Listener Bias in Categorical and Continuous Measures of Children's Fricatives

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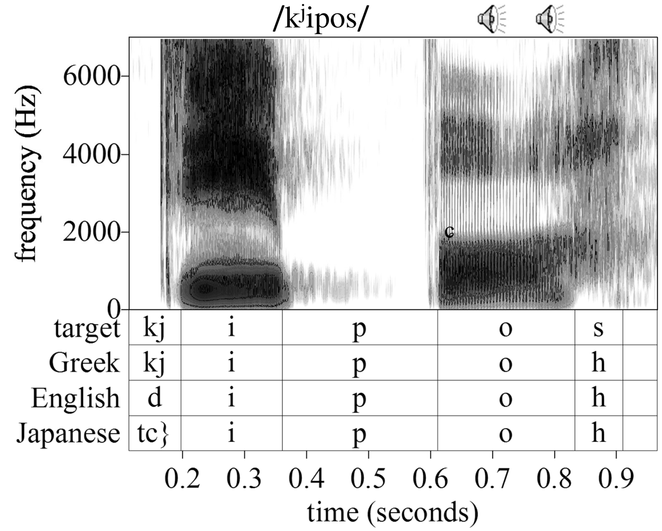
Measuring Children's Productions



/k/ before front vowels in Greek:

- Greek speakers mostly hear correct /k/
- English speakers mostly hear [t] substitution
- Japanese mostly hear [tɕ] substitution

Abstractness and Specificity

- The sound structure of language encompasses representations in multiple sensory domains and at multiple levels of abstraction away from raw sensory experiences
- Acquisition happens in all of these domains and processes

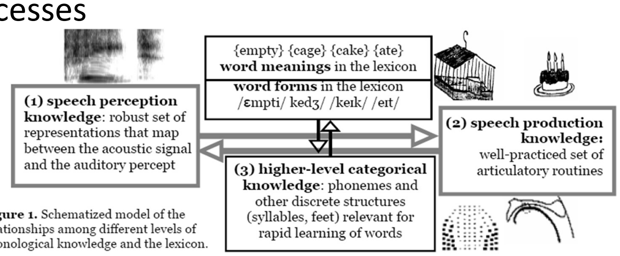
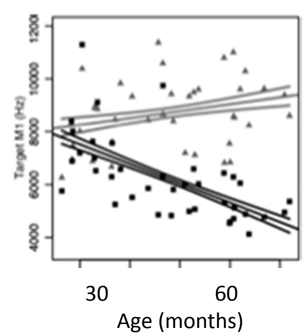


Figure 1. Schematized model of the relationships among different levels of phonological knowledge and the lexicon.

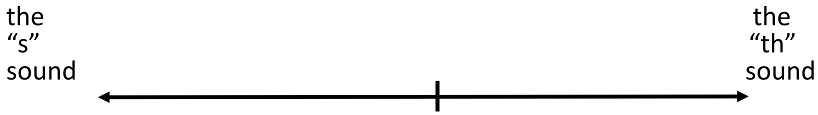
Continuous Differentiation in Development



- Li (2012): the differentiation of /s/ from /ʃ/ centroids between 30 and 60 months is continuous, and extends beyond the point at which these sounds are transcribed to be correct

Visual Analog Scaling

- An alternative: Visual Analog Scaling (VAS) used at least as early as Massaro & Cohen, 1983) to probe adult perception continuously.



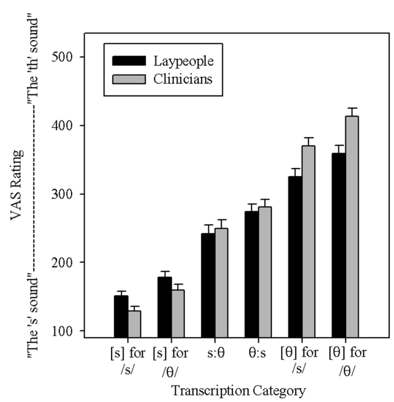
- Participant responds by clicking on the line (a visual analog to the number line, with a neutral midpoint and seemingly infinite variation to the idealized endpoints)
- Used in a variety of recent studies (Bernstein, Johnson, Beckman, Edwards, & Munson, 2015; Julien & Munson, 2012; Munson, Johnson, & Edwards, 2012; Munson, Schellinger, Edwards, Beckman, & Meyer, 2010; Schellinger, Munson, & Edwards, 2015)

Visual Analog Scaling

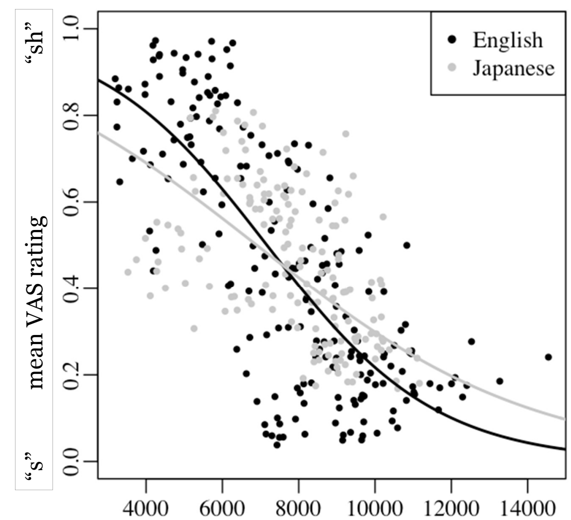
- 200 CV sequences from single-word productions of English-speaking children, aged 2 through 5 years.
  - correct /s/
  - [s] for /θ/
  - intermediate: [s:θ]
  - Intermediate: [θ:s]
  - [θ] for /s/
  - correct /θ/

Visual Analog Scaling

- VAS ratings differentiate among more transcription categories than traditional binary systems do.
- Provides evidence for covert contrasts



VAS Ratings are Related to Acoustics



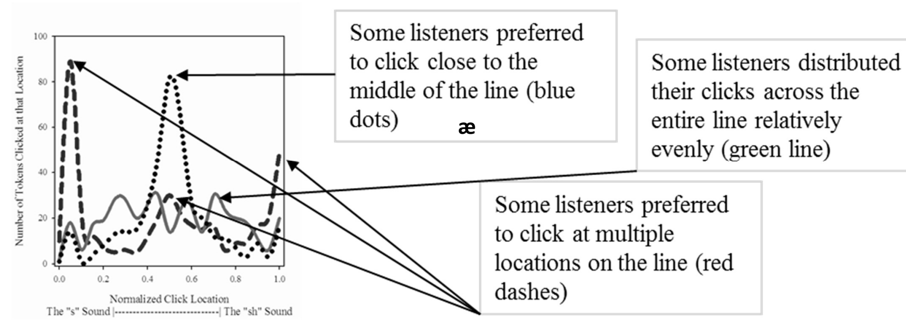
Beckman, Edwards, & Munson, 2011

You’ve Heard this all Before

- I have been presenting work on VAS ratings of children’s speech for the last seven years.
- Today’s new takes:
  - Why are some people more categorical than others?
  - Is it less susceptible to bias than binary measures are?

Degree of Categoricity

Data from Munson & Urberg-Carlson, in prep, data from an “s”-”sh” VAS



Maddeningly Hard to Measure

- Traditional measures of categoricity (like Probit analyses) don’t work, as the continua vary in multiple acoustic dimensions
- This is going to require some creativity with measurement.

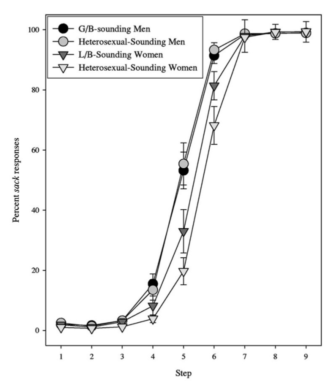
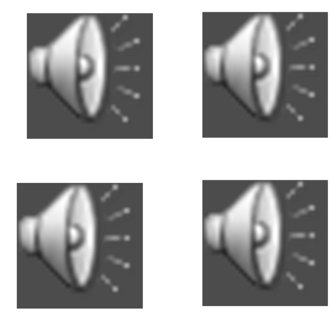


FIG. 1. Percent sack responses for GLB- and heterosexual-sounding men and women on the nine-step sack-shack continuum. Error bars represent one standard error of measurement.

From Munson, Jefferson, & McDonald, 2006

Attention to continuous vs categorical detail

- Can we change the categoricity of someone’s VAS responses by constructing an experiment that draws attention either to categorical detail or to continuous variation?

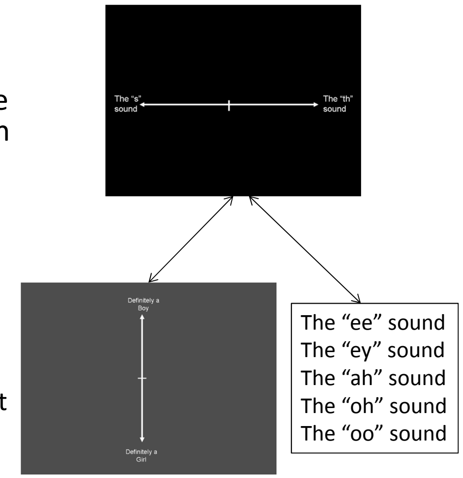


Drawing Attention

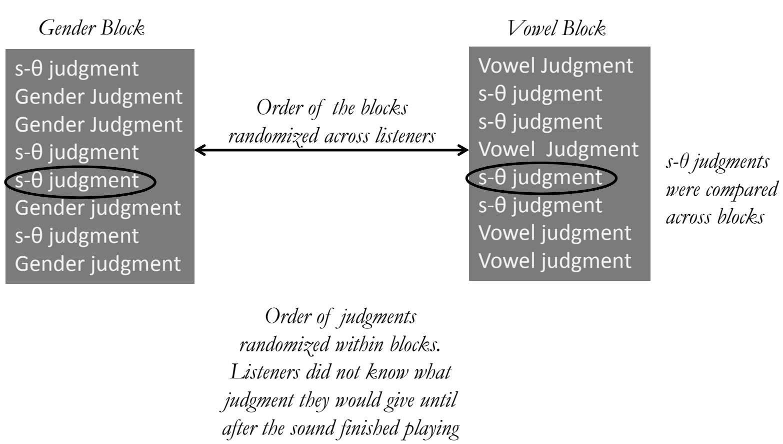
- The general design: interleave VAS ratings of children's /s/ and /θ/ productions on a "s" to "th" scale with judgments of a continuous variable (gender typicality) or a categorical variable (what vowel the child produced).

Experiment Design

- Two blocks: one randomly interleaved /s/-/θ/ ratings with gender judgments, one randomly interleaved it with vowel judgments.
  - Order of the blocks randomized.
  - Listeners never knew what ratings they were making until the stimulus was done playing
  - Each block had 200 stimuli, the same as in Schellinger et al. (2015)

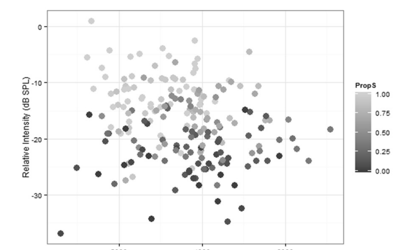


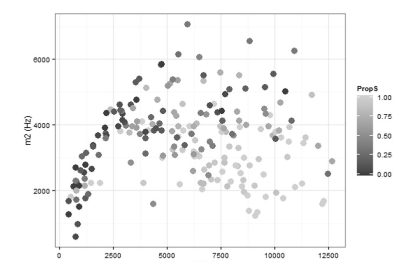
Schematic View of the Experiment



Stimuli

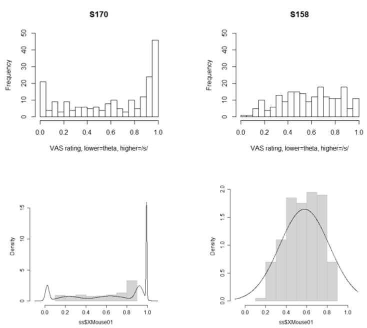
- Children aged 2-5 acquiring English
- Fricatives in initial position, either an /s/ or a /θ/ target
- Transcribed as either, [s], [θ], [s:θ], or [θ:s].
- Varied the acoustic parameters relevant for the /s/-/θ/ contrast

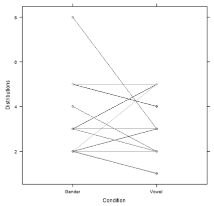




Analysis 1: Distributions

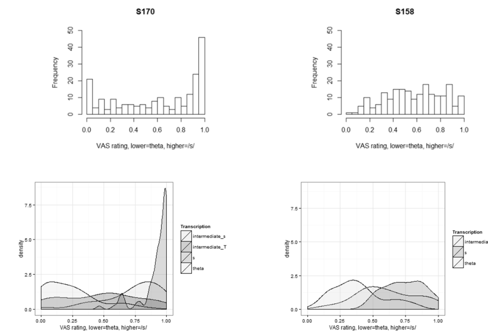
- Density Mixture Modeling in `mclust`
- Did the conditions differ in the shape of the response distributions?
- No

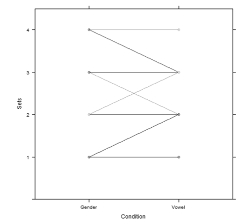




Analysis 2: Differentiation

- Did the conditions differ in how many transcription categories they differentiated among?
- No





Analysis 3: Acoustics

- Did the conditions differ in how strongly the responses were affected by the relevant acoustic characteristics of the fricatives (m1, m2, intensity relative to the following vowel)?
- No

	Estimate	Std.Error	df	t value	Pr(>|t|)	
(Intercept)	4.164e-01	2.032e-02	21	20.490	<0.00001	***
M1, middle 40 ms	-6.865e-02	6.207e-03	26	-11.060	<0.00001	***
M2, middle 40 ms	2.849e-02	4.757e-03	21	5.991	<0.00001	***
F2 at vowel onset	-7.669e-03	4.244e-03	21	-1.807	0.085	.
F0 at vowel midpoint	-2.156e-02	4.073e-03	23	-5.294	<0.00001	***
Duration	3.383e-02	3.965e-03	40.7	8.532	<0.00001	***
Relative Intensity	-1.084e-01	9.963e-03	22	-10.877	<0.00001	***

Interim Conclusion

- VAS ratings are impervious to whether they are paired with a task that asks people to rate gender or one that asks them to rate the vowel that they heard.

Is it VAS or the Experiment?

- Is VAS impervious to bias, or does this particular experimental manipulation simply not bias responses?

Redo the Experiment

- We redid the experiment with a new set of listeners. It was identical in all ways except one: listeners made a binary response of whether they heard “s” or “th” rather than a VAS judgment.
- Binary judgments in both conditions differentiated among all six transcription categories

Logit Mixed-Effects Model: Acoustics

- The two conditions differed in the weighting that listeners gave to the stimuli

	Estimate	Std.Error	z value	Pr(>|z|	
(Intercept)	0.451709	0.104600	-4.318	<0.0001	***
M1, Middle 40 ms	-0.985314	0.053929	-18.270	<0.0001	***
M2, Middle 40 ms	0.598601	0.046904	12.762	<0.0001	***
F2 at vowel onset	-0.150684	0.038941	-3.870	0.0001	***
F0 at vowel midpoint	-0.340250	0.040636	-8.373	<0.0001	***
Duration	0.373812	0.045587	8.200	<0.0001	***
Relative Intensity	-1.312905	0.063463	-20.688	<0.0001	***
M1 by Condition	**0.142988**	**0.048544**	**2.946**	**0.0032**	**
Midpoint F0 by Condition	**0.093393**	**0.040295**	**2.318**	**0.0204**	*

Logit Mixed-Effects Model: Acoustics

- If you convert the data from Experiment 1 to binary responses and do the same analysis, the acoustics do not differ as a function of experiment.

	Estimate	Std.Error	z-value	Pr(>|z|)	
(Intercept)	-0.67810	0.18076	-3.751	0.000176	***
M1, middle 40 ms	-0.58186	0.06084	-9.564	<0.000001	***
M2, Middle 40 ms	0.30108	0.05209	5.780	<0.000001	***
F2 at Onset	-0.07477	0.04100	-1.824	0.068195	.
F0 at Midpoint	-0.27981	0.04143	-6.754	<0.000001	***
Duration	0.29393	0.04293	6.848	<0.000001	***
Relative Intensity	-1.14442	0.09497	-12.050	<0.000001	***

Logit Mixed-Effects Model: Acoustics

- In the gender condition, listeners weighted m1 more strongly than they weighted it in the vowel condition
- In the gender condition, listeners attended to f0 when making judgments; in the vowel condition, they did not

Conclusion

- VAS ratings are more stable than binary ratings to the bias introduced by mixing listener ratings with ratings of continuous or categorical responses.
- Bias is introduced at the decision stage, not in the encoding stage

Future Work

- Look at other, more conventional ways of biasing responses:
  - Long- versus short-lag responses (as in Babel & Johnson, 2010)
  - Priming a bimodal or unimodal distribution (as in Clayards et al., 2008)
    - Re-analyzing these data to determine whether the condition effects are really just response-latency effects.

Acknowledgments

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