UNIVERSAL BIASES IN PHONOLOGICAL LEARNING

ACTL SUMMER SCHOOL, DAY 3

JAMIE WHITE (UCL)

EPISODE III: NATURALNESS STRIKES BACK

FINLEY & BADECKER REVISITED

Training, stem Vs			Suffix V	Old stems			New stems		
High	Mid	Low		High	Mid	Low	High	Mid	Low
X		X	High	✔		✔	✔	✔	
X	X		High	✔	✔		✔	✔	
X		X	Low	✔		✔	✔	✔	✔
	X	X	Low		✔	✔	✔	✔	✔

Finley & Badecker, 2009, *JML*

INTERACTION OF PHONETIC NATURALNESS, LOCALITY, AND FREQUENCY

DESIGN

Participants learned one of three artificial languages, consisting of:

- CVC singular stems.
- -V plural suffix, which alternated between [-u] and [-y].
- German phonemes.

Stimuli recorded naturally.

DESIGN

Rule	Frequency: Frequent (50% of trials demonstrate alternation)	Frequency: Infrequent (25% of trials demonstrate alternation)
Local Natural $V \rightarrow$ [α back] / $V_{[\alpha\ back]}C\_\_\_$ ([y] after [i, e, œ]; [u] after [o, ɔ, ʊ])	20	20
Local Unnatural $V \rightarrow$ [α back] / $V_{[\alpha\ tense]}C\_\_\_$ ([y] after [œ, ɪ, ʊ]; [u] after [a, e, o])	20	20
Non-local Unnatural $V \rightarrow$ [α back] / $C_{[-\alpha\ son]}VC\_\_\_$ ([y] if C_1 is [m, n, l, j]; [u] if C_1 is [f, d, k, z])	20	20

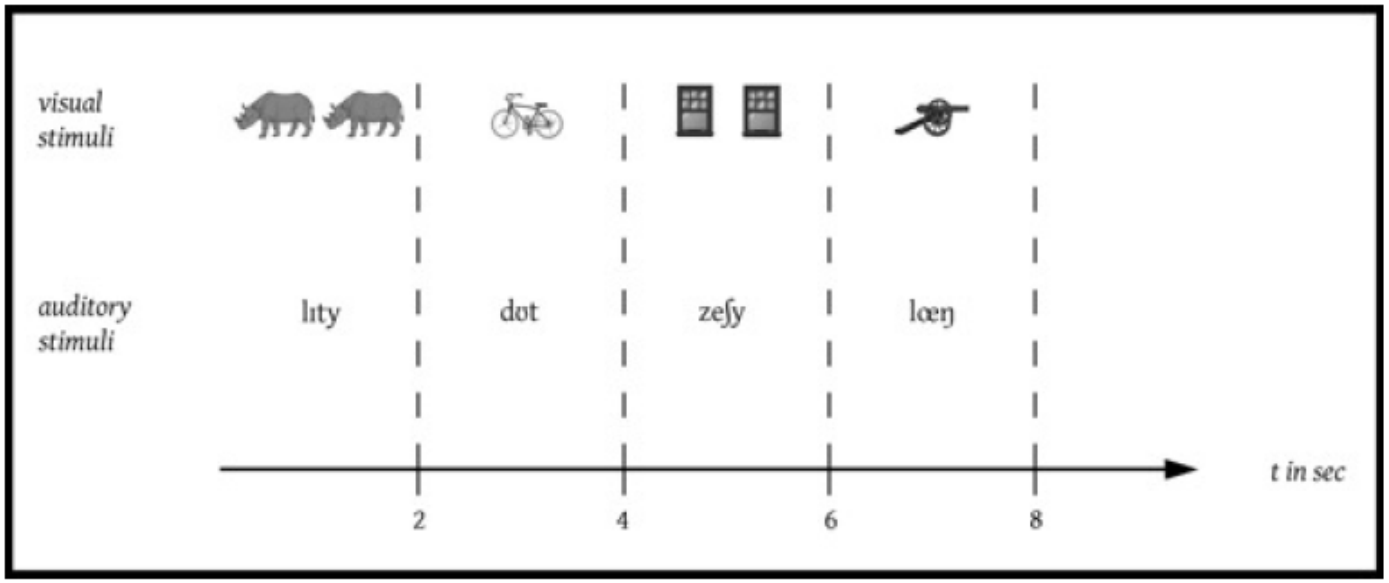
(120 total participants)

Baer-Henney & van de Vijver 2012, *LabPhon*

PROCEDURE

Exposure phase

- Instructions: Pay attention to the words in this new language.
- Each trial:
  - Auditory singular or plural word played (with singular/plural pictures).
  - Only plural forms demonstrated the alternation.
  - Proportion of singular and plural words according to frequency condition.

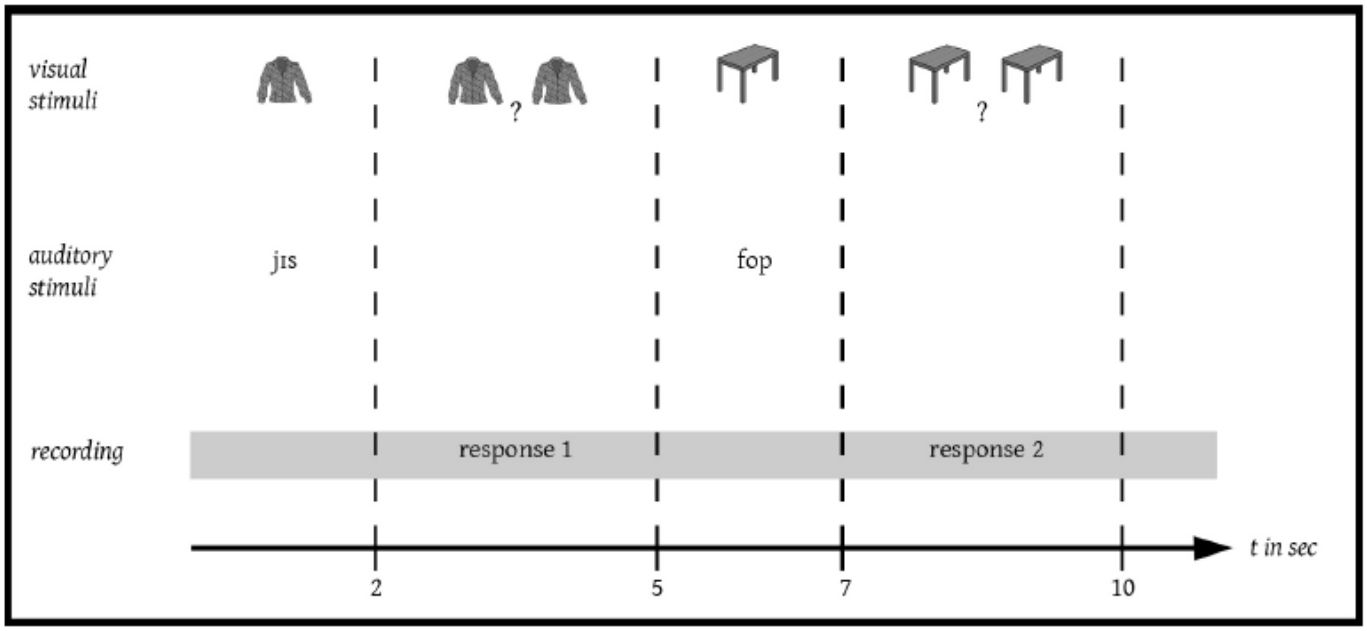


Baer-Henney & van de Vijver 2012, *LabPhon*

PROCEDURE

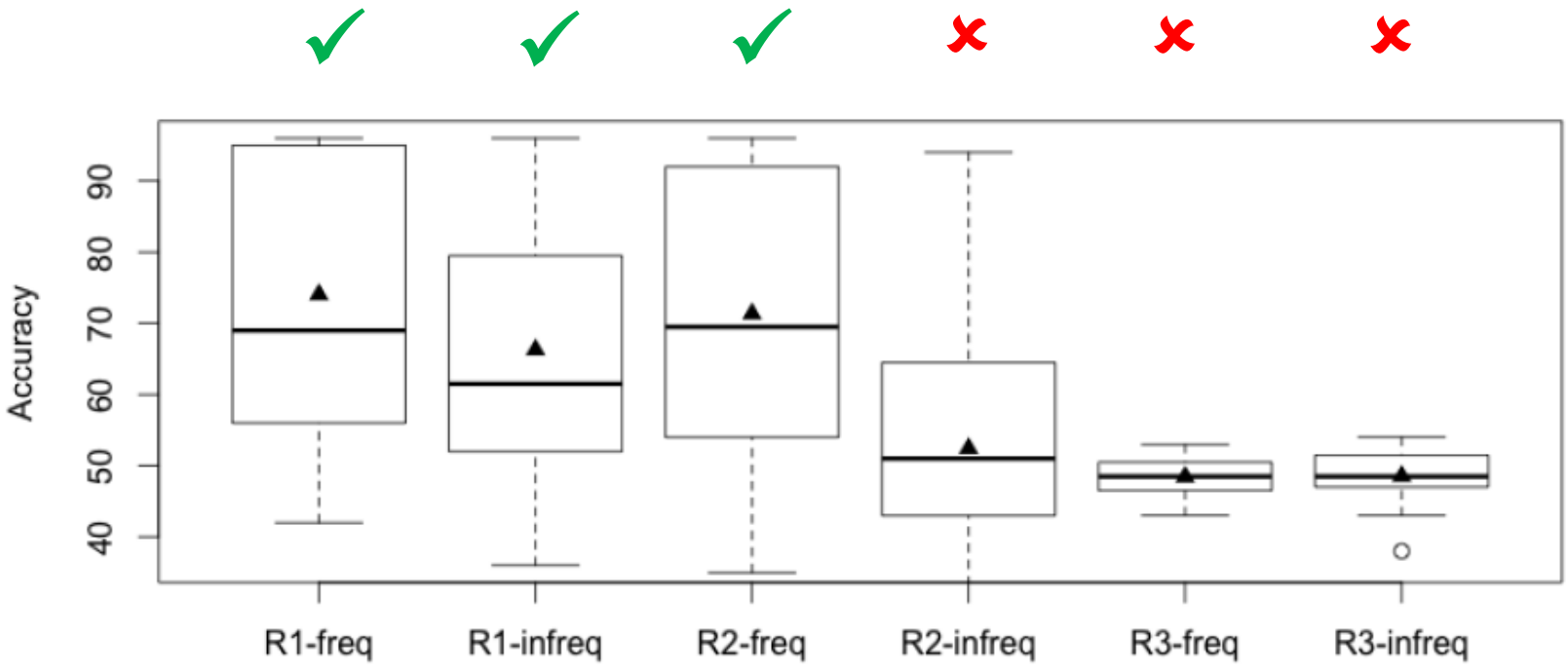
Test phase (96 trials; novel items)

- Presented with singular word and picture, followed by plural picture.
- **Task**: Produce the correct plural form (out loud, to be recorded and later coded).



Baer-Henney & van de Vijver 2012, *LabPhon*

RESULTS



Baer-Henney & van de Vijver 2012, *LabPhon*

NATURAL AND UNNATURAL STRESS PATTERNS

DESIGN

Participants learned one of two languages:

- **Natural**: Stress leftmost **low** vowel, else stress leftmost vowel.
  - [ˈpɑtikæ]
  - [puˈtɑkæ]
  - [pituˈpɑ]
  - [ˈpitupi]

- **Unnatural**: Stress leftmost **high** vowel, else stress leftmost vowel.
  - [ˈputæki]
  - [pɑˈtuki]
  - [pætɑˈpu]
  - [ˈpætɑpæ]

All items: 3- or 4-syllable nonce words.

Carpenter 2010, *Phonology*

STIMULI

Isolated syllables recorded in a carrier sentence.

- Natural duration and intensity differences between high and low vowels wiped out.
- Stress percept enhanced (pitch and intensity differences between stressed/unstressed vowels enhanced).
- Syllables then concatenated together to make the nonce words.

Near-identical items used in the two languages.

- C inventory: [p, t, k, b, d, g, s, z]
  - Same C sequences used in both languages.
- V inventory: [i, u, æ, ɑ]
  - [i, u] substituted for [æ, ɑ], and *vice versa*, to maintain the stress pattern.

PROCEDURE

Familiarization (27 items total)

- Conforming training item played, with a picture shown.

Familiar word testing

- Presented with two options (e.g. [ˈpitupi]…[pituˈpi]), with accompanying picture provided.
- **Task**: Does the 1st or 2nd option sound correct? (button press)
- Feedback provided (correct/incorrect).

Novel word testing (66 items total)

- Tested on novel items (same task).
- No pictures provided.
- No feedback in final test phase.

Carpenter 2010, *Phonology*

PROCEDURE

Pre-training	Subjects complete AXB test: 26 triplet groups
Training block 1	Subjects hear 4 three-syllable training words, randomly repeated 4 times, each word represented by a unique photographic image.
Testing block 1	Subjects tested (2AFC) on the 4 three-syllable words just heard. They get feedback with the correct answer after responding to each pair presented.
Training block 2	Subjects hear 5 four-syllable training words, randomly repeated 4 times, each word represented by a unique photographic image.
Testing block 2	Subjects tested on the 5 four-syllable training words just heard, with feedback.
Review	Subjects hear the first 9 training words, presented randomly and repeated once, i.e. each word heard twice.
Testing block 3	Subjects tested on the first 9 training words, with feedback.
Training/ testing blocks 4 and 5	Each training block presents new words and subjects are tested on just the words presented in that training block. Same procedure as blocks 1 and 2 above.
Review	Subjects hear the second 9 training words, presented randomly and repeated once, i.e. each word heard twice.
Testing block 6	Subjects tested on the second 9 training words, with feedback.
Review	Subjects hear the first 18 training words, presented randomly and repeated once.
Testing block 7	Subjects tested on the first 18 training words, with feedback.
First novel words test	Subjects presented with 18 novel three- and four-syllable test words. They get feedback as to the correct answers.
Training/ testing blocks 8 and 9	Same procedure as training/testing blocks 1, 2, 4 and 5 above. Training and testing block 8 presents and tests a new set of three-syllable words and block 9 trains and tests a new set of four-syllable words.
Review	Subjects hear the third set of 9 training words, presented randomly and repeated once.
Testing block 10	Subjects tested on the third set of 9 training words, with feedback.
Review	Subjects hear all 27 training words, presented randomly and repeated once.
Testing block 11	Subjects tested on the 27 training words they have learned, with feedback. This test measures how well they have learned the training words.
Final novel words test	Subjects presented with 48 novel test words, with no feedback.

Carpenter 2010, *Phonology*

RESULTS

English speakers (n = 40)

English speakers (novel words)	Raw score (% correct)	SD	Arcsine transformed score (% correct)	SD
natural group	70·40 $p < 0·001$	12·11	80·30 $p < 0·001$	20·4 9
unnatural group	61·97 $p < 0·05$	12·90	68·33 $p < 0·05$	18·89

	Stress position					
	Initial (%)	SD	Medial (%)	SD	Final (%)	SD
natural group	69·6 5	11·93	72·86	11·57	68·6 6	9·74
unnatural group	68·42	8·77	56·84	11·01	55·6 4	11·81

N.B.: Equally good on trained items (90% vs. 89%)

Carpenter 2010, *Phonology*

RESULTS

Quebec French speakers (n = 40)

N.B.: They were first trained to hear stress.

French speakers (novel words)	Raw score (% correct)	SD	Arcsine transformed score (% correct)	SD
natural group	59·62 $p < 0·001$	8·92	64·39 $p < 0·001$	11·70
unnatural group	53·71 $p < 0·05$	6·6 9	56·88 $p < 0·05$	7·85

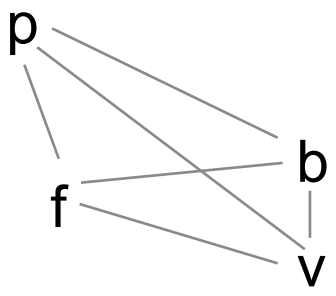
	Stress position					
	Initial (%)	SD	Medial (%)	SD	Final (%)	SD
natural group	64·33	17·14	57·14	16·06	56·50	18·4 6
unnatural group	54·83	13·83	54·64	10·69	55·00	12·92

P-MAP BIAS
(MINIMAL MODIFICATION BIAS)

WHAT IS THE P-MAP?

Components of Steriade's P-map proposal:

1. Speakers have a mental representation of the relative perceptual similarity of different pairs of speech sounds.
   - = the perceptibility map (P-map)
   - Context-dependent – sounds might be more or less similar in different contexts.
   - Possible fragment might look like this:



2. Speakers have a minimal modification bias during phonological learning.
   - They assume that phonological processes will require the smallest possible perceptual change.

Steriade 2001/2008

MOTIVATION FOR THE P-MAP

Steriade's main motivation for the P-map is typological, as a solution to the 'Too-many solutions problem'.

E.g.: A restriction on final voiced obstruents could be satisfied in several ways:

- Devoicing: /tæb/ → [tæp]
- Nasalization: /tæb/ → [tæm]
- Lenition: /tæb/ → [tæw]
- Deletion: /tæb/ → [tæ]
- Insertion: /tæb/ → [tæbə]
- Reversal: /tæb/ → [bæt], and so on…

All should occur if constraints are freely ranked.

- But only devoicing is common; others are rare or unattested.

Steriade 2001/2008

STERIADE'S IMPLEMENTATION

The P-map results in a universal ranking hierarchy for faithfulness constraints:

- If Sim(b, p) > Sim(b, m) after vowels, then IDENT(nasal) >> IDENT(voice).

/tæb/	*D#	IDENT(nasal)	IDENT(voice)
☞ tæp			*
tæm		*!	
tæb	*!		

This suggests a hard bias (probably too strong).

- But the same idea can be implemented as a soft bias (Wilson 2006, Zuraw 2007, White 2013).

Steriade 2001/2008

DO LEARNERS PREFER ALTERNATIONS THAT INVOLVE PERCEPTUALLY MINIMAL CHANGES?

DESIGN

Condition		Alternations learned (sample phrases)	
Small phonetic distance	(group 1)	ʁe pamu ~ nø tamu	ʁe zafam ~ nø ʒafam
	(group 2)	ʁe ʃamu ~ nø samu	ʁe dafam ~ nø bafam
		(1 feature difference: place)	
Medium phonetic distance	(group 1)	ʁe pamu ~ nø samu	ʁe dafam ~ nø ʒafam
	(group 2)	ʁe ʃamu ~ nø tamu	ʁe zafam ~ nø bafam
		(2 feature difference: place & manner)	
Large phonetic distance	(group 1)	ʁe pamu ~ nø zamu	ʁe tafam ~ nø ʒafam
	(group 2)	ʁe ʃamu ~ nø damu	ʁe safam ~ nø bafam
		(3 feature difference: place, manner, voicing)	

Skoruppa, Lambrechts & Peperkamp (2011), *NELS*

METHOD

Training:

Moi: ([ʁe pamu])

Vous: (oral response)

Correct: ([nø tamu])

(Instructed that [ʁe] meant 'small' and [nø] meant 'big'.)

Test:

Moi: ([ʁe pamu])

Vous: (oral response)

(No feedback)

Skoruppa, Lambrechts & Peperkamp (2011), *NELS*

METHOD

Participants: 36 French speakers (12 per condition)

Training phase: 36 trials (6 pairs x 6 repetitions)

- 4 pairs of phrases with target sounds (demonstrating alternations)
- 2 filler pairs with sonorants (no alternation).

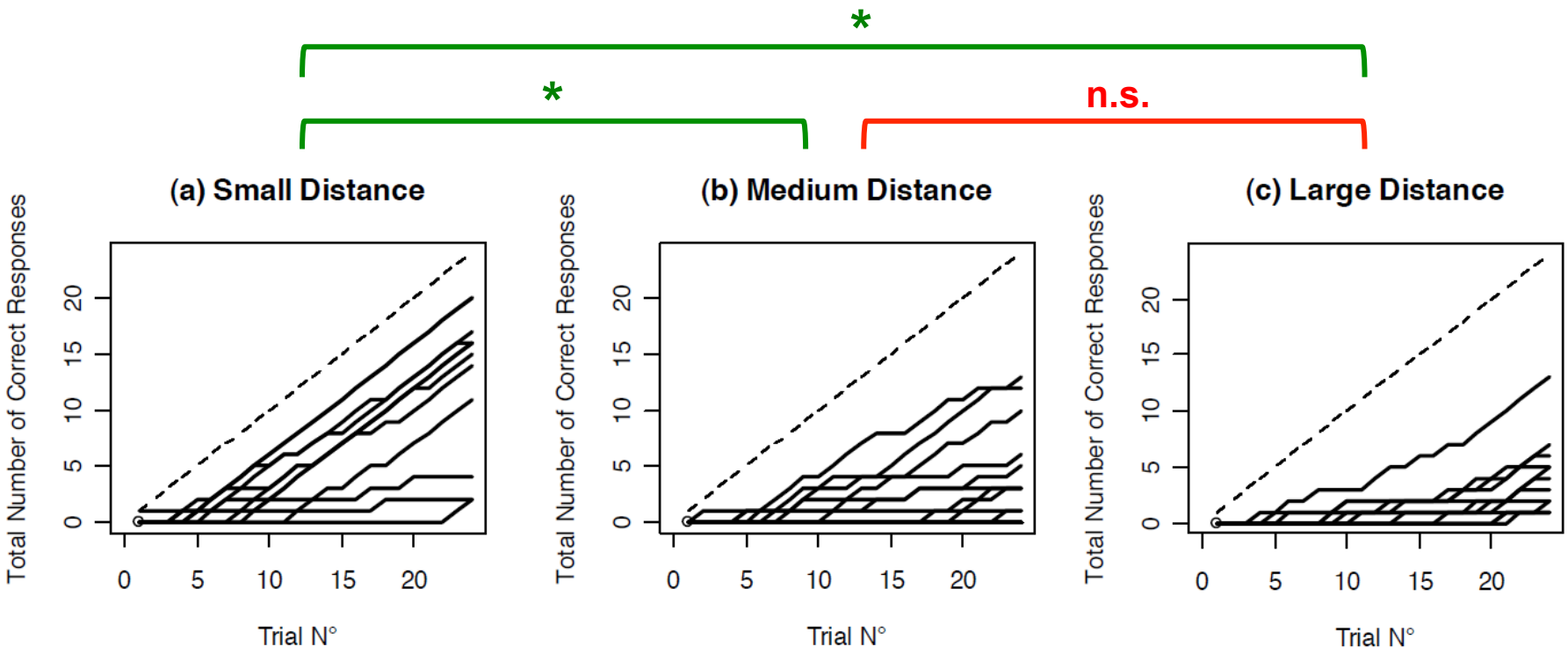
Test phase: 36 trials (18 pairs x 2 reps)

- 6 trained pairs
- 12 novel pairs (8 target, 4 filler)

Stimuli recorded by French speaker; penultimate stress.

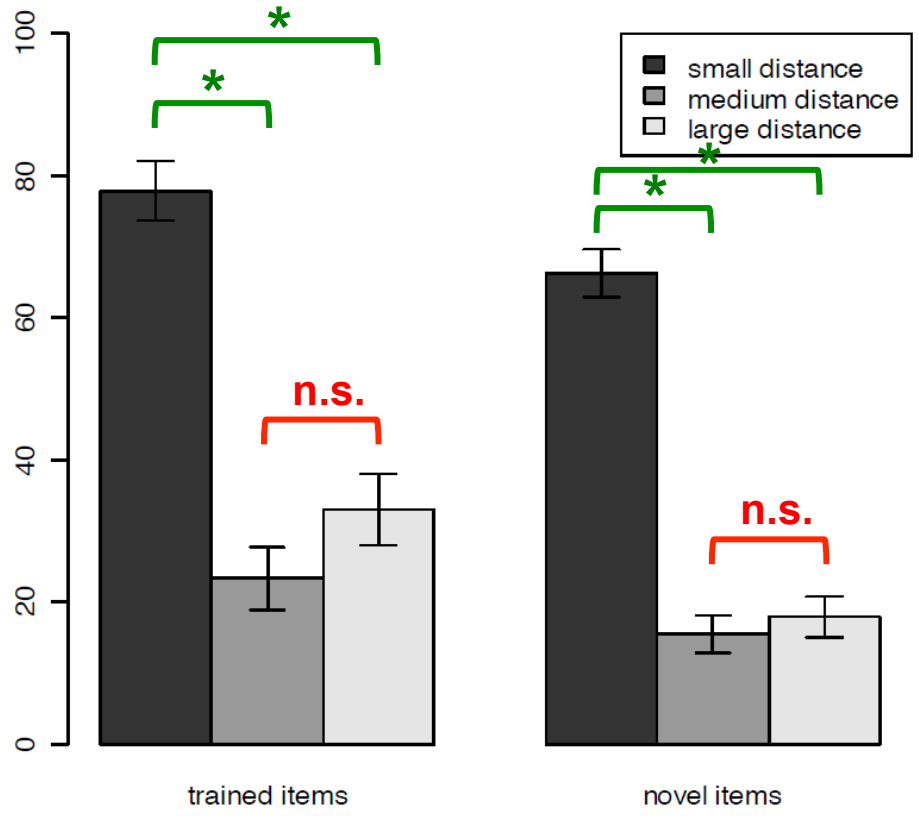
Skoruppa, Lambrechts & Peperkamp (2011), *NELS*

LEARNING RATE RESULTS



Skoruppa, Lambrechts & Peperkamp (2011), *NELS*

TEST PHASE ACCURACY



Skoruppa, Lambrechts & Peperkamp (2011), *NELS*

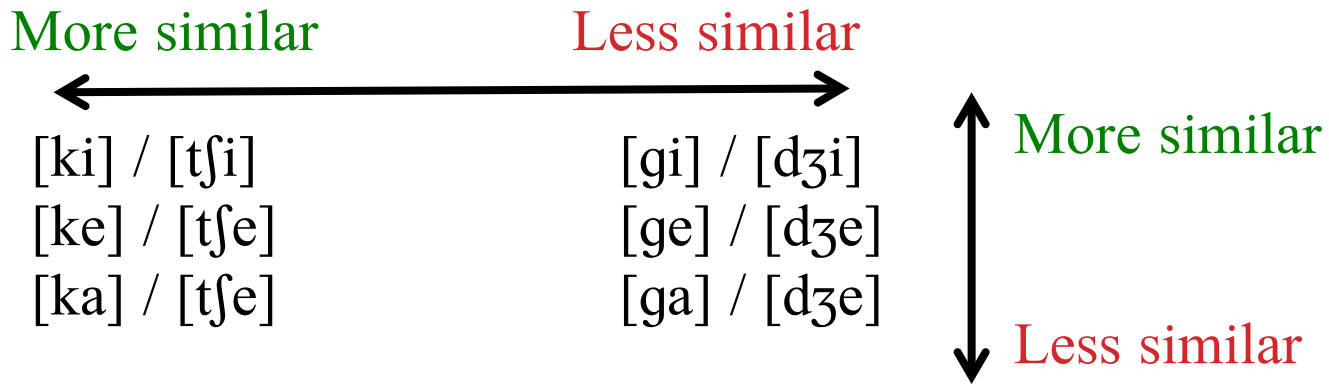
VELAR PALATALIZATION

Typological facts:

- Two implicational universals:
  1. Palatalization before backer vowels ⟶ palatalization before fronter vowels (recall: [i] is fronter than [e]).
  2. Palatalization of voiced velars ⟶ palatalization of voiceless velars.

- Sequence [ki] is statistically under-represented in languages.

Perceptual facts:



Wilson 2006, *Cognitive Science* (see also Guion 1998, *Phonetica*)

DESIGN

Participants told they would be learning a novel language game.

'Poverty of the stimulus' paradigm (the original!)

Two languages:

- **High condition**:
  - Explicit palatalization of [k] and [g] before [i].
  - Explicit non-palatalization of [k] and [g] before [a].
  - No examples of [k] or [g] before [e].
- **Mid condition**:
  - Reverse (palatalization before [e], no input for velars before [i]).

Wilson 2006, *Cognitive Science*

STIMULI

Exposure input

Exposure trials for the two conditions in Experiment 1

Condition	Trial Type (number)
High	kiCV … t͡ʃiCV (4) giCV … d͡ʒiCV (4)
Mid	keCV … t͡ʃeCV (4) geCV … d͡ʒeCV (4)
Both	kɑCV … kɑCV (3) gɑCV … gɑCV (3)
	piCV … piCV (3) biCV … biCV (3)
	peCV … peCV (3) beCV … beCV (3)
	pACV … pɑCV (3) bɑCV … bɑCV (3)

Test stimuli (same for both conditions)

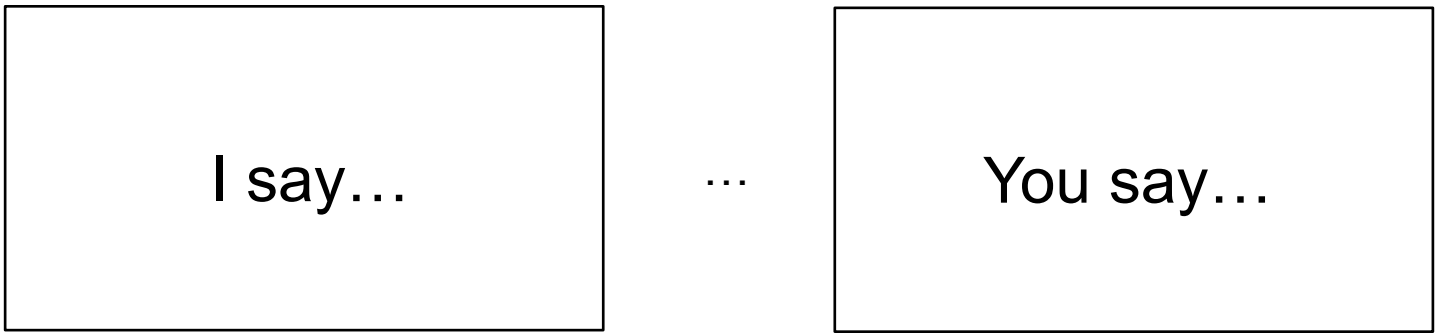
Testing trials for the two conditions in Experiment 1

Critical trial type (number)	Filler trial type (number)
kiCV … (8) giCV … (8)	piCV … (6) biCV … (6)
keCV … (8) geCV … (8)	peCV … (6) beCV … (6)
kɑCV … (6) gɑCV … (6)	pɑCV … (6) bɑCV … (6)

Wilson 2006, *Cognitive Science*

PROCEDURE

Exposure phase:



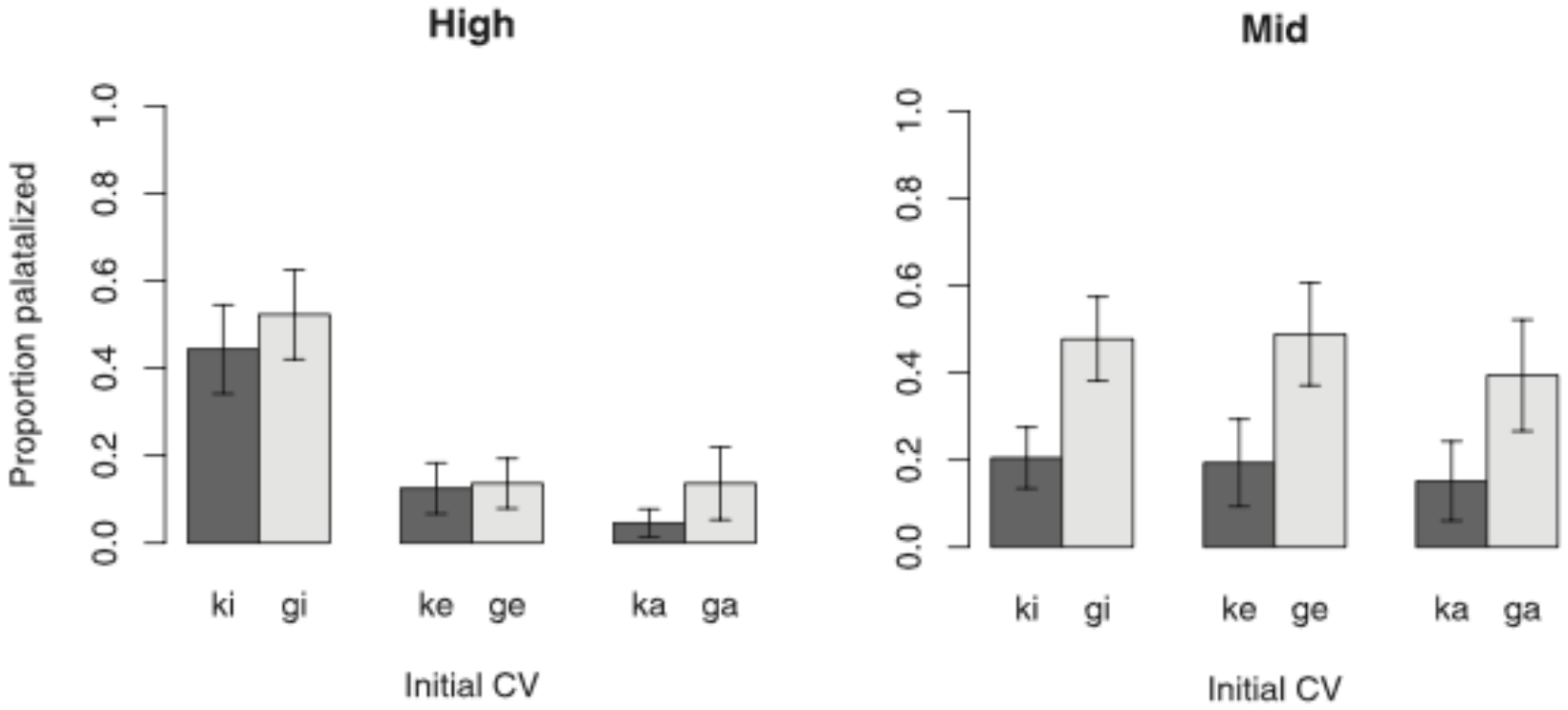
Test phase:

Same but participants had to produce an oral response.

Wilson 2006, *Cognitive Science*

PREDICTIONS?

RESULTS



Wilson (2006), *Cognitive Science*

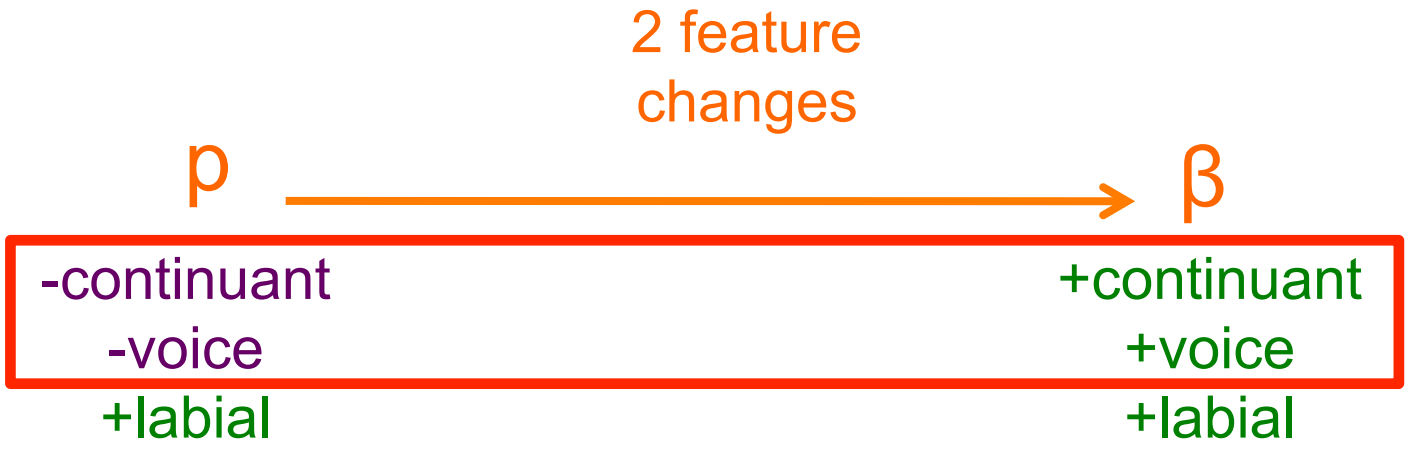
SALTATORY ALTERNATION: A GROSS VIOLATION OF THE P-MAP

SALTATORY ALTERNATION

- Example from Campidanian Sardinian (Bolognesi 1998):
  - p ⟶ β/ V __ V, but /b/ remains unchanged

[pãi] ⟶ [s:u βãi] 'the bread'

[bĩu] ⟶ [s:u bĩu] 'the wine'



Hayes & White (in press), *Phonology*

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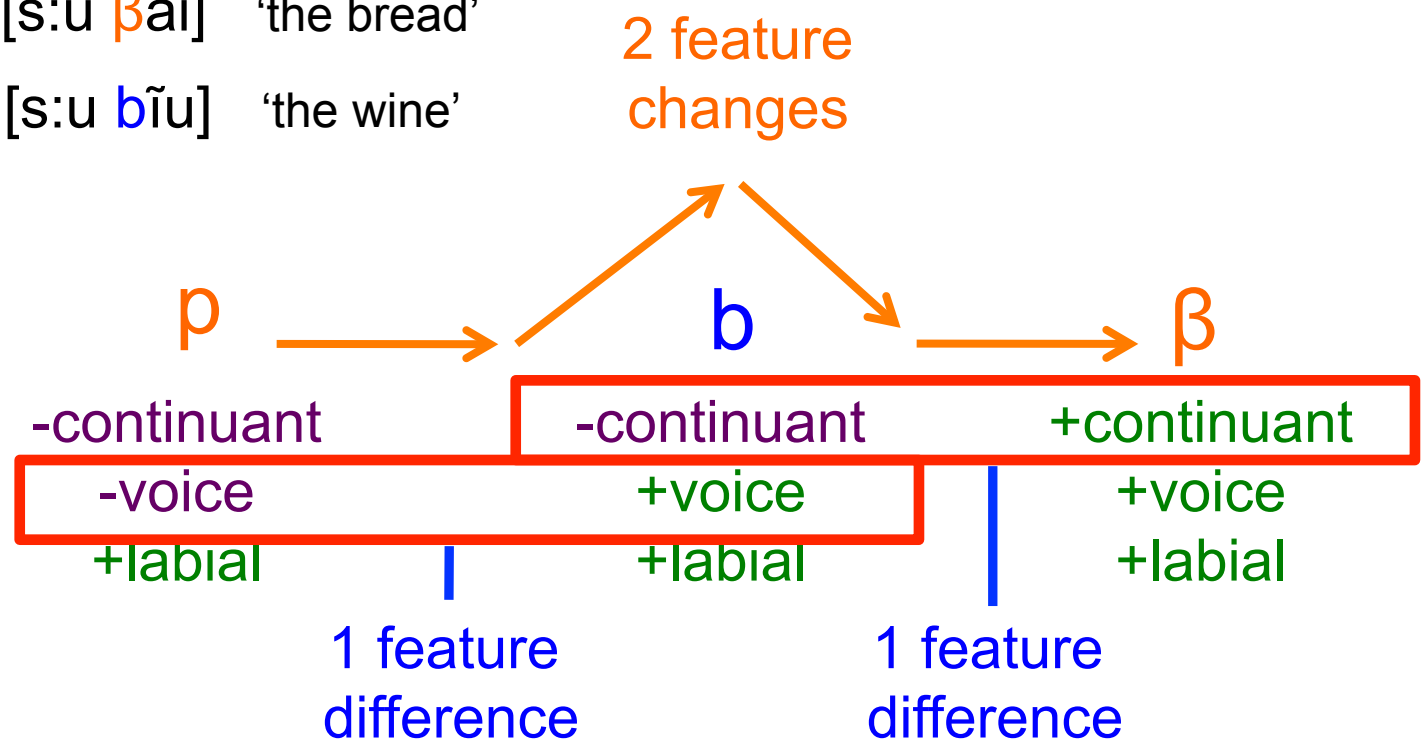
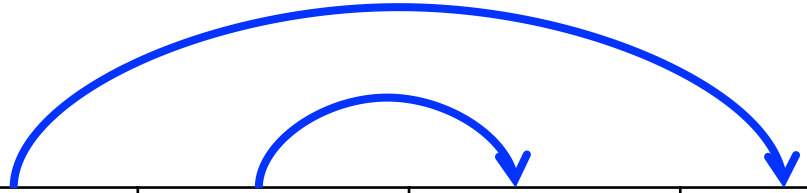


Hayes & White (in press), *Phonology*

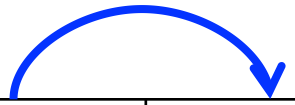
NOT DERIVABLE IN CLASSICAL OT

For /p/ ⟶ [β]:



/ V p V/	*V[-voice]V	*V[-cont]V	IDENT(cont)	IDENT(voice)
☞ V β V			*	*
V p V	*!	*		
V b V		*!		*
V ɸ V	*!		*	

For /b/ ⟶ [b]:



/ V b V/	IDENT(cont)	*V[-cont]V
☞ V b V		*
V β V	*!	

Hayes & White (in press), *Phonology*

NOT DERIVABLE IN CLASSICAL OT

For /p/ ⟶ [β]:

/ V p V/	*V[-voice]V	*V[-cont]V	IDENT(cont)	IDENT(voice)
☞ V β V			*	*
V p V	*!	*		
V b V		*!		*
V ɸ V	*!		*	

For /b/ ⟶ [b]:

/ V b V/	IDENT(cont)	*V[-cont]V
☞ V b V		*
V β V	*!	

A ranking paradox!!

Hayes & White (in press), *Phonology*

DO LEARNERS DISPREFER SALTATORY ALTERNATIONS?

EXPOSURE PHASE

[kamap]

White (2014), *Cognition*

EXPOSURE PHASE

[kamavi]

White (2014), *Cognition*

PROCEDURE

1. Exposure phase

[kamap]

[kamavi]

White (2014), *Cognition*

PROCEDURE

1. Exposure phase

[kamap]

[kamavi]

2. Verification phase

[kamap]

[kamapi]
or
[kamavi]???

No

Yes ← 80% correct?

3. Generalization phase

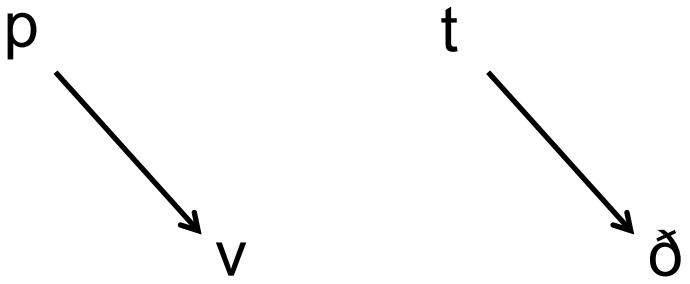
[lunub]

[lunubi]
or
[lunuvi]???

White (2014), *Cognition*

EXPOSURE INPUT

Potentially Saltatory condition



Control condition

Both conditions: non-alternating **filler** sounds [m, n, l, r, s, ʃ]

From now on, I will be representing only the labials for simplicity.

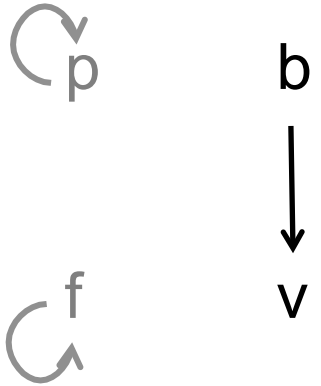
White (2014), *Cognition*

EXPOSURE INPUT

Control condition input:

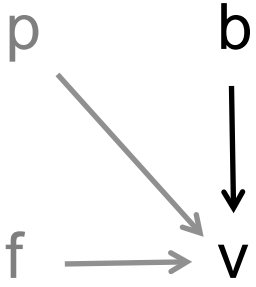
(also: m → m, n → n, l → l ...)

Possible interpretations:



Non-saltatory

No new alternations posited



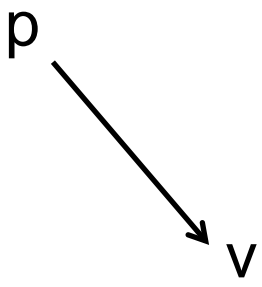
Non-saltatory

New alternations posited

White (2014), *Cognition*

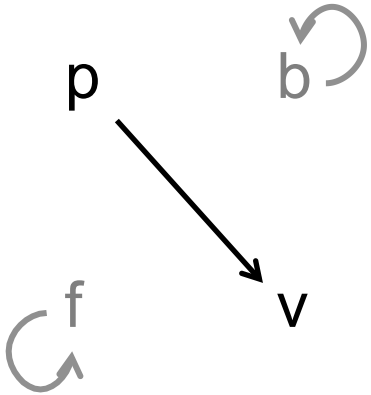
EXPOSURE INPUT

Potentially Saltatory condition input:



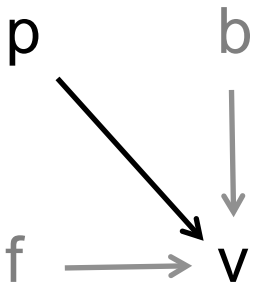
(also: m → m, n → n, l → l ...)

Possible interpretations:



Saltatory

No new alternations posited



Non-saltatory

New alternations posited

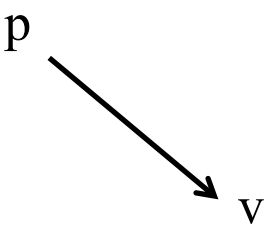
White (2014), *Cognition*

PREDICTIONS?

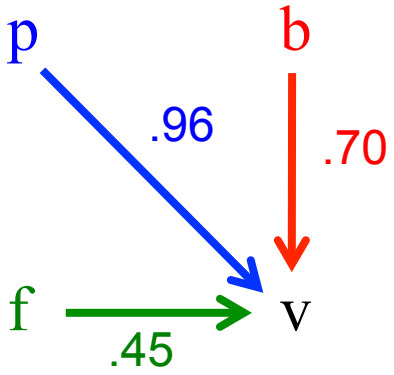
RESULTS (GENERALIZATION PHASE)

Potentially Saltatory condition

Input:



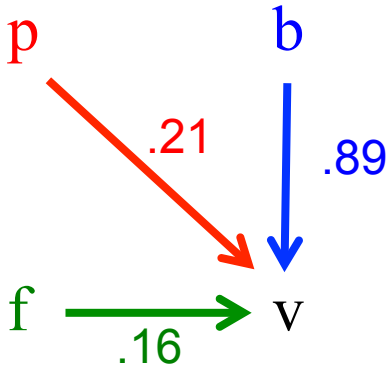
Results:



Control condition

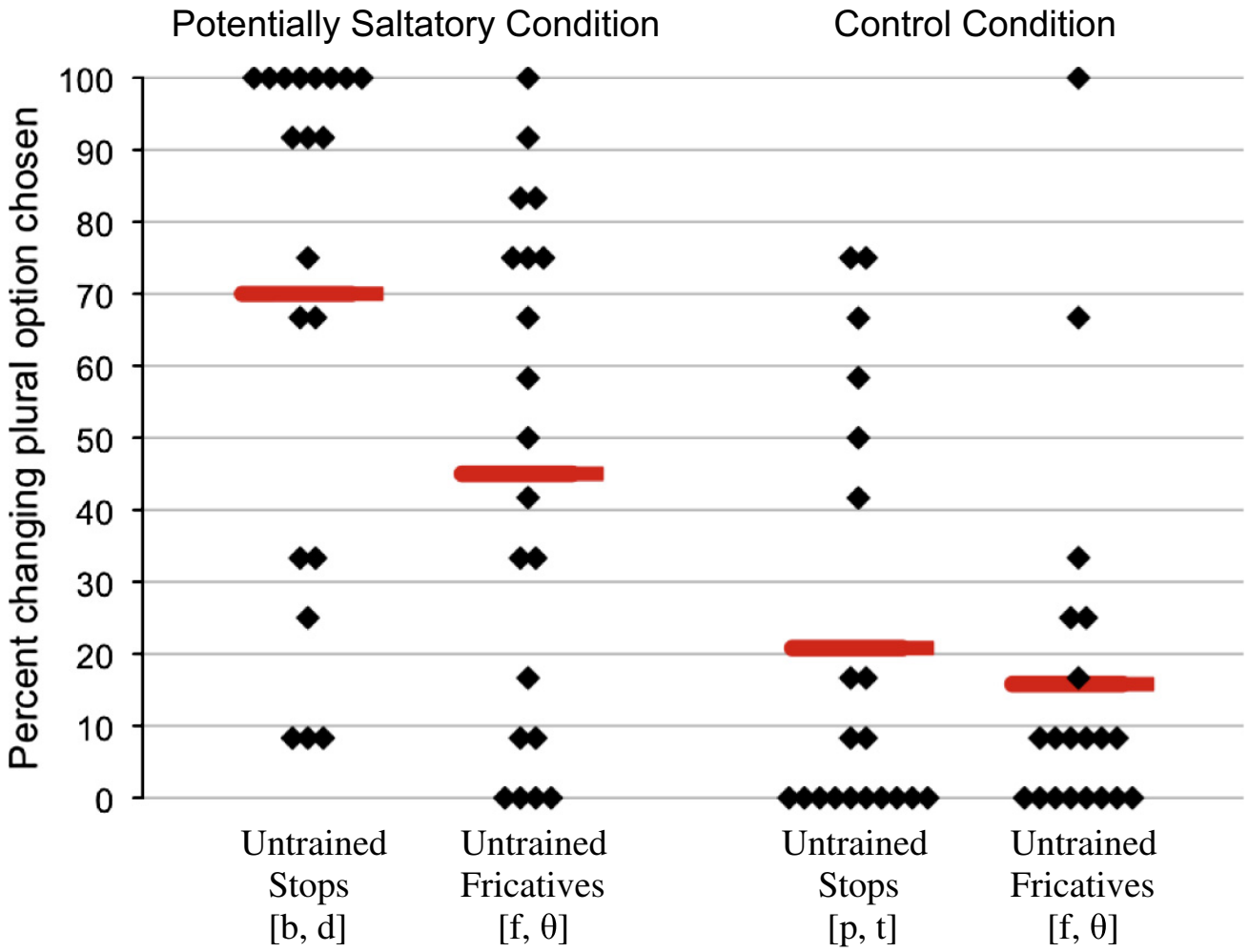
Input:

Results:



White (2014), *Cognition*

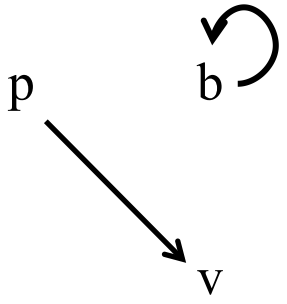
INDIVIDUAL RESULTS



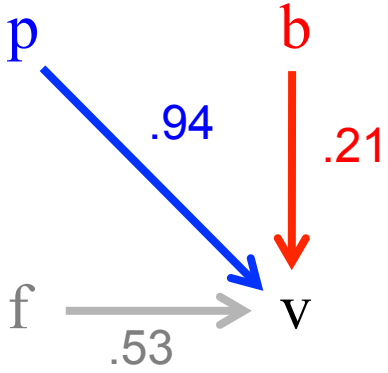
EXP. 2

Explicitly Saltatory condition

Input:

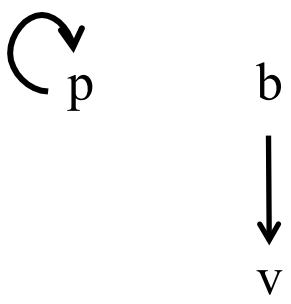


Results:

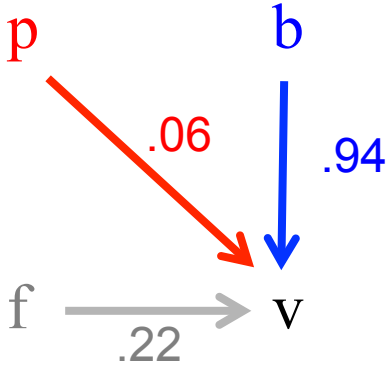


Control condition

Input:



Results:



White (2014), *Cognition*

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