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Acoustic Memory, Phonological Memory and Attention Control in L2 Speech Perception

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Introduction

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Cross-linguistic phonetic similarity affects:

- L2 perception
- accurate formation of L2 categories
- L2 production

Why?

- L1 phonetic prototypes function as perceptual "magnets"
- Perceptual assimilation to the most similar L1 phoneme

What to do?

- Phonetic differences between L1 and L2 must be discerned to form a new L2 phonetic category

Individuals vary in L2 speech learning and ultimate attainment in L2 pronunciation

Kuhl, 1994; Best, 1995; Flege, 1995

Factors affecting L2 speech learning

- Age of L2 learning (Long, 1990; Flege *et al.*, 1995, 1999)
- Quality and quantity of input (Flege, 2009; Moyer, 2009)
- Amount of L1/L2 use (MacKay *et al.*, 2001; Piske *et al.*, 2001)
- Individual differences (Gardner, 1985): affective, personality-related AND

- Individual differences in cognitive ability:
- aptitude (Skehan, 1998; Robinson, 2005)
- phonetic talent (Jilka *et al.*, 2007)
- musical ability (Gottfried, 2007; Isaacs & Trofimovich, 2011)
- working memory (Kormos & Safar, 2008)
- phonological short-term memory (Cerviño-Povedano & Mora, 2011; MacKay *et al.*, 2001)

The Present Study: Focus

- Focus
- Individual differences in Phonological memory (PM), Acoustic memory (AM) and Attention Control (AC)
- Inter-subject variability in weighting of phonetic cues in speech perception
- Spanish/Catalan EFL learners difficulty in target-like perception of English /iː/ and /ɪ/ contrast

  - Single Category assimilation
    English /i̇ː/ - /ɪ/ to the Native /i̇/ category
  - Overreliance on duration when perceiving /i̇ː/ and /ɪ/ contrast

Best, 1995; Cerviño-Povedano & Mora, 2009; Escudero & Boersma, 2004; Flege, 1991; Mora & Fullana, 2007

The Present Study: Aim and RQ

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AIM:

- To investigate the extent to which individual differences in PM, AM and AC are related to L2 vowel perception.

RQ:

- Are L2 learners with higher cognitive ability (PM, AM and AC) better able to rely on spectral information than lower ability learners in the perception of the English tense-lax /iː/-/ɪ/ contrast?

Hypothesis

- Differing individual capacities in these cognitive skills involved in speech processing might partly explain inter-subject variability in L2 vowel discrimination scores.

The Present study: Method

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- Participants:

- 113 Spanish/Catalan EFL learners
- No speech disorders or hearing problems
- Self-estimated proficiency level: from intermediate to advanced

- Tasks and Procedure:

- Linguistic Background Questionnaire
- PM (Serial nonword recognition task - SNWR)
- AM (SNWR Spectrally rotated nonwords)
- AC (attention-shift task)
- Cue-weighting in L2 vowel perception (Vowel Discrimination Task)

DmDx display software
(Foster & Foster, 2003)

Phonological short-term memory (PM)

- Temporary storage of verbal–acoustic information
- Subvocal rehearsal of encoded information

Predicts:

- L1&L2 vocabulary knowledge
- L2 grammatical development
- L2 oral fluency
- L2 speech perception

ASSUMPTION: Individuals with greater PM capacity

- use more native-like L2 cue-weighting in the perception of L2 vowel contrasts
- attend to both durational and spectral information of a sound.

Baddeley & Hitch, 1974; Gathercole *at al.*, 1997; Masoura & Gathercole, 2005; French & O'Brien, 2008; O'Brien *et al.*, 2006; Cerviño-Povedano & Mora, 2011; MacKay *et al.*, 2001

The Present Study: Materials

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- Phonological memory: SNWR task

Stimuli:

- 144 one-syllable Danish CVC nonwords (AVOID Language Dominance)
- organized into 5-, 6- and 7-item length sequences,
- 8 pairs of sequences at each item length (24 pairs in total)

- Participants had to decide (within 5 seconds) whether the sequences were the same or different.
- Measure: weighted score (out of 144) (O'Brian *et al.*, 2007)

Danish	1	2	3	4	5	6	7
1	tys	dam	rød	mild	fup		
2	vul	bend	sids	påk	ryd	ham	jøb

Acoustic Memory (AM)

- Memory capacity for temporary storing of non-verbal acoustic information at pre-phonological level, i.e. prior to phonological encoding

PSTM	AM
Operates at the phonological level	acoustic/phonetic details of the speech signal
Between-category discrimination	Within-category vowel discrimination L2-L1 sound mapping

- Spanish/Catalan EFL: /iː/-/ɪ/ - within-category discrimination

ASSUMPTION: Individuals with greater AM capacity
more sensitive to differences in acoustic information between perceptually similar L2 vowels and perceptually close L2-L1 vowel pairs.

Baddeley, 2003; Isaacs & Trofimovich, 2011; Darwin & Baddeley, 1974; Pisoni, 1973; Cowan & Morse, 1986

The Present Study: Materials

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- Acoustic memory task:
- SNWR task adapted:

  Same or in a different

3-item length sequence:	
Original	Rotated

- Stimuli
- Catalan nonwords (144 nonwords) spectrally rotated using Praat
- 3-, 4-, 5- and 6-item length sequence pairs
- 32 testing trials and 2 initial warm-up trials

Spectrally Rotated Speech

- temporal and spectral complexity of ordinary speech, but NOT intelligible
- cannot be phonologically encoded, understood, repeated or sub-vocally rehearsed (Scott *et al.*, 2000)
- subjects are forced to rely only on the acoustic information
- Measure: weighted score (out of 144) (O'Brian *et al.*, 2007)

The Present Study: Materials

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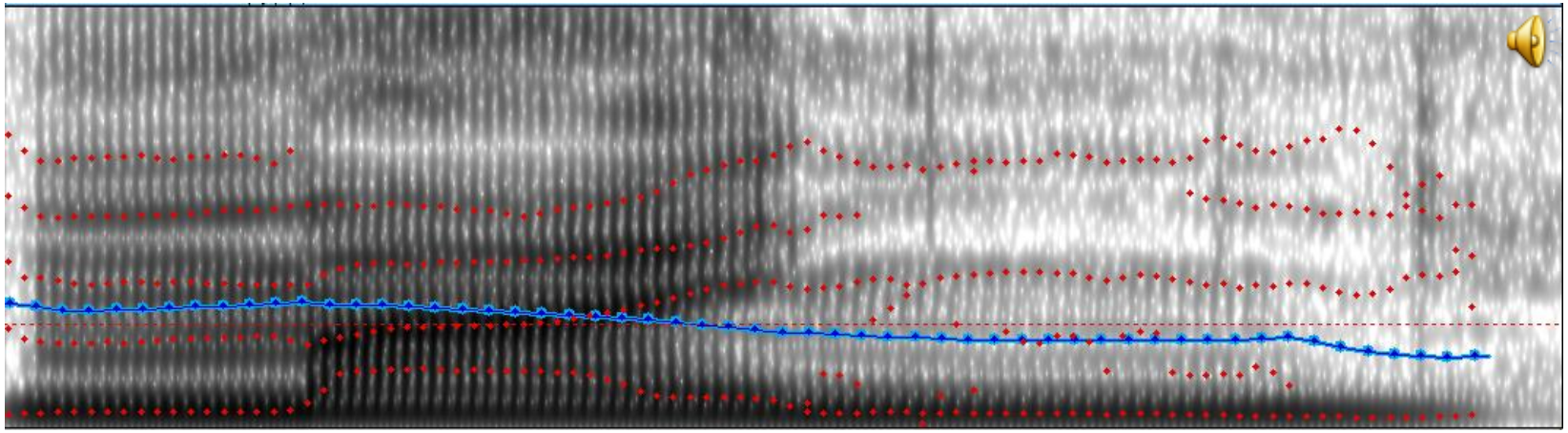
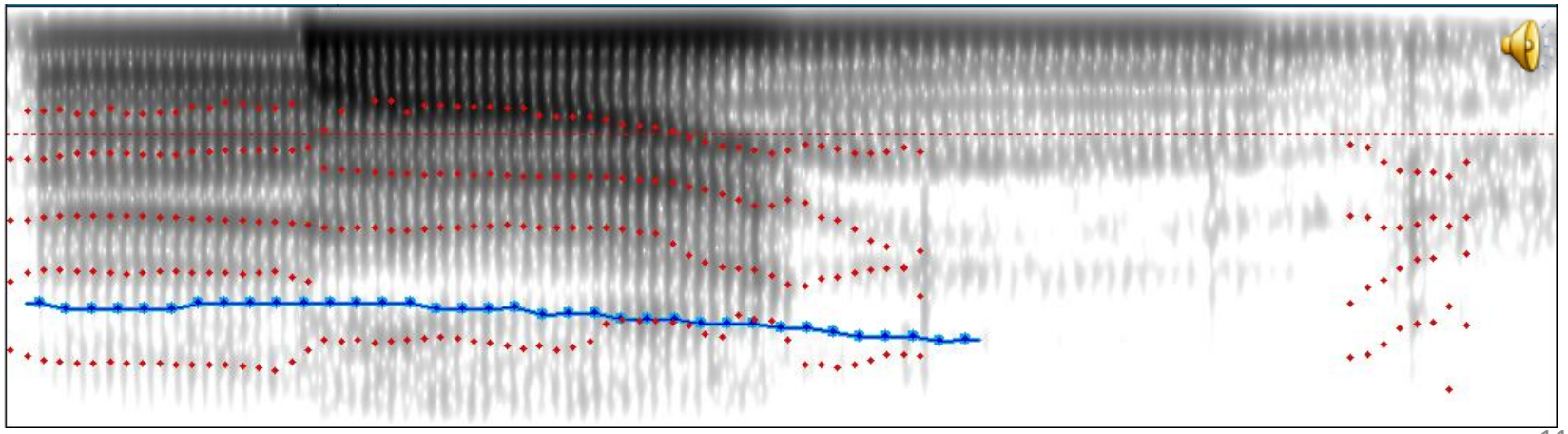
[map]



Rotated [map]



Acoustic Memory

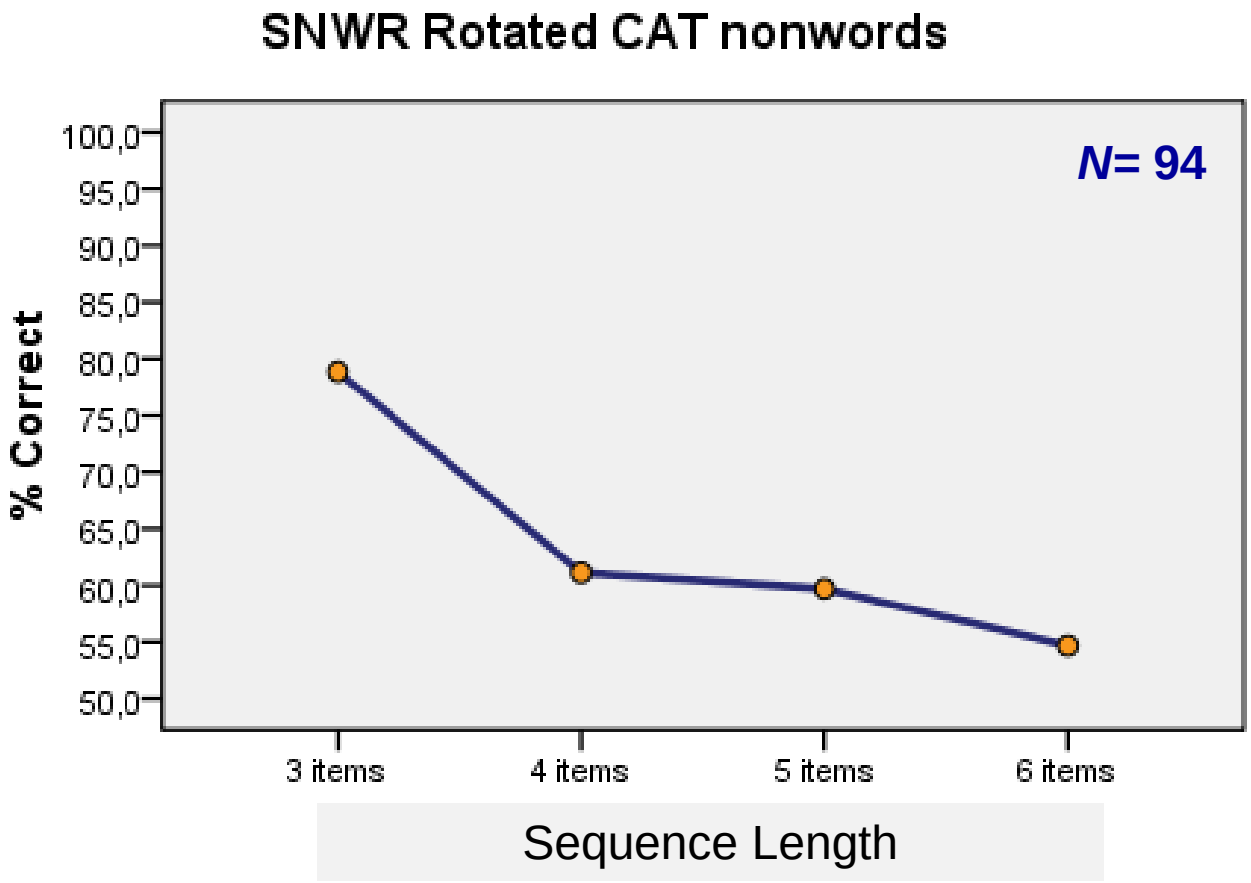
Sequences of 3 – 4 – 5 – 6 "Rotated Nonwords":

3

4

5

6



Attention Control (AC)

- L1/L2 processing – complex cognitive skill
- L1: efficient and flexible AC (automatic processing)
- L2: controlled processing (requires greater attentional resources)

AC ability to shift attention efficiently among different sets of linguistic relationships

- foregrounding/backgrounding of relevant/irrelevant linguistic info

ASSUMPTION: Individuals with higher AC capacity might be better able to rely on spectral information in the categorization of English /i:/ and /ɪ/ because they would be more successful at bringing segmental duration to the background.

(Isaacs & Trofimovich, 2011; Segalowitz, 2010; Talmy, 1996)

The Present Study: Materials

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- **Attention Control: Attention-shift task**

  A speech-based version of the alternating runs procedure

  (Rogers & Monsell, 1995; Segalowitz & Frenkiel-Fishman, 2005)

  Stimuli: 7 Catalan vowels /i e ɛ a ɔ o u/

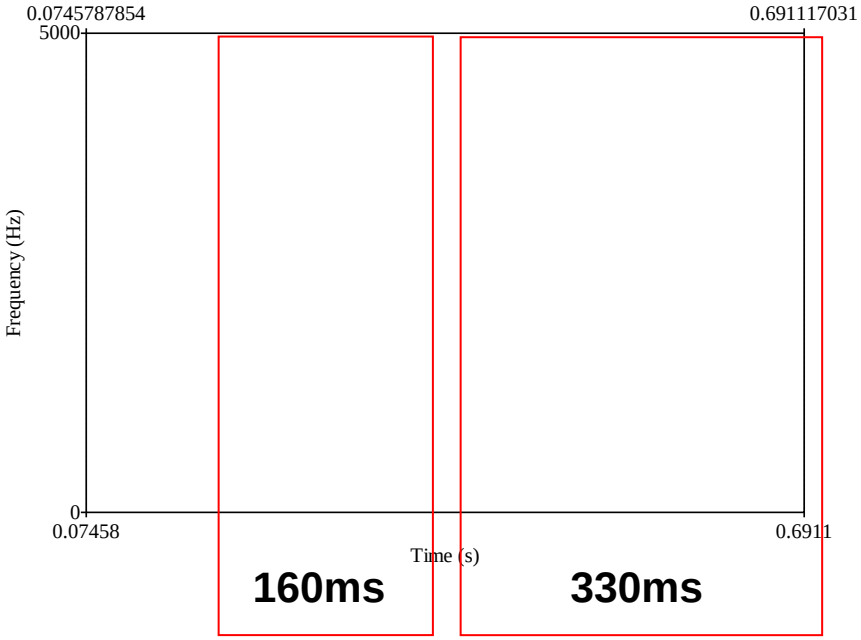
- Dimension 1: segmental duration — short (200ms) / long (500ms)
- Dimesion 2: voice quality — male / female
- 3 Practice blocks = 48 trials; Test block = 224 trials
- Picture of a 'loudspeaker'
- Auditory feedback 'beep'

- Measures:
  - Shift Cost = Shift RT (longer) – Repeat RT (shorter)
  - Error rates: Overall, Repeat, Shift

Attention-shift task

A person's ability to shift focus of attention from one speech-based attention-directing function to another

[pleɪs]



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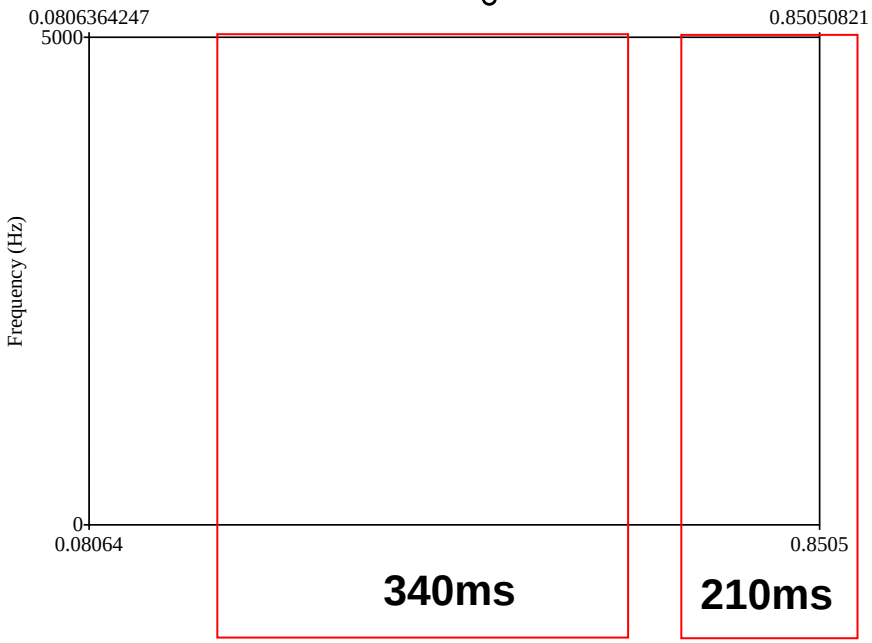
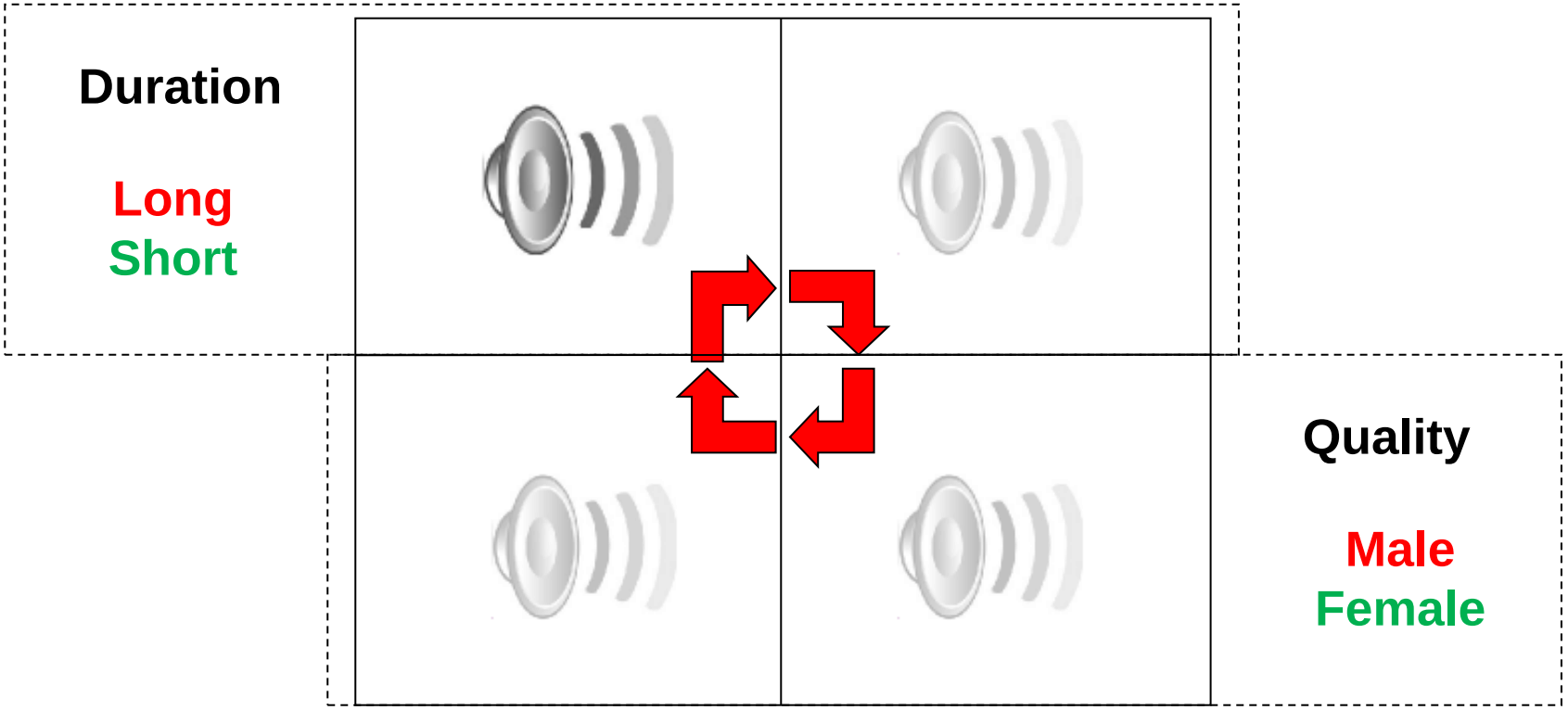


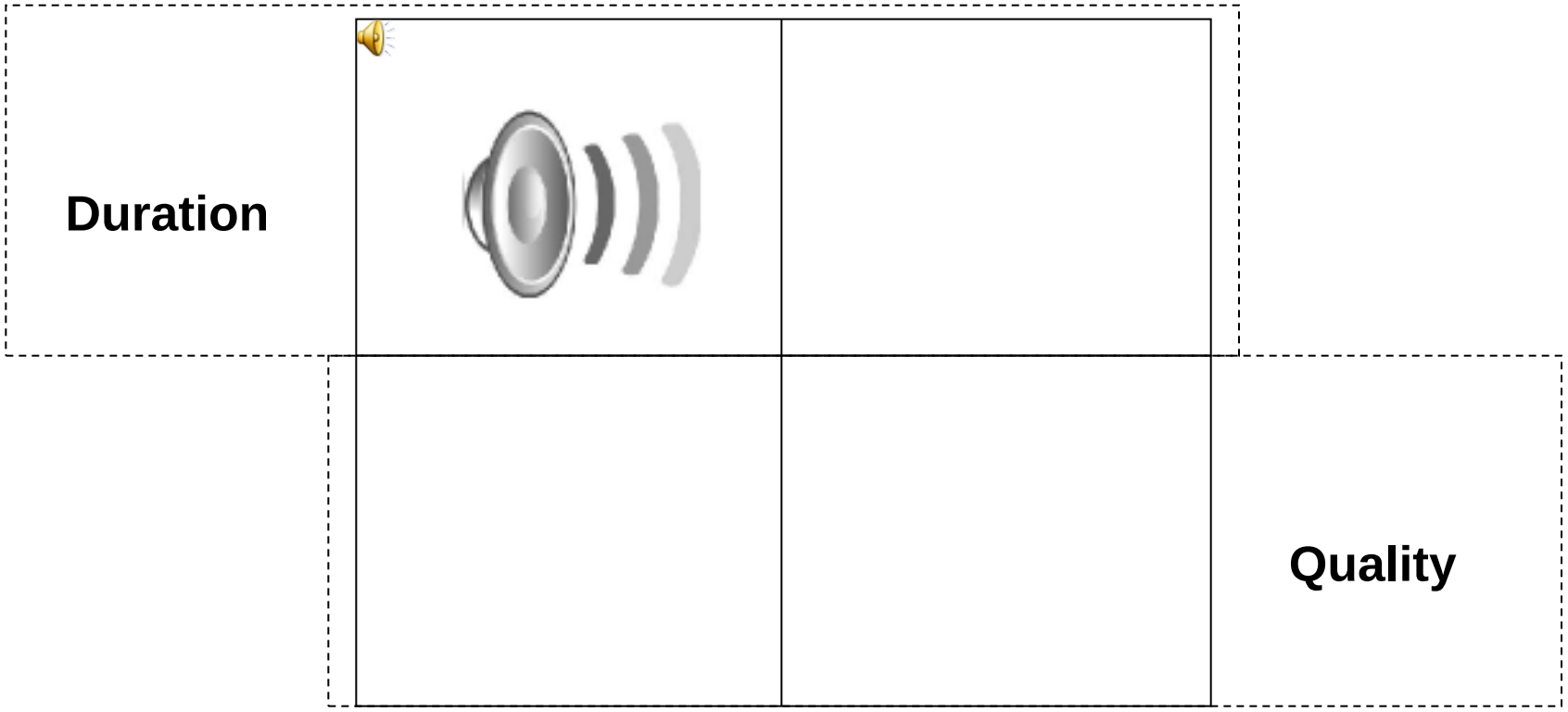
Foregrounding of duration vs. backgrounding of (partial) closure voicing in word-final obstruents.

(Safronova 2011, Safronova & Mora *forthcoming*)

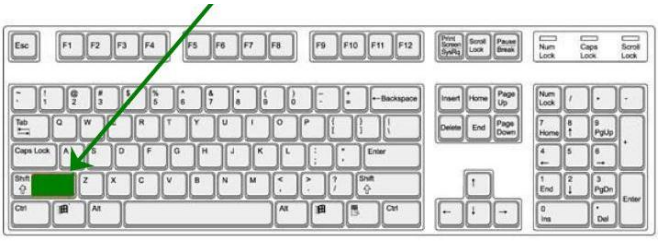
Attention-shift task



Attention-shift task

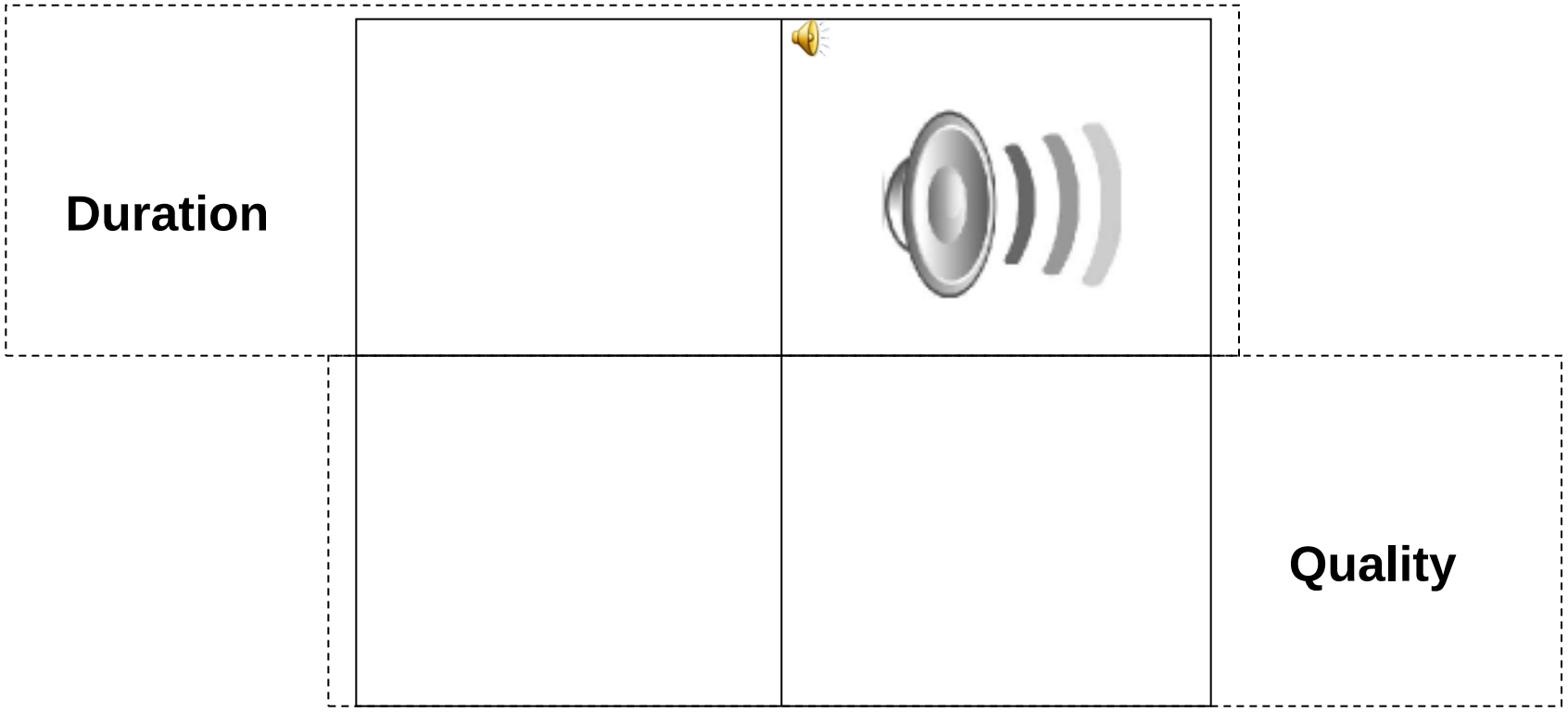


Long Left key Female

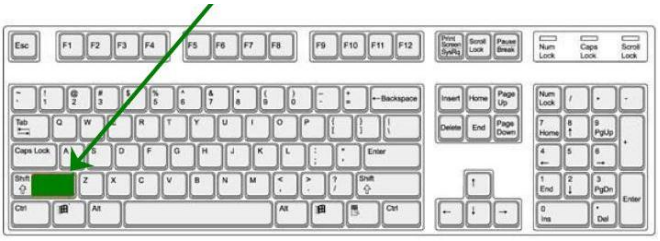


Short Right key Male

Attention-shift task

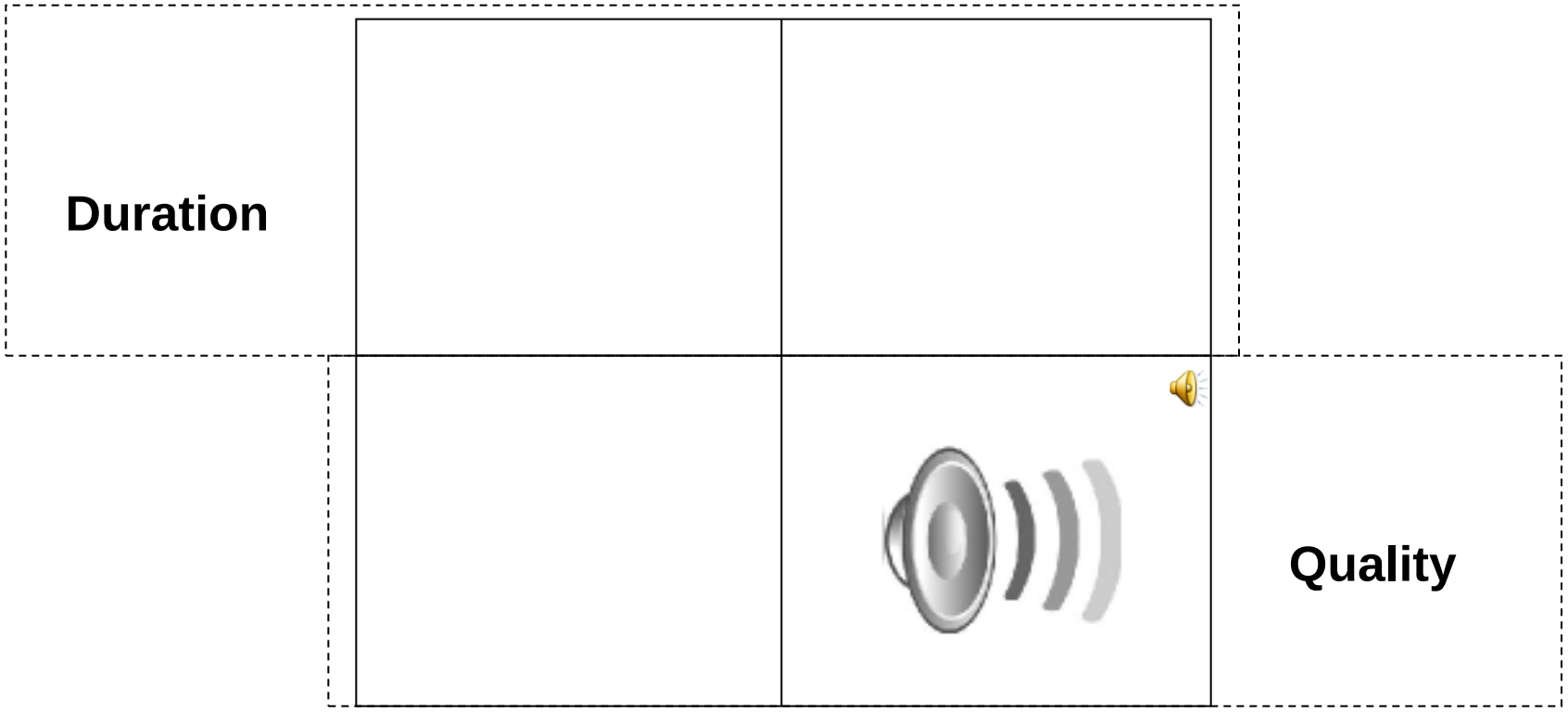


Long Left key Female

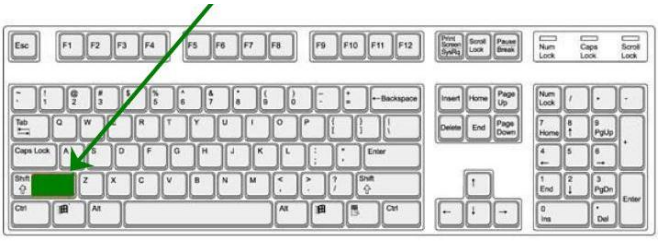


Short Right key Male

Attention-shift task

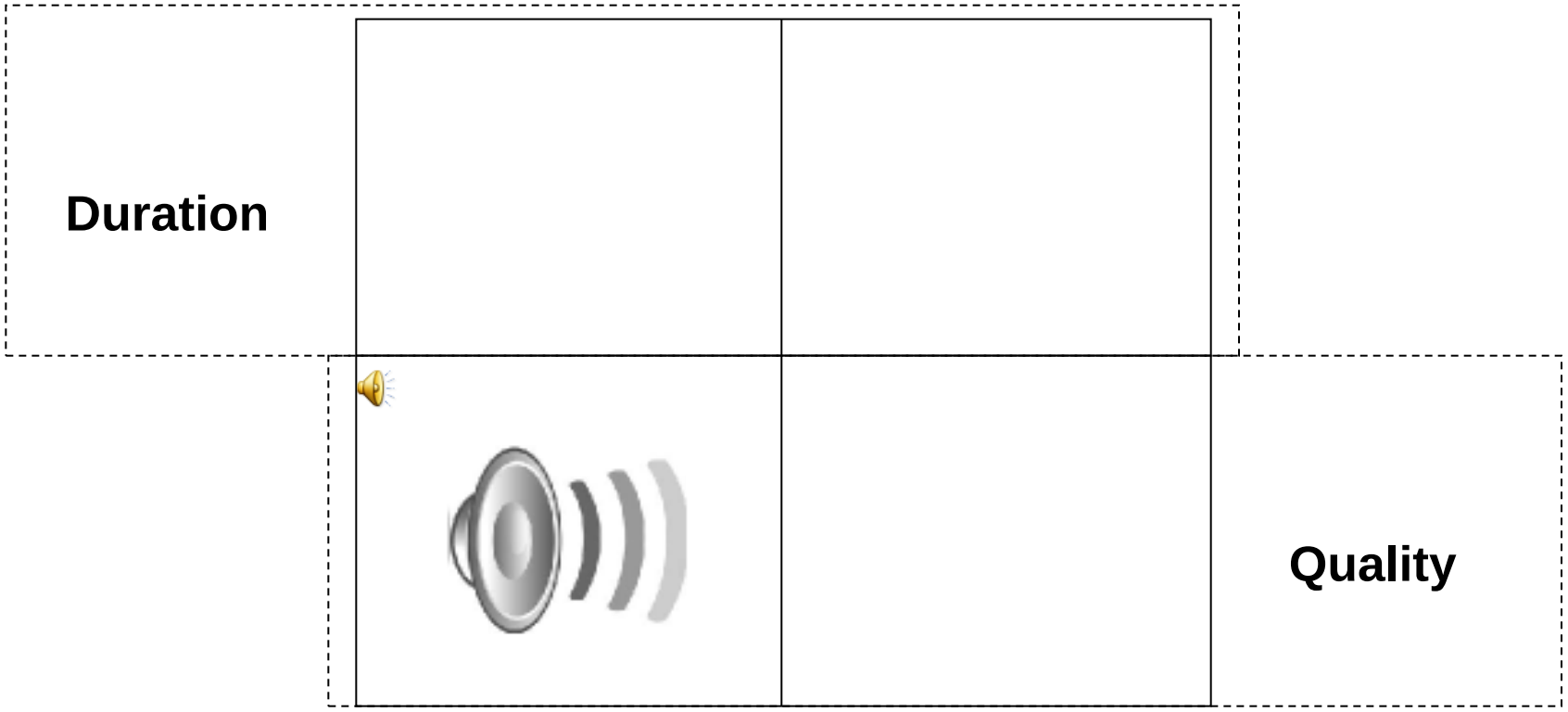


Long Left key Female

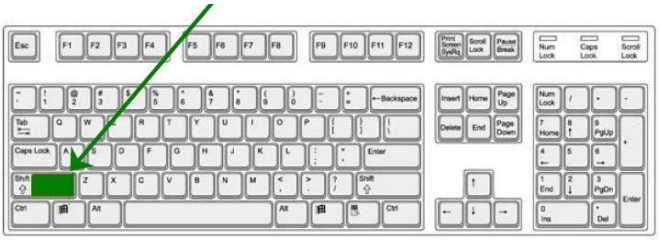


Short Right key Male

Attention-shift task

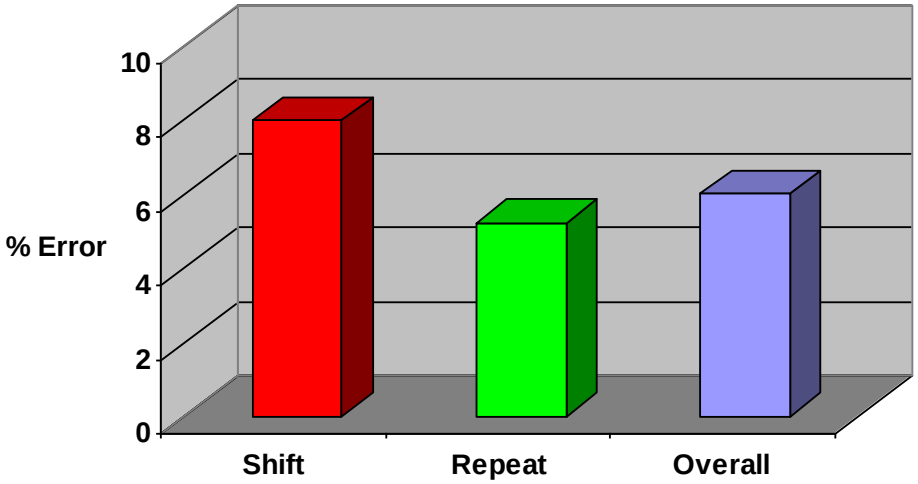


Long Left key Female

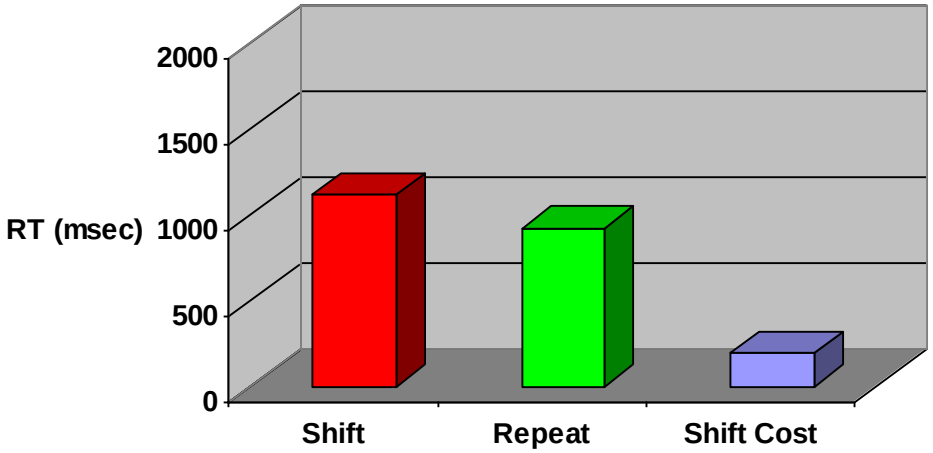


Short Right key Male

Attention Control descriptives *N*= 83



Error Rate (% ER)
S trials = 8.00
R trials = 5.23
Overall = 6.01



RTs
S RTs = 1117 ms
R RTs = 923 ms
R RTs-S RTs = 193 ms
Shift Cost (SC)

(Safronova & Mora, *forthcoming*)

The Present Study: Materials

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- Vowel Discrimination Task

FC AXB Categorial Discrimination Test (Moya-Galé & Mora, 2011)

- /i:/ and /ɪ/ in 6 CVC minimal pairs /b_d/, /d_d/, /s_d/, /b_t/, /p_k/, /p_t/
- 6 native English speakers (3 males, 3 females)
- 72 natural and 72 duration manipulated stimuli
- Different tokens within trial
- Different speakers within trial

bead – bid –bid
(male[1] - female[3] - male[2])

Results: Correlations

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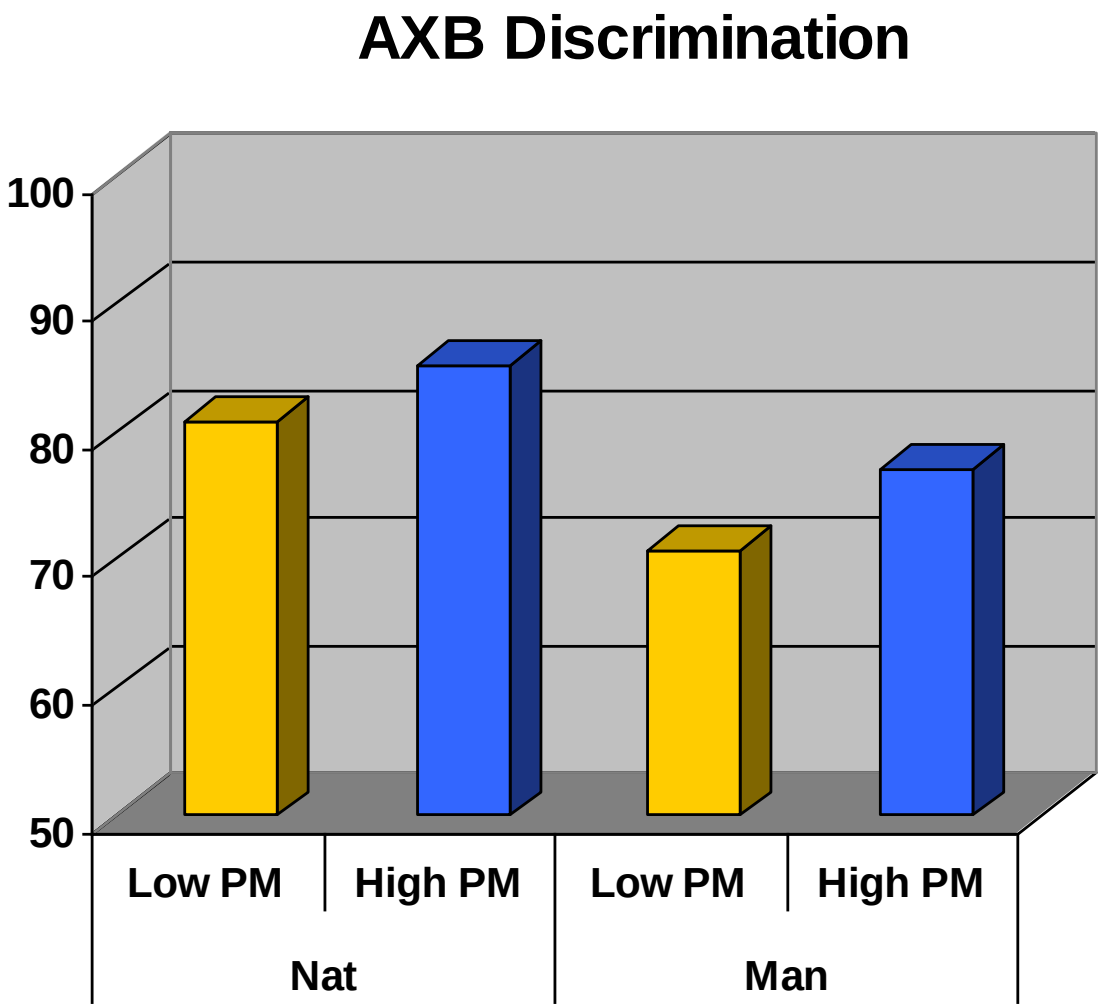
	PM	AM	AC (ERR)	AC (SC)	DIS (NAT)	DIS (MAN)
PM		.361**	-.410**	-.065	.198	.194
AM			-.466**	.048	.502**	.435**
AC (ERR)				.176	-.431**	-.476**
AC (SC)					-.039	-.159
DIS (NAT)						.760**

** Correlation is significant at .001 level

Results: Phonological Memory



Pearson r	PM
DIS Nat n.s.	.198
DIS Man n.s.	.194

ANOVA
within: Nat/Man *p*<.001
between: Low/High n.s.

Group differences:
Low PM (*N*=33)
High PM (*N*=28)
Nat: *p*=.435
Man: *p*=.098

(Safronova 2011, Safronova & Mora *forthcoming*)

Results: Phonological Memory

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Previous Reserach:

Greater PM capacity may provide learners with an advantage
(Mora & Cerviño-Povedano, 2010)

Present Study: **NON-significant**

Methodological issues:

- nature of the SNWR task.
- may be more directly involved in ID (than in DIS)
- language knowledge effects.
- cross-language differences in vowel and consonant inventory size.

Results: Acoustic Memory

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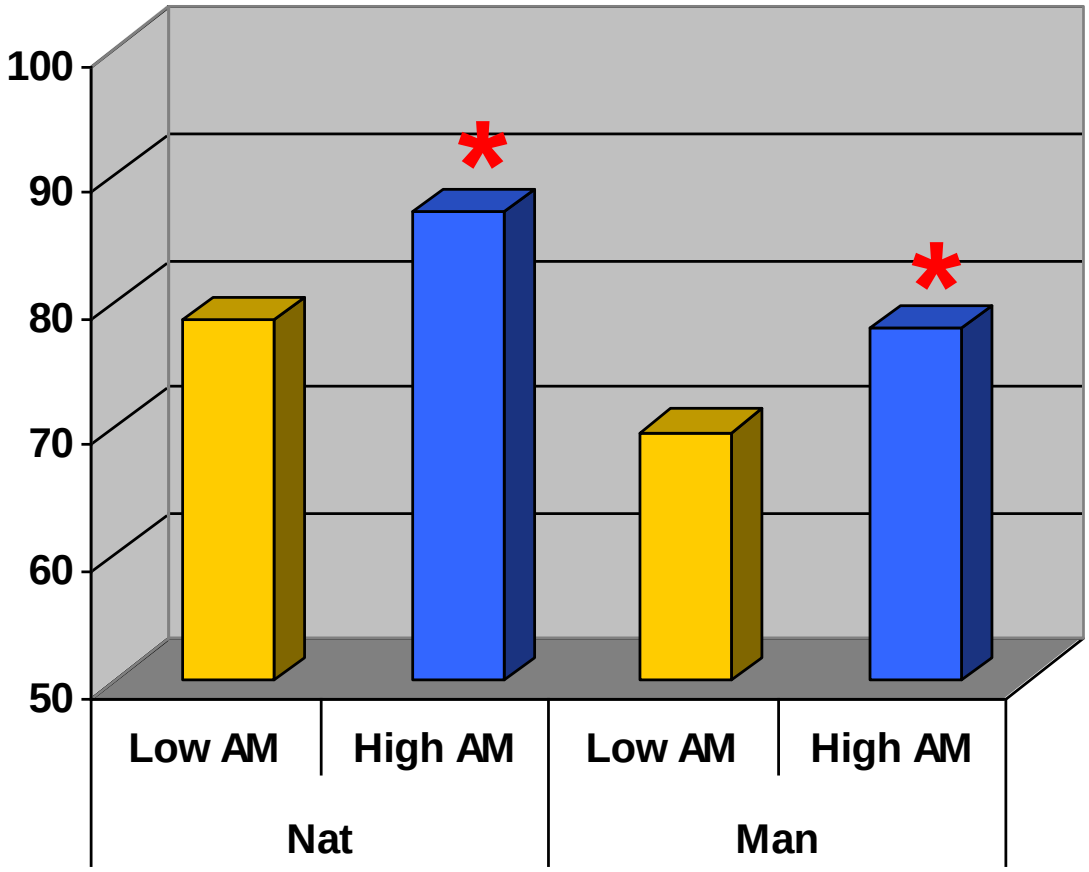
AXB Discrimination



Pearson r	AM
DIS Nat	.502***
DIS Man	.435**

ANOVA
within: Nat/Man *p*<.001
between: Low/High *p*=.009

Group differences:
Low AM (*N*=27)
High AM (*N*=39)
Nat: *p*=.007
Man: *p*=.010

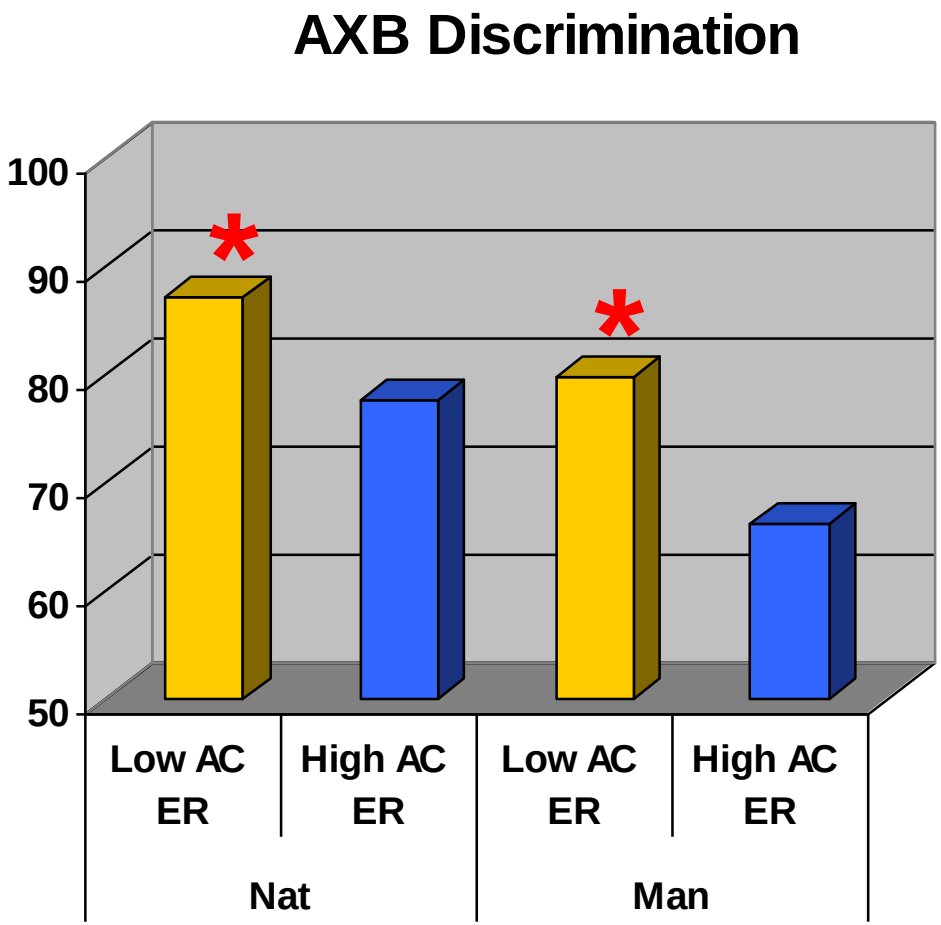
Results: Acoustic Memory

Greater AM capacity may provide learners with an advantage in perceptual cue-weighting in L2 speech.

Methodological issues:

- sequence item length and ISI probably needs adjusting
- may be more directly involved in DIS (than in ID)

Results: AC
Error Rate



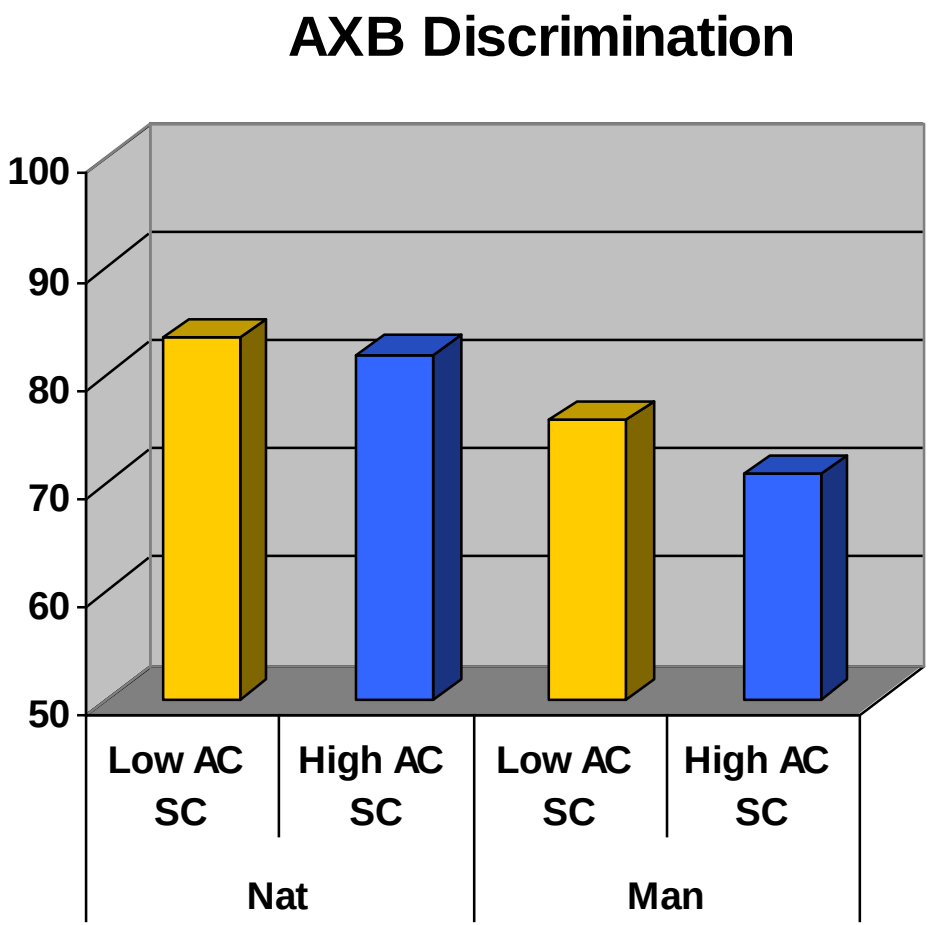
Pearson r	AC ER
DIS Nat	-.431**
DIS Man	-.476**

ANOVAs
within: Nat/Man $p<.001$
between: Low/High $p<.001$

Group differences:
Low AC ER (*N*=32)
High AC ER (*N*=28)
Nat: $p=.002$
Man: $p<.001$

(Safronova & Mora, *forthcoming*)

Results: AC
Shift Cost



Pearson r	AC SC
DIS Nat n.s.	-.039
DIS Man n.s.	-.159

ANOVAs
within: Nat/Man *p*<.001
between: Low/High n.s.

Group differences:
Low AC SC (*N*=30)
High AC SC (*N*=30)
Nat: *p*=.572
Man: *p*=.209

(Safronova & Mora, *forthcoming*)

Results: AC

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Greater AC may provide learners with an advantage

- in perceptual cue-weighting in L2 speech
- in phonetic training involving backgrounding and foregrounding of L2-specific use of acustic features

Methodological issues:

- speech dimensions need to be operationalized more accurately.
- participants focused mainly on accurate performance (feedback)

Results: Regression

- **R^2=.286 (28.6%); *p*=.001 (Nat)**
- **R^2=.285 (28.5%); *p*=.001 (Man)**

	% Unique variance explained	*p*=		
PM	**0.01**	**.945**	NAT	AXB Discrimination
	0.03	**.881**	MAN	
AM	**11.3**	**.007**	NAT	
	4.9	**.070**	MAN	
AC (**Error Rate**)	**3.5**	**.123**	NAT	
	9.5	**.013**	MAN	

Results: Regression

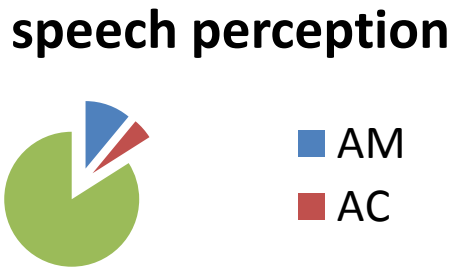
- **R^2=.258 (25.8%); *p*=.002 (Nat)**
- **R^2=.236 (23.6%); *p*=.004 (Man)**

	% Unique variance explained	*p*=		
PM	**0.23**	**.696**	NAT	AXB Discrimination
	0.55	**.552**	MAN	
AM	**20.4**	**.001**	NAT	
	14.6	**.003**	MAN	
AC (**Shift Cost**)	**0.7**	**.510**	NAT	
	4.5	**.092**	MAN	

Conclusions

AM and AC

- involved in the processing of L2 speech
- may facilitate target-like cue-weighting
- may explain inter-learner variation in L2 phonological attainment



Future research:

- Solve methodological issues
- Other cognitive abilities: E.g. ability for oral mimicry
- Focus on both: L2 speech perception and production

Thank you!

Acknowledgments:

Participants in this study
Eva Cerviño-Povedano
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