predictability of words within sentences. The results of the two conditions (no instruction to imitate, vs. told to imitate), found the predictability of the target word to be a significant factor in the degree of imitation, where unpredictable words were more closely imitated than their predictable counterparts, particularly when given no instruction to imitate. Predictability

was still significant when told to imitate, however this effect was realized as a predictability by order interaction.

These findings suggest a speaker's listening mode may be modulated by semantic and syntactic factors such as contextual predictability. However, considering the results of the two conditions in experiment #2, it seems the situation may be more complicated than simply having two categorical modes--- the 'what' and 'how' mode (as proposed by Lindblom). Listening in the "how" mode--- perhaps activated in single word imitation studies, devoid of sentential context, as well as when particular words are unpredictable within sentences--- may cause listeners to be more likely to process the actual exemplars being perceived, such that these will more greatly affect future productions of those particular words. This mode of listening fits nicely with the exemplar-based theories of Johnson (1997) and Pierrehumbert (2002). On the other hand, listening in the 'what' mode may result in the activation of abstracted, phonological forms of words, where phonetic details of the particular exemplars are largely ignored and discarded. In any case, 'what' and 'how' may represent two extreme ends of the listening spectrum, such that both particular exemplars and abstracted forms may be activated under most conditions, but with different relative weightings for their influence on perception and production.

In the second study of the current paper, subjects were either given no instructions to imitate or were told explicitly to imitate. The results showed a stronger effect of predictability when no instruction to imitate was given, while the difference in predictability was less profound and non-significant, when told to imitate. These findings suggest that when given no instruction to imitate, this likely induced a more natural style of listening to sentences, and given the abundance of syntactic and semantic context, this would suggest speakers could recognize and process the sentences using the 'what' mode. However, when the context fails to give clues that might help identify a subsequent word, listeners process the phonetic details of these unpredictable words. As a result, a larger perceptual weight is given to exemplars of unpredictable words, which is reflected in the speech of these listeners turned speakers.

When told to imitate, subjects were closer to the model in VOT and pitch as opposed to when given no instruction to imitate (whether for target predictable or unpredictable words). Additionally, there was a smaller effect of predictability. This suggests that speakers were consciously tuning in to the phonetic details more than they normally would for merely being able to identify and repeat the words in a sentence. Thus, this suggests something closer to the

'how' mode was induced when told to imitate. Subjects were largely able to override the more typical 'what' mode in this task, and listened for phonetic details whether or not the speech they heard was predictable or not. The stronger order effects seen in purposeful imitation suggest that speakers were in fact trying to sound like the model and became better at doing so after hearing and producing more speech. The predictability by order interaction--- the main effect of predictability observed in the told-to-imitate condition--- is a more surprising result. While being told to imitate seems to induce listening more in the 'how' mode, it is possible that over time in this particular experiment that subjects became accustomed to hearing words with initial stress. For predictable words, not only was the word was predictable, but the stress pattern may have become predictable as well. In imitating the predictable words, subjects merely had to make sure the word was in fact the word they anticipated, and that the initial syllable was stressed, and then in their own production applied their own abstracted notion of stress rather than imitating the phonetic details of the particular exemplar. On the other hand, when hearing unpredictable words, the word itself could not be anticipated (even if the stress pattern was predictable). Thus, more thorough phonetic processing would occur in order to identify the word, resulting in more precise imitation of the actual perceived exemplar. Subjects would become no better at anticipating unpredictable words throughout the course of the experiment, unlike with the learnable predictability of the stress pattern, yielding the difference in behavior observed for predictable and unpredictable words over time. Figure 7 shows a more detailed account of how abstracted forms or exemplars may be activated depending on the instructional conditions and predictability of the words.

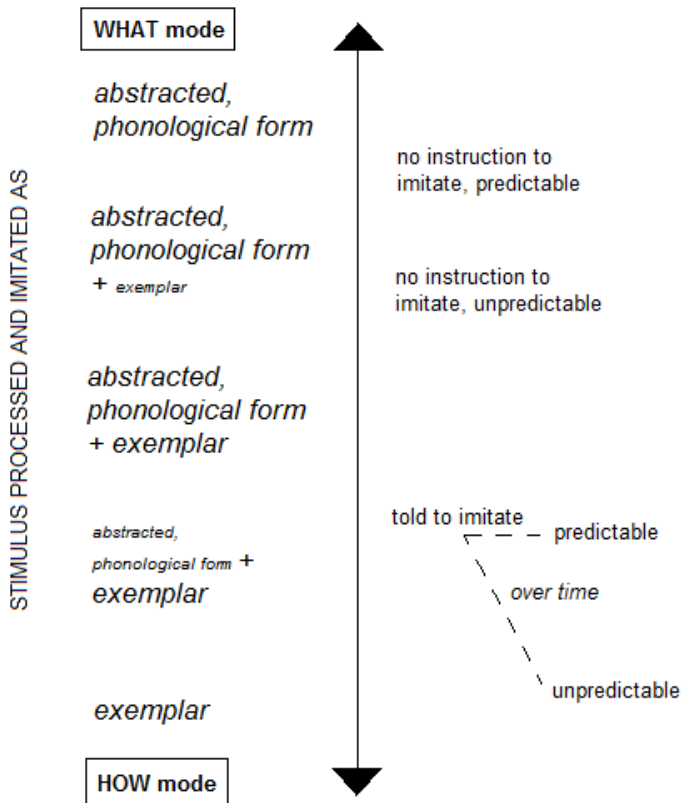


Figure 7: Proposed relative weight of exemplar vs. phonological form by condition and predictability

Lastly, the results of both experiments add new insight to the phenomenon of phonetic accommodation. As with the findings of Pardo (2006) and Babel (2010, 2012), who found social conditions modulating accommodation, as well as Nye & Fowler (2003) and Nielsen (2011) who found elements of linguistic structure also facilitating or impeding accommodation, the present study finds an interaction between higher level linguistic information and accommodation, in particular contextual predictability. While our findings show that accommodation does in fact occur in words placed in a sentence context, it is not yet clear whether accommodation fails to occur at all in certain conditions, such as when shadowing predictable words. In any case, accommodation does not seem to be a purely automatic process, but interacts in complex ways with social factors and linguistic information at many structural levels.

5. Conclusion

The results from these experiments demonstrate that higher level linguistic information such as contextual predictability modulate the listener's attention of phonetic details. Even within fluid speech, listeners adjust the degree of phonetic processing needed for word recognition depending on the predictability of anticipated words. Other studies (Lindblom et al. 1995, Garrett & Johnson 2012) have considered how processing speech in different listen modes (such as the 'what' or 'how' mode) may be relevant in sound change. The findings of this paper suggest that details of more predictable words may go unnoticed, while these phonetic details are more likely noticed when hearing contextually unpredictable words. Ultimately, this may begin to shape the pool of exemplars differently for words that more commonly occur in predictable or unpredictable contexts, leading to a bias for certain sound changes to affect only one group of words or another. While contextual predictability may merely be an additional factor to consider alongside frequency within the theory of lexical diffusion (Bybee 2001, Phillips 2006), it may also be relevant when considering the differences between broad classes of words, such as function versus content words. Function words (and morphemes), in being both fewer in number and often being grammatically required in certain contexts, should be more contextually predictable than content words, which are far more numerous. Given the dichotomy in sound changes affecting content and function words (such as the widespread reduction and lenition favored in function words), this distinction may arise from differences in attention and listening modes when hearing function and content words. Thus, it remains an open question as to how phonetic attention affects sound change, particularly in word classes differing in contextual predictability.

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Notes

¹ Phrases were used instead of isolated words because the experiment was originally designed for investigating whether part of speech is a variable in impeding the carry-over imitation effect (from target to novel words). Thus, the stimuli needed a preceding word to

unambiguously mark the part of speech--- such as the verb ‘to pin’ as opposed to the potential noun ‘the pin’.

² RelVOTDiff in the second experiment normalized VOT to vowel length, rather than word length as in the first experiment, due to technical reasons involving the scripts that extracted this information from the textgrids.

³ Table is not included for the response variable VotDiff, which had the same pattern of significance as RelVotDiff.

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Appendix A – Experiment #1 stimulus sentences (target words underlined)

20 target NP sentences:

- 1) The pail is full.
- 2) The old man smokes a pipe.
- 3) The dogs licked their paws.
- 4) The porch is white.
- 5) The nations made a pact.
- 6) The fisherman sees the pond.
- 7) The boy watched the pandas.
- 8) The pelican flew over the beach.
- 9) The pope led the service.

- 10) A pentagon has five sides.
- 11) The man found the portal.
- 12) Eric bought a pillow.
- 13) The pagans worshipped many gods.
- 14) John is a patron of the arts.
- 15) The chef chopped the parsley.
- 16) The palace is magnificent.
- 17) Your brother is a pest.
- 18) Tom saw a panther in the mountains.
- 19) Susan is a poet.
- 20) The pantry is empty.

20 novel NP sentences:

- 1) The pulp is thick.
- 2) The girl broke the pane.
- 3) The pears are delicious.
- 4) The peas are green.
- 5) The farmer harvests the peaches.
- 6) They climbed the peak.
- 7) William is a peasant.
- 8) Singing is her passion.
- 9) Emily is wearing a parka.
- 10) The pasture is very large.

- 11) The woman sees the path.
- 12) The pauper stole bread to eat.
- 13) Mary wants to see the pageant this year.
- 14) The soldier needs the powder for his gun.
- 15) The policy is strict.
- 16) The porcupine is eating twigs.
- 17) The pigeon is walking through the city.
- 18) Each student has a partner for the game.
- 19) The children used the paste.
- 20) Anna moved the pawn.

20 novel VP sentences:

- 1) Bill published three articles this month.
- 2) Kathy poached the egg.
- 3) Steve polished his shoes.
- 4) Sally purchased a new car.
- 5) The boy panicked about the test.
- 6) The governor pardoned the criminal.
- 7) Jane pondered the meaning of life.
- 8) The Vikings pillaged a monastery.
- 9) The woman pampers her dog.
- 10) Many citizens perished from the famine.
- 11) The referee penalized the team.

- 12) The boy poked the dog.
- 13) Martha paid the cashier.
- 14) The children popped the bubbles.
- 15) Steven paused the movie.
- 16) Sally pinned the banner up.
- 17) The woman pumped the tire up.
- 18) The workers paved the street.
- 19) Susan patted the dog on the head.
- 20) Rita punished her children.

Appendix B - Experiment #2 stimulus sentences (target words underlined)

Sentences with contextually *predictable* target words. In parentheses the predictability values are given, as the number of respondents in the Mechanical Turk survey (out of 34) who correctly guessed the predictable word when omitted:

- 1) Pennies are made out of copper. (25/34, 73.5%)
- 2) The printer needs a new ink cartridge. (28/34, 82.4%)
- 3) When there is a blackout we light candles. (32/34, 94.1%)
- 4) A spreadsheet has rows and columns. (30/34, 88.2%)
- 5) The pioneers made log cabins. (28/34, 82.4%)
- 6) Harvard University is a prestigious college. (17/34, 50%)
- 7) The largest library in the U.S. is the Library of Congress. (27/34, 79.4%)
- 8) Root vegetables include parsnips and carrots. (9/34, 26.5%)
- 9) John stacked the plates and put them away in the cupboard. (16/34, 47.1%)

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- 10) Sauerkraut is made from fermented cabbage. (29/34, 85.3%)
- 11) Kings and queens live in castles. (25/34, 73.5%)
- 12) Nobody puts baby in the corner. (17/34, 50%)
- 13) The dog is wearing a collar. (22/34, 64.7%)
- 14) The vampires are sleeping in coffins. (26/34, 76.5%)
- 15) Mary prefers milk and sugar in her coffee. (23/34, 67.6%)
- 16) The witch is brewing a potion in her cauldron. (15/34, 44.1%)
- 17) Butterfingers are my favorite type of candy. (26/34, 76.4%)
- 18) Bob spilled wine on the white carpet. (15/34, 44.1%)
- 19) Debbie drinks milk straight from the carton. (19/34, 55.9%)
- 20) The windows are covered with curtains. (10/34, 29.4%)
- 21) In the desert, we rode on camels. (25/34, 73.5%)
- 22) The great barrier reef has beautiful coral. (14/34, 41.1%)
- 23) A young cat is called a kitten. (33/34, 97.1%)
- 24) T-shirts are made out of cotton. (27/34, 79.4%)
- 25) Five nickels equal one quarter. (26/34, 76.5%)
- 26) In India, the most deadly snake is the cobra. (25/34, 73.5%)
- 27) The refrigerator and stove are in the kitchen. (32/34, 94.1%)
- 28) The needle always points north on a compass. (33/34, 97.1%)
- 29) We looked up at the night sky and saw Halley's comet. (31/34, 91.2%)
- 30) In Arizona, tourists come to the Grand Canyon. (30/34, 88.2%)
- 31) The girl dressed as a ghost for her Halloween costume. (18/34, 52.9%)
- 32) A one-person canoe is sometimes called a kayak. (19/34, 55.9%)

- 33) France, Spain, and Germany are European countries. (31/34, 91.2%)
- 34) In the desert, Anna saw a spiky Saguaro cactus. (18/34, 52.9%)
- 35) Dave likes hotdogs with mustard and ketchup. (17/34, 50%)
- 36) The photographer put film in her camera. (32/34, 94.1%)
- 37) Cats are felines while dogs are canines. (28/34, 82.4%)
- 38) The historian dug up a time capsule. (19/34, 55.9%)
- 39) At the circus they shot a man out of a cannon. (29/34, 85.3%)
- 40) A prism breaks light into separate colors. (34/34, 100%)
- 41) Bill woke up after twenty years in a coma. (26/34, 74.5%)
- 42) Six people were elected to city council. (29/34, 85.3%)
- 43) The president's words were taken out of context. (28/34, 82.4%)
- 44) Amanda won the pie eating contest. (28/34, 82.4%)
- 45) The horror movie is about a serial killer. (32/34, 94.1%)
- 46) Kathy wears glasses instead of contacts. (30/34, 88.2%)
- 47) The pitcher threw the ball to the catcher. (20/34, 58.8%)
- 48) The women are singing Christmas carols. (30/34, 88.2%)
- 49) Matt doesn't like riding big roller coasters. (27/34, 79.4%)
- 50) The Wizard of Oz is set in Kansas. (18/34, 52.9%)
- 51) Boxes are made out of cardboard. (27/34, 79.4%)
- 52) Separate words in a list with commas. (20/34, 58.8%)
- 53) The lion asked the Wizard of Oz for courage. (24/34, 70.6%)
- 54) A popular spice in Indian cuisine is curry. (14/34, 41.2%)
- 55) Sarah's favorite video game is Mortal Kombat. (34/34, 100%)

- 56) The team was down but made a huge comeback. (20/34, 58.8%)
- 57) Painters paint on a material called canvas. (29/34, 85.3%)
- 58) Jim baked chocolate chip cookies. (29/34, 85.3%)
- 59) Panthers or mountain lions are also called cougars. (14/34, 41.2%)
- 60) Art and music are part of a nations' culture. (22/34, 64.7%)

Sentences with contextually *unpredictable* target words:

- 1) The next word is 'copper.'
- 2) What I need is a cartridge.
- 3) The man is looking at the candles.
- 4) Chris said he saw the columns.
- 5) Joe turned and saw the cabins.
- 6) Linda is thinking about college.
- 7) Albert is always thinking about congress.
- 8) Molly's favorite thing is the world is carrots.
- 9) Ron decided to look at the cupboard.
- 10) Mary wishes she had more cabbage.
- 11) The woman suddenly saw the castles.
- 12) The dog stopped and looked at the corner.
- 13) The first word on the page is 'collar.'
- 14) The first thing Mary saw was the coffins.
- 15) My grandmother needs more coffee.
- 16) Matilda said that she wants a cauldron.

- 17) I have been thinking a lot about candy.
- 18) Bob is always thinking a lot about carpet.
- 19) Debbie sat and stared at the carton.
- 20) Wanda says she wants curtains.
- 21) Nick turned around and saw the camels.
- 22) Barbara turned the page and saw the coral.
- 23) The first thing I saw was a kitten.
- 24) Ashley really needs more cotton.
- 25) Paul opened his eyes and saw a quarter.
- 26) The woman kept thinking about the cobra.
- 27) Jack sat thinking about his kitchen.
- 28) The first thing the man thought of was a compass.
- 29) The people looked and saw a comet.
- 30) Don knows there is a canyon.
- 31) The first thing Julie saw was her costume.
- 32) Everybody began to stare at the kayaks.
- 33) John thinks a lot about different countries.
- 34) Anna looked to the right and saw a cactus.
- 35) Dave's favorite thing in the world is ketchup.
- 36) Lisa decided that she wants a camera.
- 37) The word at the bottom of the page is 'canines.'
- 38) The last word of the book is 'capsule.'
- 39) I know that the man has a cannon.

- 40) The boy said he saw lots of colors.
- 41) The last word bill said was 'coma.'
- 42) The man looked directly at the council.
- 43) Lately I've been thinking a lot about context.
- 44) Amanda wants to have a contest.
- 45) Frank has been thinking a lot about the killer.
- 46) Cindy wants to get more contacts.
- 47) The man turned and looked at the catcher.
- 48) Zack says he really likes carols.
- 49) The first word Matt spelled was 'coasters.'
- 50) Courtney likes to think about Kansas.
- 51) I really need to get more cardboard.
- 52) The women were talking about commas.
- 53) Ben wishes that he had more courage.
- 54) Tom's favorite thing in the world is curry.
- 55) They have been thinking a lot about combat.
- 56) What I really need now is a comeback.
- 57) Eric decided to get more canvas.
- 58) All day long Jim thought about cookies.
- 59) The boy decided to look at the cougars.
- 60) Lately everyone has been discussing culture.