От звука к смыслу: Влияние контекста на разрешение фоно-лексической неоднозначности

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From sound to meaning: The role of context in resolution of phonolexical ambiguity

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Listening comprehension is one of the most difficult aspects of L2 acquisition

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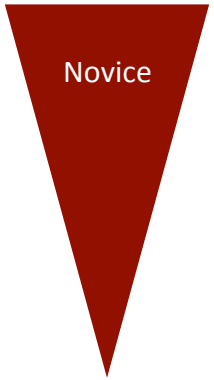

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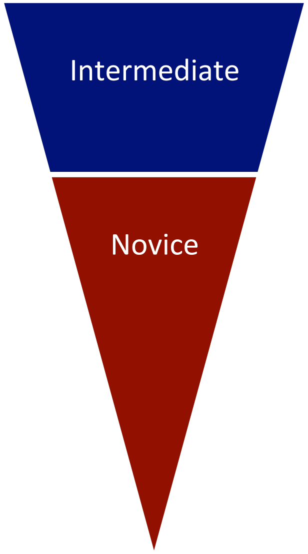

Listening comprehension is one of the most difficult aspects of L2 acquisition

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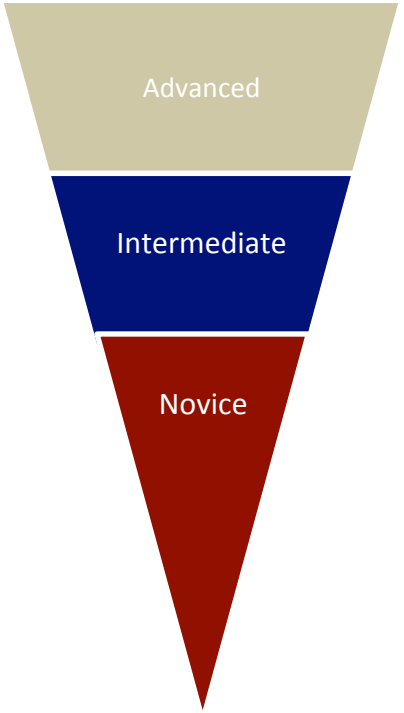

Listening comprehension is one of the most difficult aspects of L2 acquisition

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blah ???? blah blah blah blah blah
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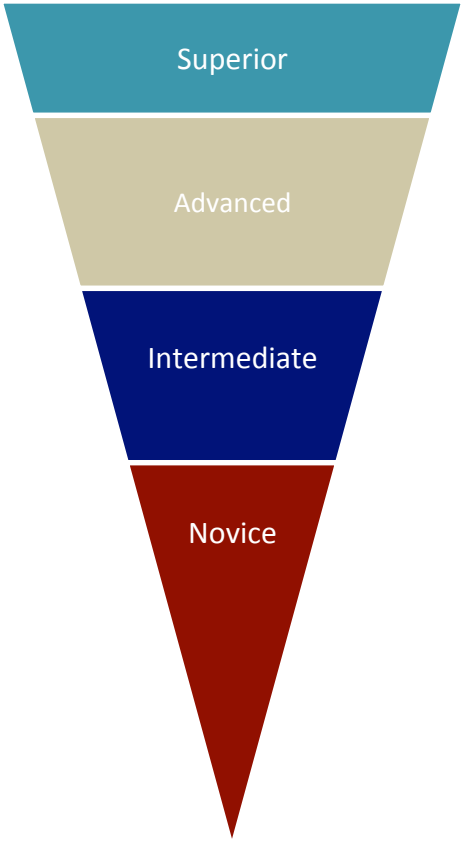


What makes L2 speech comprehension difficult?

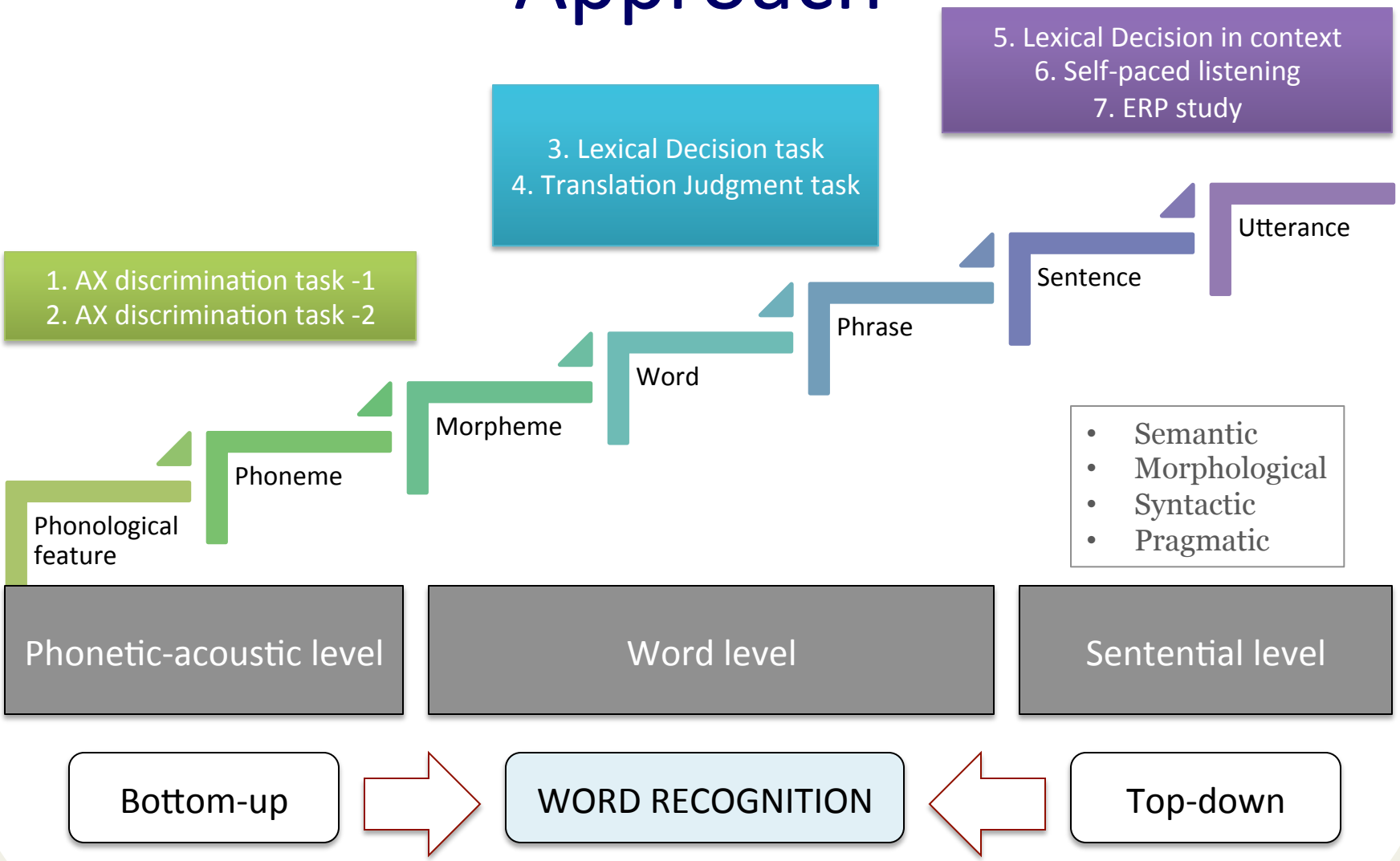
- Speed: *An adult listener can encode up to 25-30 phonetic segments/second and recognize up to 180 wpm*
- No repetition, cannot easily go back
- Continuous, not easily segmented: *therearenospacesbetweenwords*
- Non-linear: *Sounds overlap, speech reduction/deletion, smeared acoustic features*
- Lack of invariance: *Speaker variation, Coarticulation effects → No single acoustic cue is reliably present for any given phoneme (e.g., string, tin, cat)*
- Each phoneme has more than one acoustic cue
- Noisy

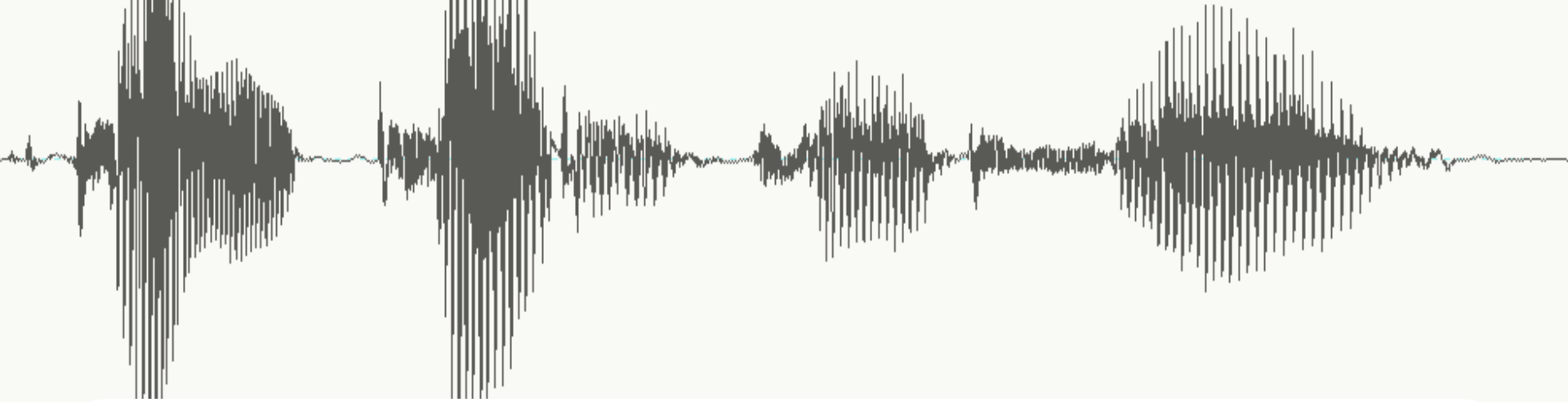
- **L1-L2 differences in sound systems**

Objectives

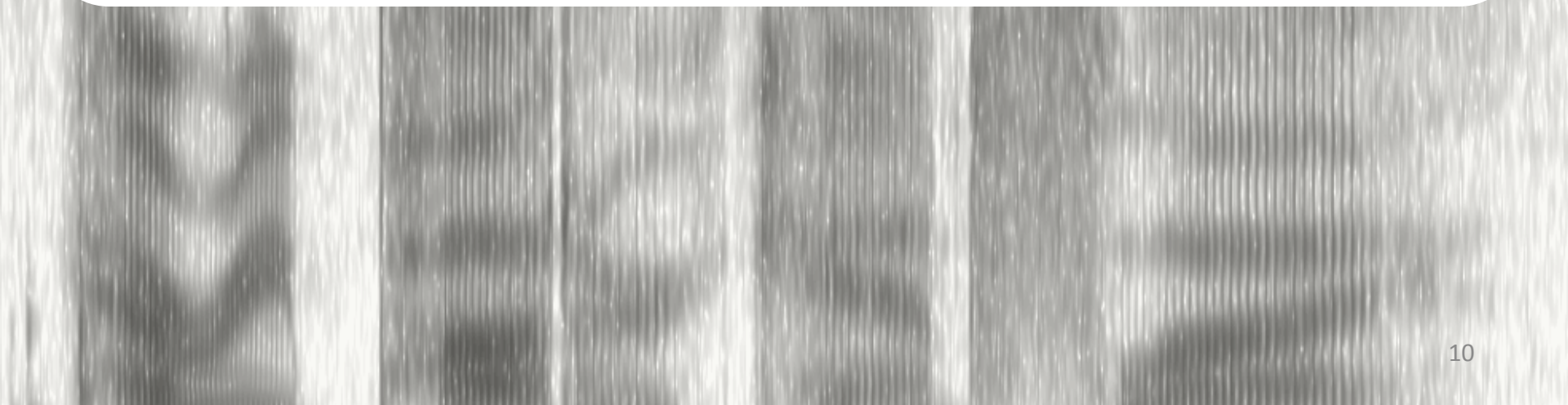
1. Identify difficult features in L2 phonology;
2. Examine what implications phonological difficulties have for the lexical level (word recognition);
3. Quantify how and under what conditions phonological difficulties are resolved (or not) in sentence comprehension.

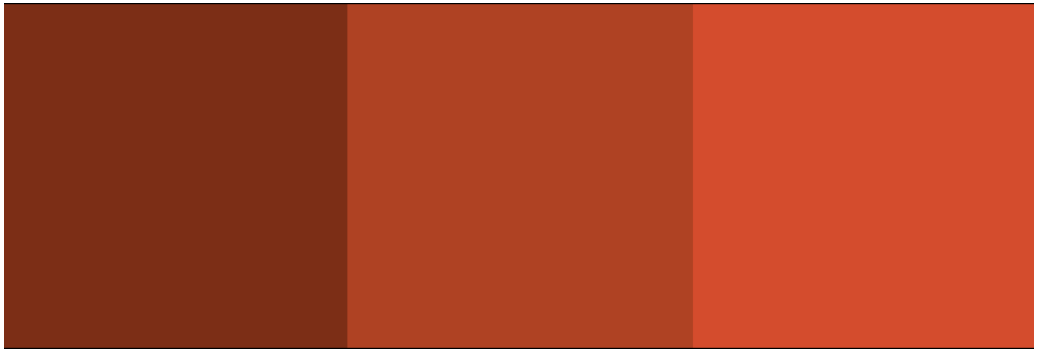
Approach

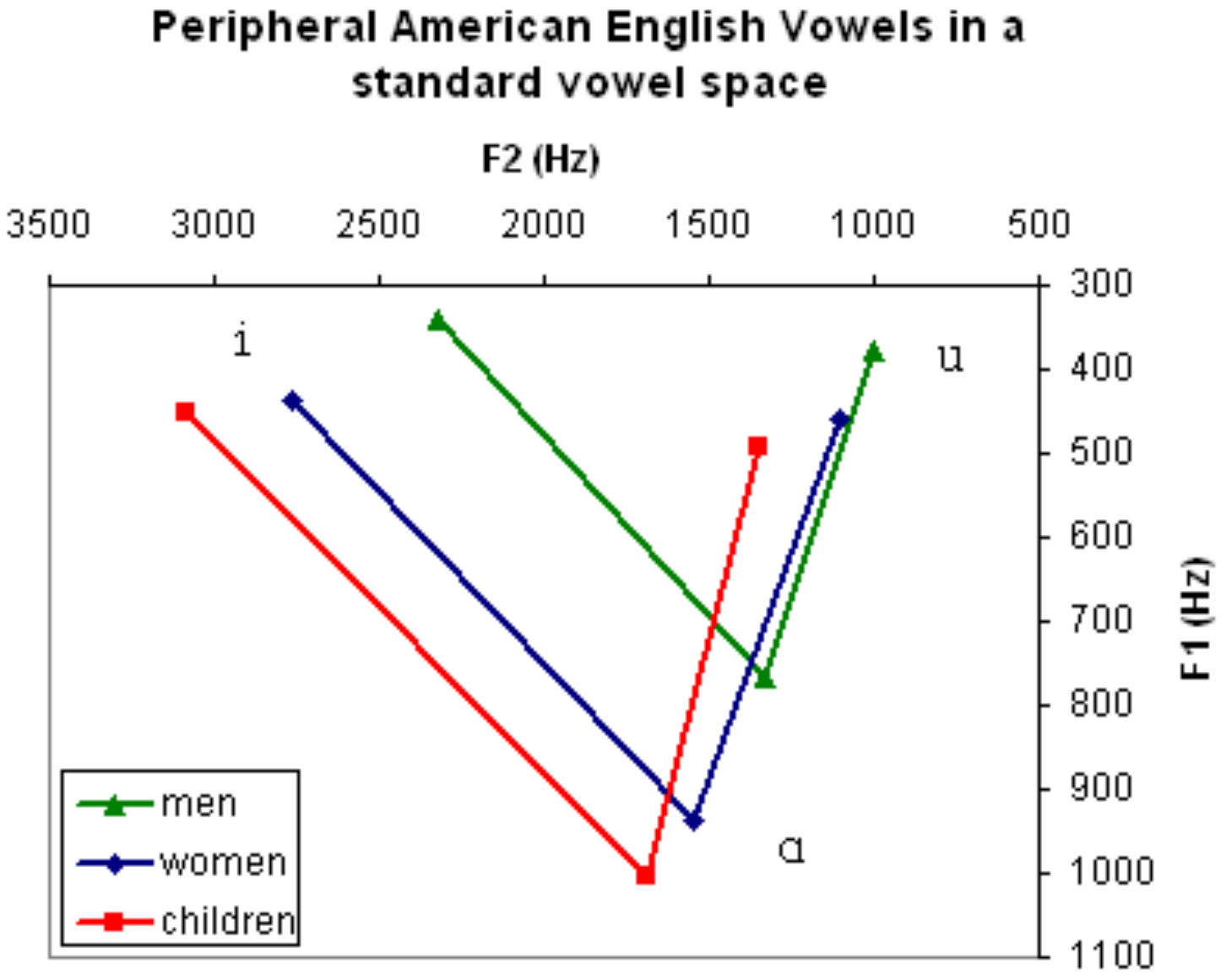

5. Lexical Decision in context
6. Self-paced listening
7. ERP study
3. Lexical Decision task
4. Translation Judgment task
1. AX discrimination task -1
2. AX discrimination task -2
Utterance
Sentence
Phrase
Word
Morpheme
Phoneme
Phonological feature
• Semantic
• Morphological
• Syntactic
• Pragmatic
Phonetic-acoustic level
Word level
Sentential level
Bottom-up
WORD RECOGNITION
Top-down



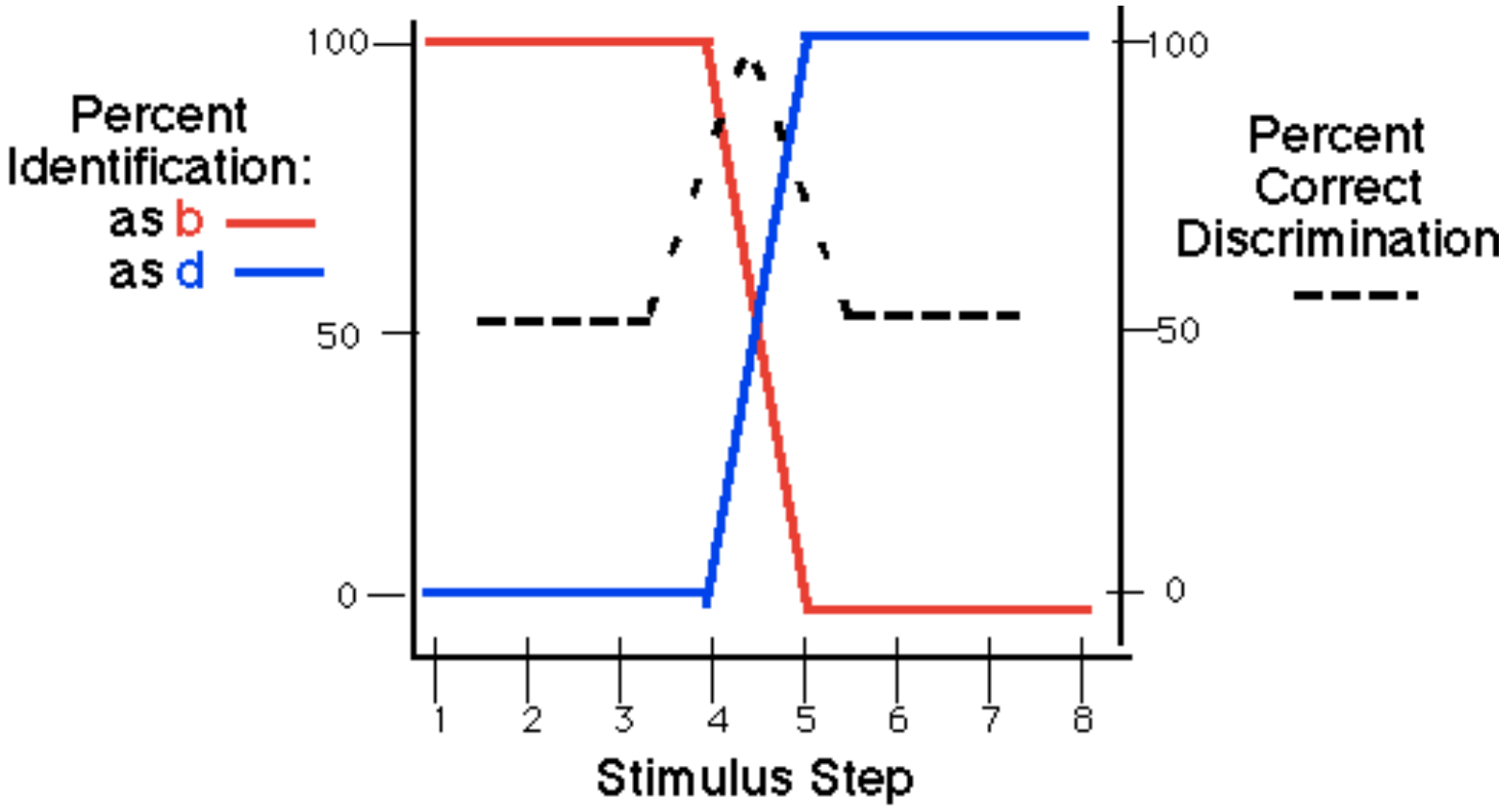
Part 1. Acoustic-phonetic level



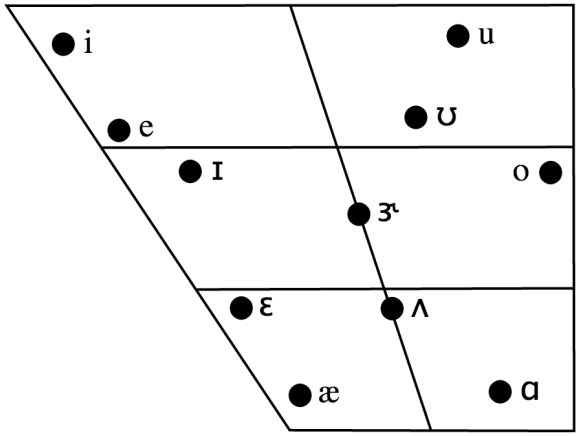


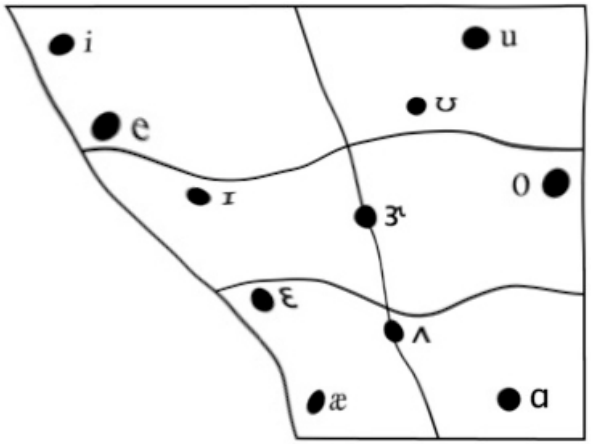

Peripheral American English Vowels in a standard vowel space
F2 (Hz)
3500
3000
2500
2000
1500
1000
500
300
400
500
600
700
800
900
1000
1100
F1 (Hz)
i
u
ɑ
men
women
children

Speech perception is categorical



L1	L2
• Categorical perception is established early in life	• L2 sounds are perceived through the prism of the already established L1 sound system
• Robust, stable phonological representations and automatic, effortless speech perception	• L2 phonetic segments which are not contrastive in L1 are miscategorized

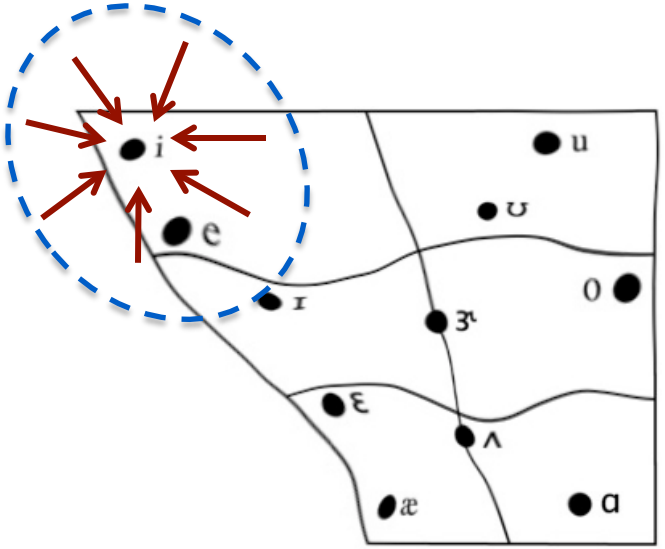




- The native phonological system acts as a 'sieve,' filtering out the phonetic properties in the L2 speech signal that are not relevant for the L1 system [Polivanov, 1931; Shcherba, 1939; Trubetzkoy, 1969];
- L1 sounds act as perceptual magnets 'absorbing' L2 sounds into the same L1 category so that L2 sounds are 'caught' in the perceptual space of the L1 prototype [Perceptual Assimilation Model (Best, 1995, Best & Tyler, 2007); Speech Learning Model (Flege, 1993); Native Language Magnet model (Kuhl, 1991)];
- Perceived similarity between L1 and L2 sounds impacts the way the new L2 sound is assimilated into the shared phonological space.

L2

- L2 sounds are perceived through the prism of the already established L1 sound system
- L2 phonetic segments which are not contrastive in L1 are miscategorized



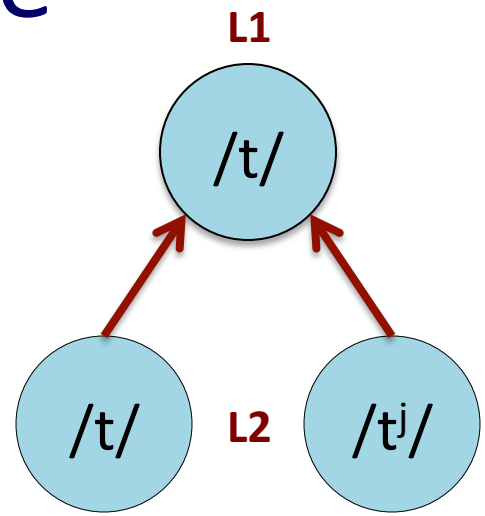
Predicted sound learning difficulties

1. **two-category pattern**: two L2 categories correspond to two separate L1 categories.
2. **category goodness pattern**: two L2 categories differ in their perceived L1 category goodness (one is closer than the other) .
3. **single category pattern**: two L2 categories are perceived as equally good exemplars of a single L1 category.

Target feature

[± soft] consonants in Russian

мат	**мать**
/mat/	/mat^{j}/
«checkmate»	«mother»



Target feature properties

- Used contrastively;
- Permeates almost the entire consonantal system: 15 pairs; *ш, ж, ц* (always hard); *щ, ч, й* (always soft);
- Does not have one single articulatory or acoustic correlate for all consonants;
- May “flow” at the syllable level (in CV position);
- It is the vowel that accommodates itself to the consonants, not the consonant, like in English;
- Difficult for L2 speakers [Bondarko, 2005; Kochetov, 2002].

Exp.1. AX discrimination - 1

Objective: *to measure the level of perceptual difficulty of the hard/ soft consonant contrasts for speakers of L2 Russian with* ***intermediate*** *proficiency (ILR 1+, 2), N(L1)=10, N(L2)=10*

Manipulations

Critical contrast:

p-p^{j}, t-t^{j}

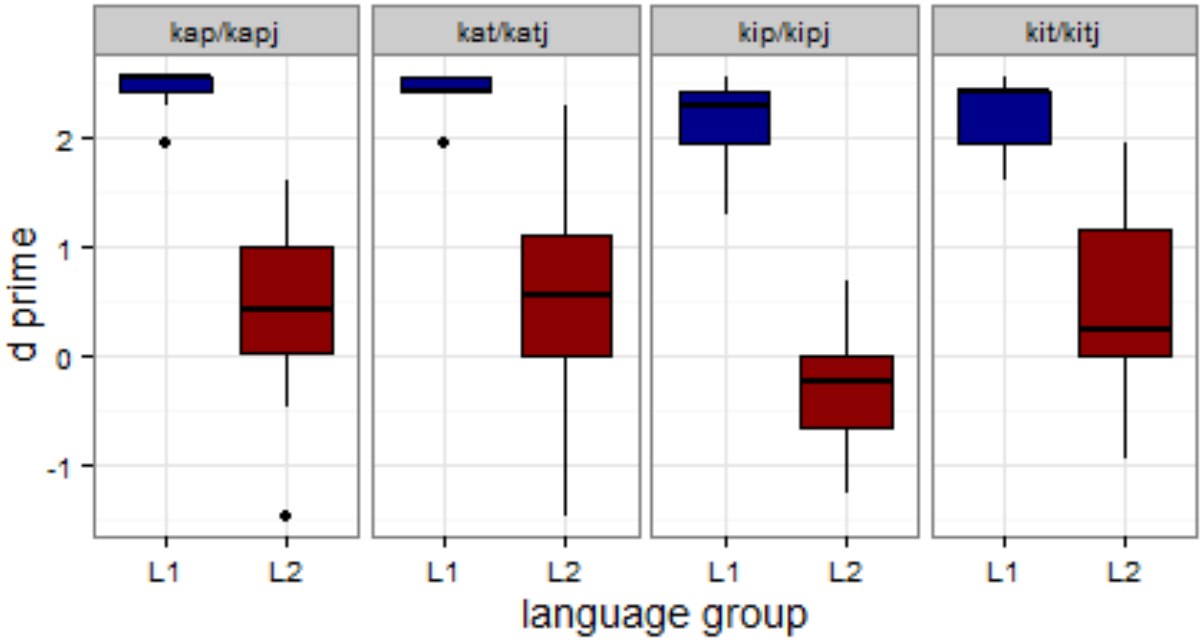
Word position:

#CV, VC#

Vowel: a, i

Items: N=224

Multiple talkers



Exp.2. AX discrimination - 2

Objective: *to measure the level of perceptual difficulty of the hard/ soft consonant contrasts for speakers of L2 Russian with* ***advanced-superior*** *proficiency (ILR 2+, 3, 3+), N(L1)=12, N(L2)=32*

Manipulations

Critical contrast:

f-f^{j}, l-l^{j}, t-t^{j}

Control contrast:

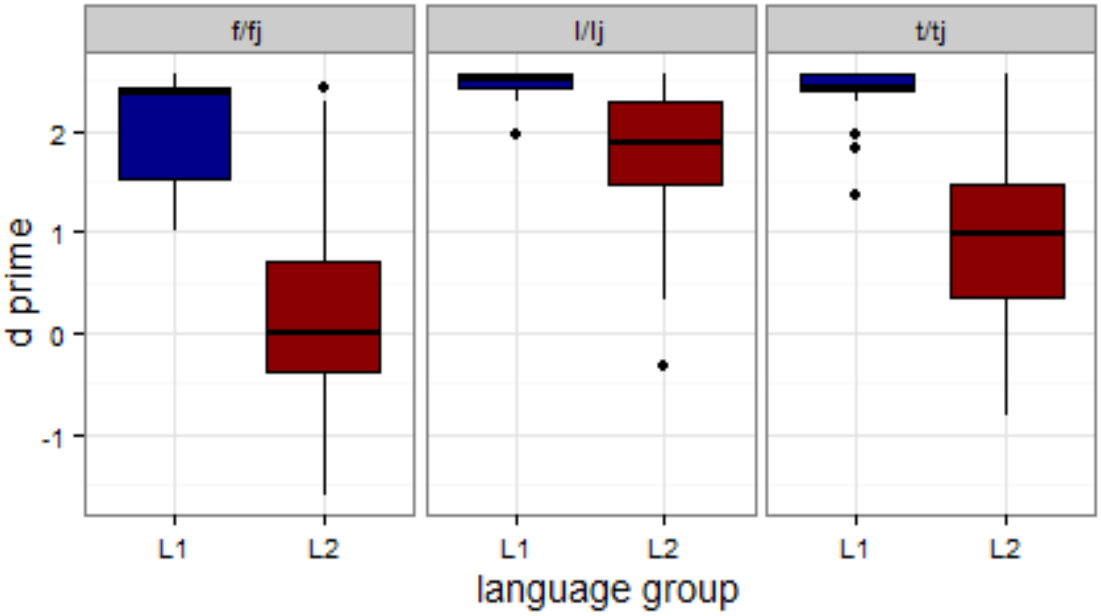
tʃ-k, s-ʃ

Word position: VC#

Vowel: a, i

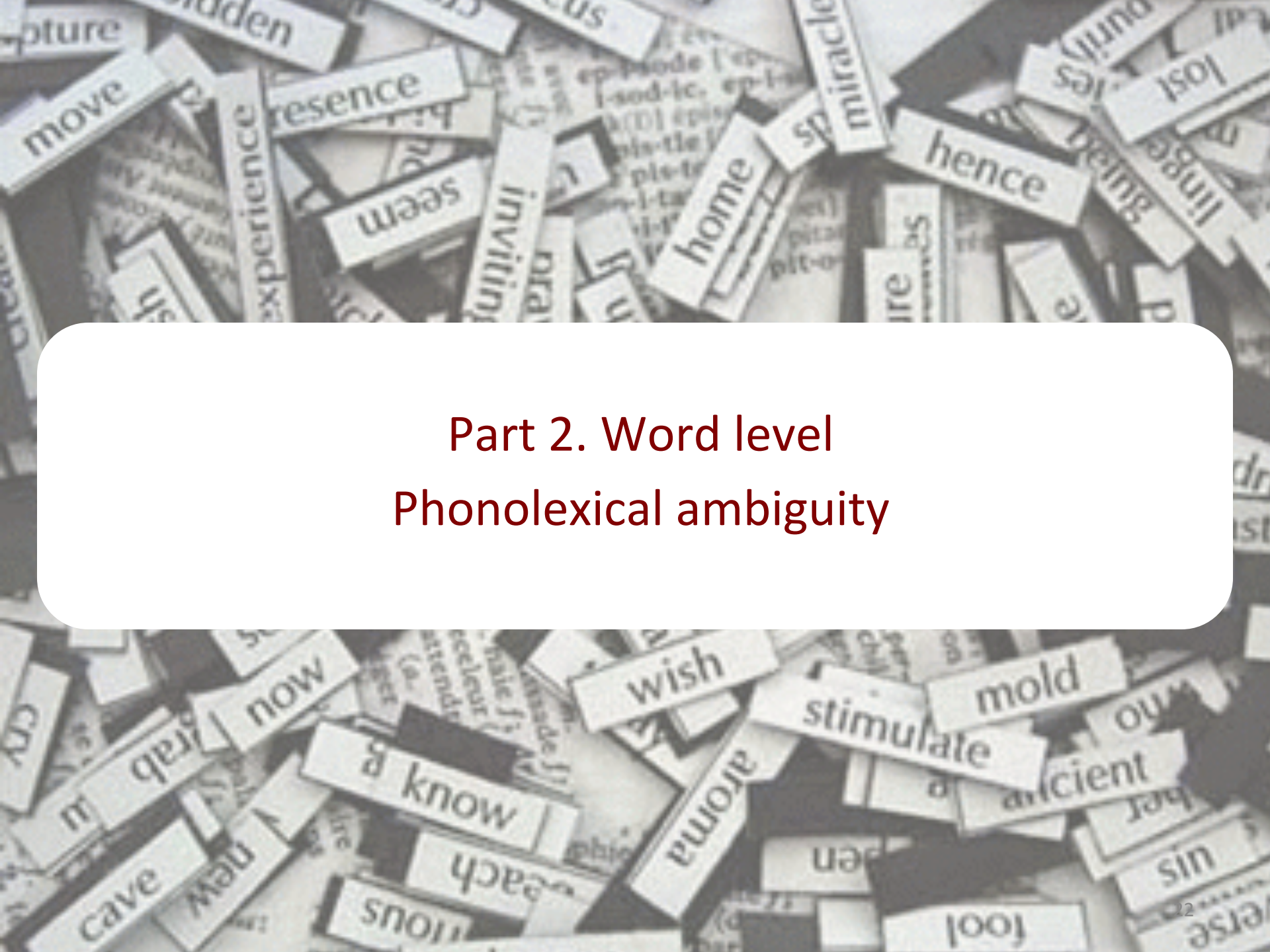
Items: N=160

Multiple talkers



Interim summary

- Unlike L1 speakers, L2 speakers experience perceptual difficulties with the Russian hard and soft consonant contrasts even at high levels of proficiency;
- Perceptual difficulty of the phonological feature of consonantal softness for L2 listeners is not instantiated equally for all consonants; it depends on the properties of an individual consonant, such as place and manner of articulation (Kochetov, 2002); not all contrasts are homophonous.



Part 2. Word level

Phonolexical ambiguity

Why does it matter?

"Listeners suffer from the difficulties of sound perception only to the extent that their word recognition and speech comprehension is affected." [Broersma & Cutler, 2011]

Principle №1: Bottom-up priority

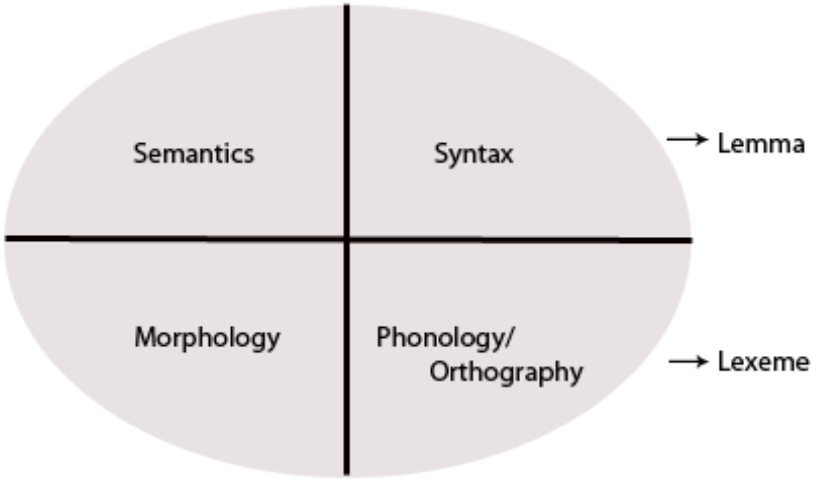
"A sequence of sounds is much like the combination to a safe; the tumblers in a combination lock fall into place as the correct sequence of rotations is performed."
[Altmann, 1997]

Phonological information = activation code to the mental lexicon.

Lexical Representation

- Successful word recognition is contingent on the ability of the phonological system to encode and categorize acoustic/phonetic information efficiently and accurately in order to prevent activation of irrelevant candidates and not to overload the lexical system.
- Traditionally, lexical representations contain only contrastive information about the phonological structure of words (i.e. phonemes)

PHONOLOGICAL AMBIGUITY → LEXICAL AMBIGUITY?



[Levelt, 1989]

So does this mean that when L2 speakers experience perceptual difficulties with certain L2 phonological contrasts, pairs of words that differ minimally with respect to a given contrast get encoded as homophones in the learner lexicon?

Exp.3. Auditory Lexical Decision Task

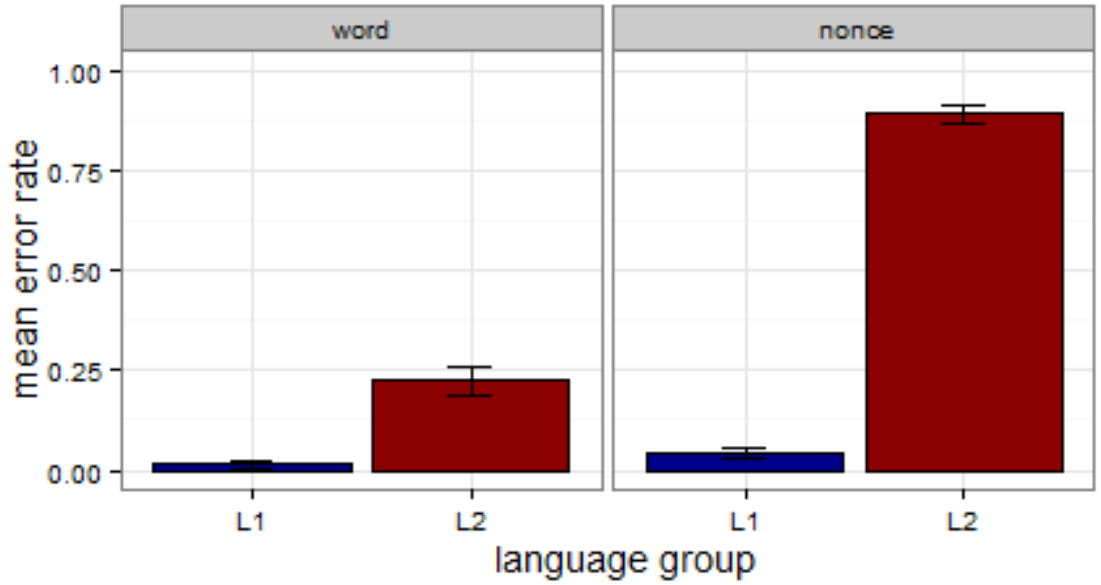
Objective: *to examine whether perceptual difficulties extend to the lexical level for speakers of L2 Russian with* ***advanced-superior*** *proficiency (ILR 2-3+), N(L1)=22, N(L2)=22*

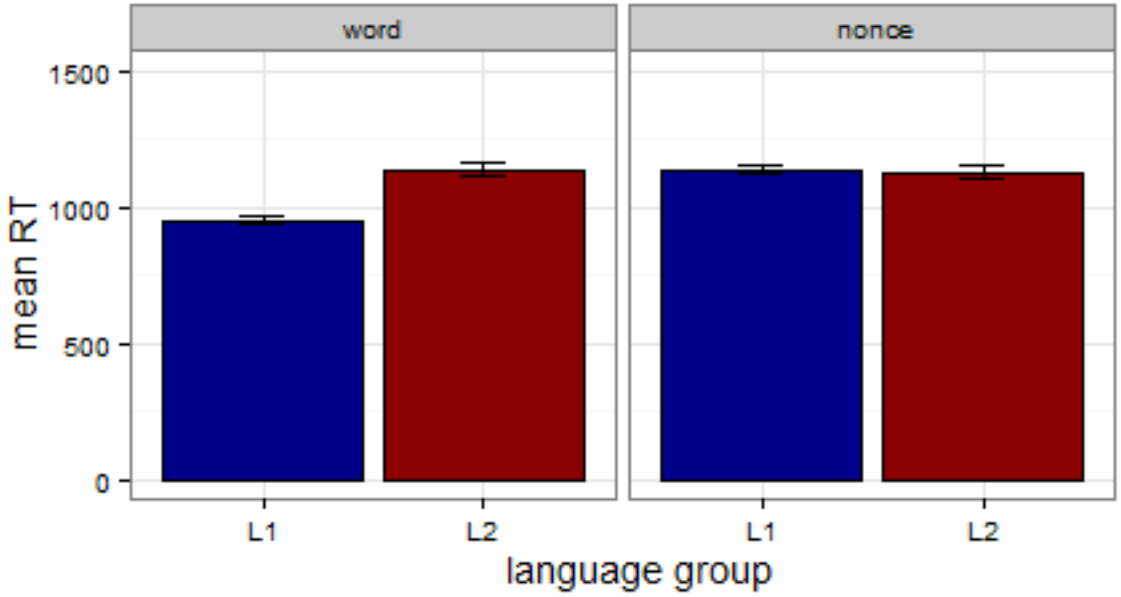
Manipulations

- Lexical status (words vs. nonwords)
- Stem manipulation in nonwords:
  - Hard-to-soft substitutions: ***сын*** (‘son’) → ***сынь*** (nonword)
  - Soft-to-hard substitutions: ***дверь*** (‘door’) → ***двер*** (nonword)

Predictions

If L2 learners do not have robust representations for the hard/soft distinction, they should incorrectly accept the nonwords with manipulated stems as real words more often than native speakers.


word
nonce
1.00
0.75
0.50
0.25
0.00
mean error rate
L1
L2
L1
L2
language group


word
nonce
1500
1000
500
0
mean RT
L1
L2
L1
L2
language group

Exp.4. Translation Judgment Task

Objective:

- to provide additional information on the degree of ambiguity and confusability of words with hard/soft consonant contrast (translation provides more precise evidence than lexical decision);
- to examine whether L2 speakers accept nonwords as real Russian words as a result of phonolexical ambiguity.

Participants: N = 34 (M age 29.5, range 21-50; 20 F)

Task

- Choose a correct English translation of the Russian word that you heard.

Materials and Design

Manipulations

- lexical status: **word, nonce**
- condition: **semantic** (мат-мать)**, morphological** (говорит-говорить)**, syntactic** (брат-брать)
- block: **critical, control**

Nonce words (matched in frequency):

- **Hard-to-soft:** *двор<u>ь</u>* (/dvor^{j}/) instead of *двор* (/dvor/, «yard»)
- **Soft-to-hard:** *двер* (/dver/) instead of *двер<u>ь</u>* (/dver^{j}/, «door»),
- **Filler**

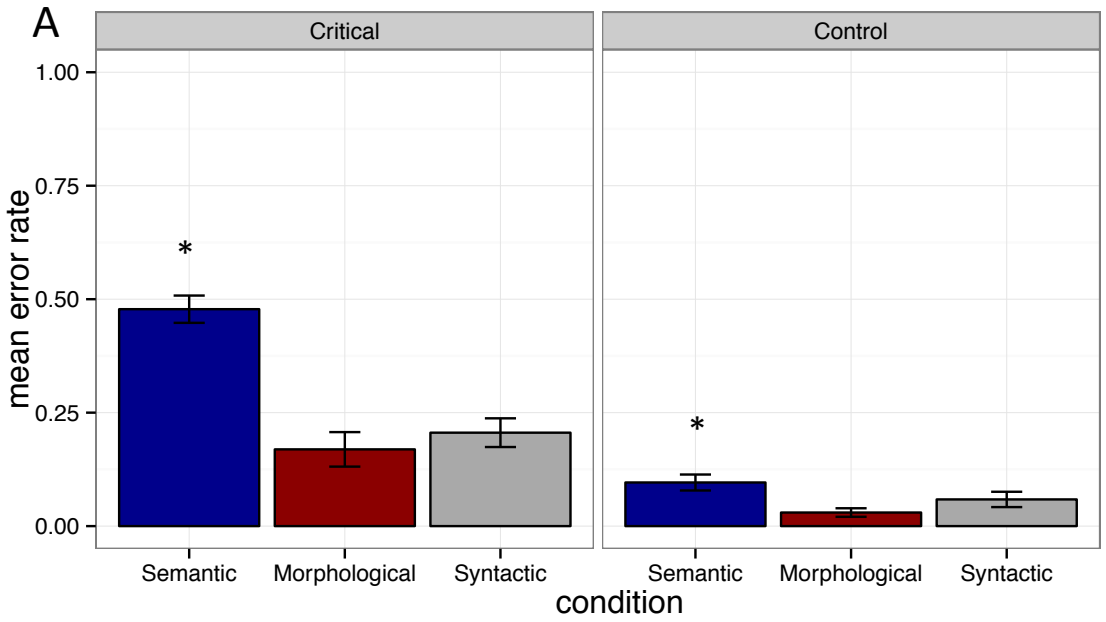
2 lists x 96 items

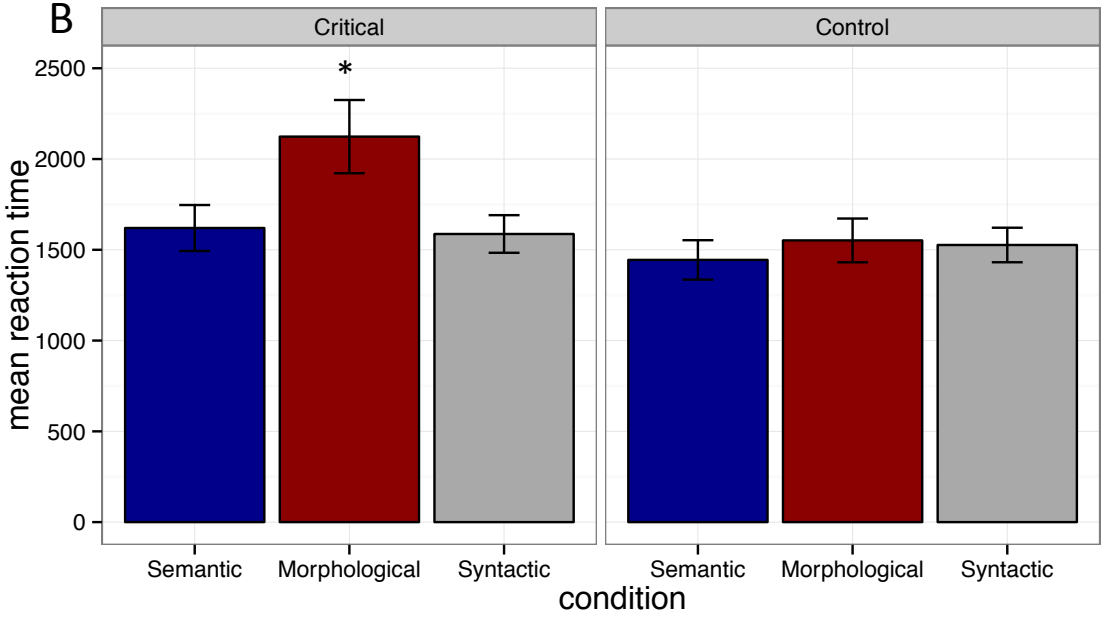
мать

(mother)

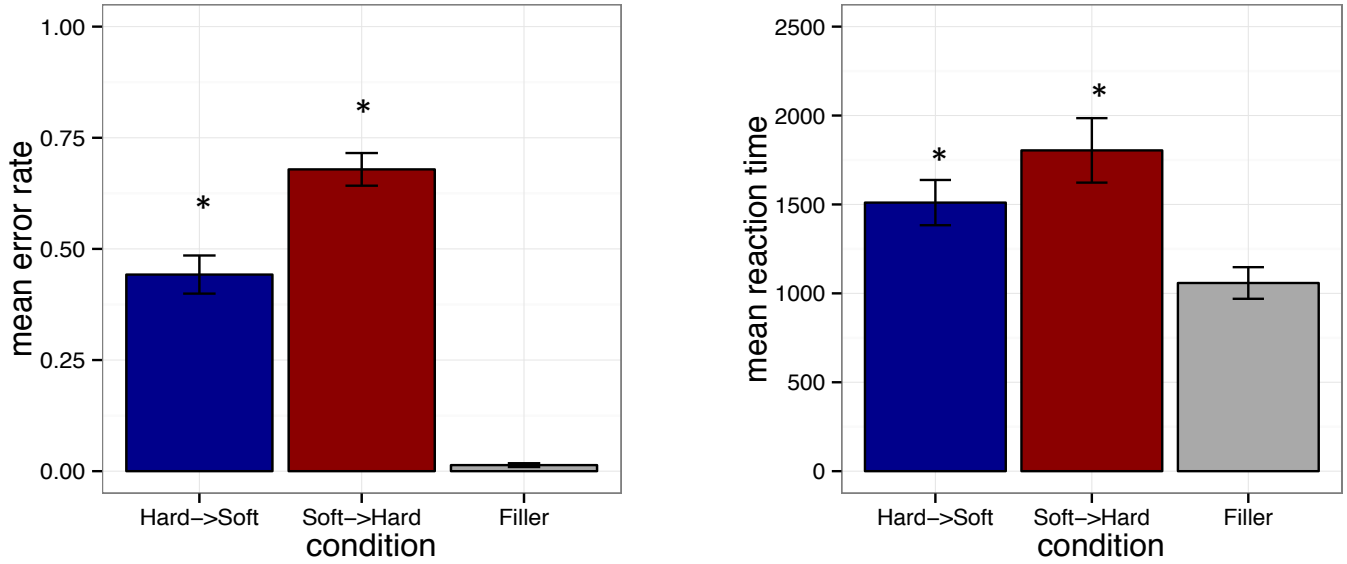
1. mother **(correct translation) –** мать
2. checkmate **(confusable) –** мат
3. father **(distractor) –** отец
4. not a word

L2 participants' mean (A) error rate and (B) reaction time for translation of real words in the translation judgment task.



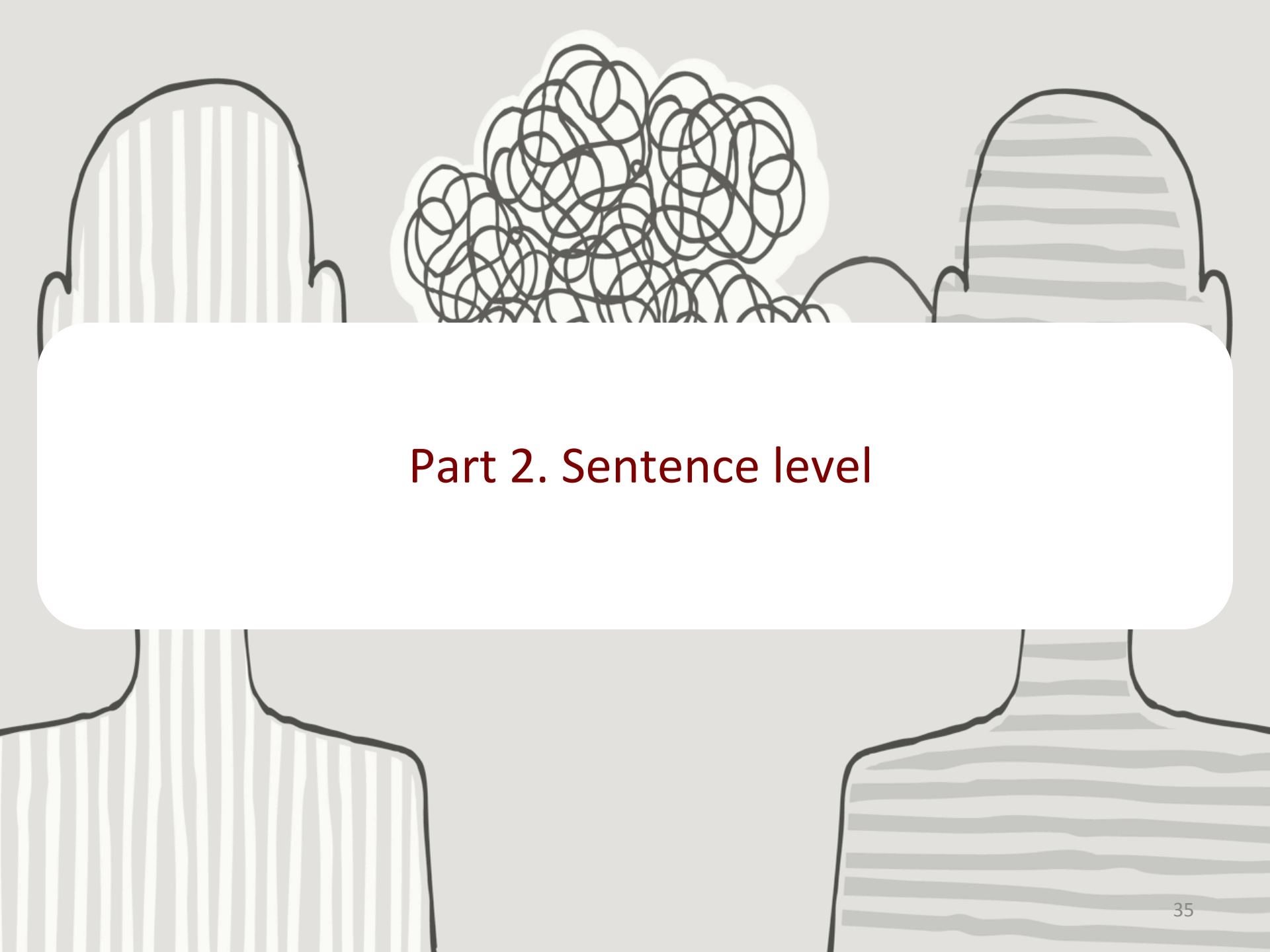


L2 participants' mean (A) error rate and (B) reaction times for identification of nonce words in the translation judgment task.



Interim summary

- L2 listeners incorrectly chose the translation of the target's minimal pair counterpart more frequently when the words differed on the basis of consonantal hardness/softness;
- Translation accuracy was on average lower for the words in the semantic condition compared to the morphological and syntactic conditions;
- Participants accepted nonce words that included substitutions of hard and soft consonants more often than they accepted nonce words in the filler condition;
- The effect of phonolexical ambiguity is asymmetric, the active category in the hard/soft consonant distinction for the L2 Russian speakers is the hard consonant.



Part 2. Sentence level

Principle №2: Predictive nature of processing

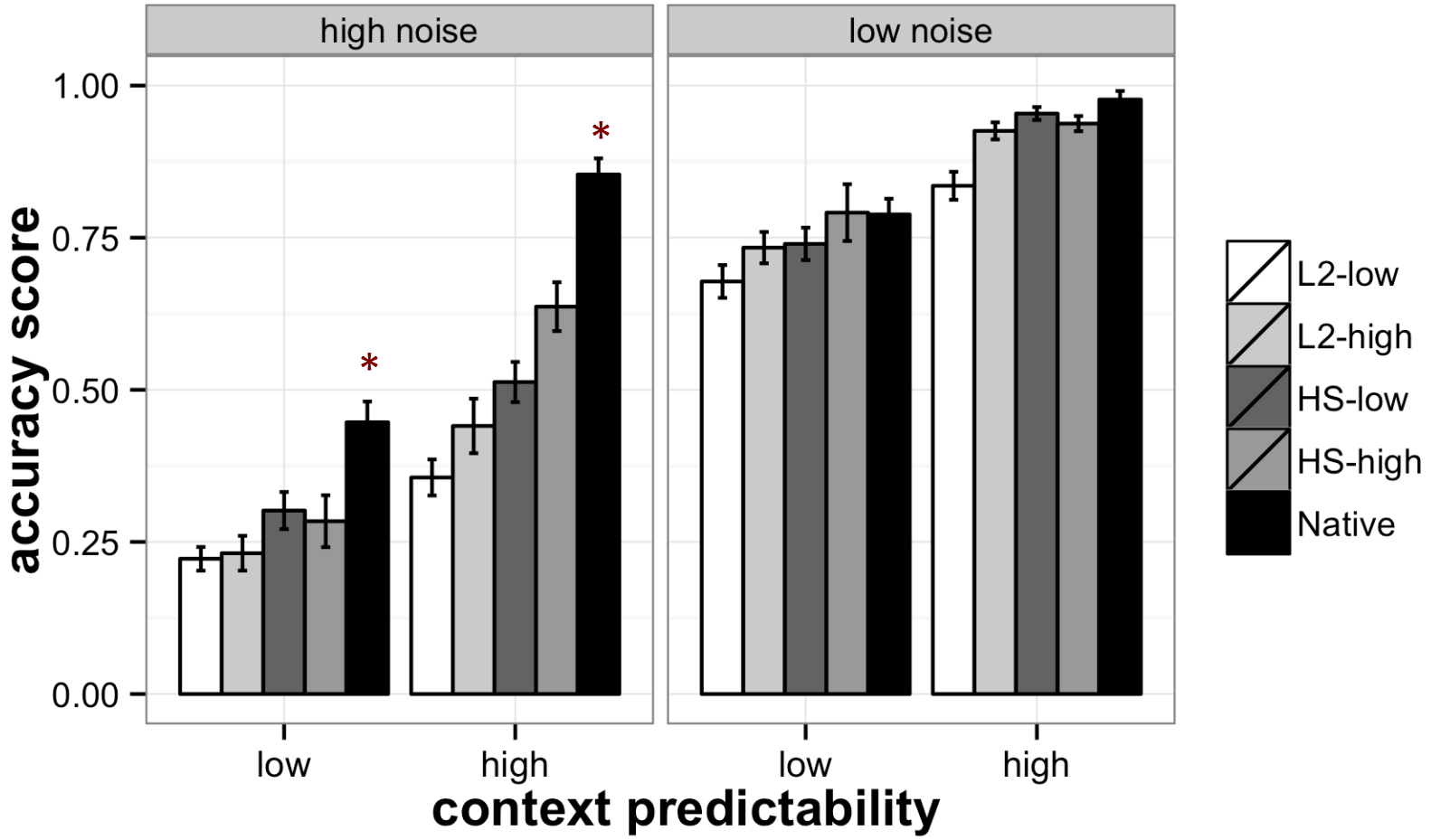
Brain is the mechanism to predict the future

[Jeff Hawkins, On Intelligence (2004)]

[Chow, 2013; DeLong, 2009; Federmeier, 2007; Lau, 2009]

Role of prior knowledge in speech comprehension

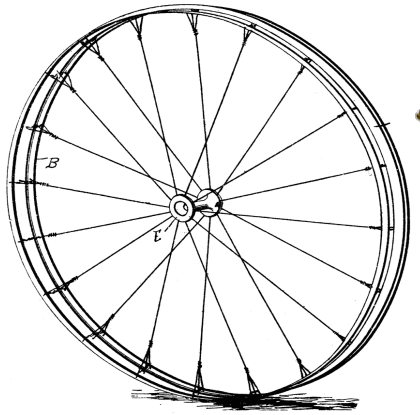
- Distorted (vocoded) speech 
- Clear speech 



[Gor & Lukyanchenko, 2012]

Phoneme Restoration effect [Warren, 1970]

- It was found that the *eel was on the orange.
- It was found that the *eel was on the axle.
- It was found that the *eel was on the fishing-rod.



The phoneme that listeners restored depended on the semantic context

Phoneme Labeling task [Miller et al., 1984; Connine, 1987; Connine et al., 1991; Isenberg et al., 1980]

1. VOT continuum from 'bath' to 'path':

- "She needs hot water for the __".
- "She likes to jog along the ___".

If unambiguous → get semantically implausible sentences

If midrange (ambiguous) tokens → get semantic context effects

2. A continuum of /tə-ðə/:

- "We tried ___ go/gold".
- "__ go/gold is essential".

Listeners reported hearing 'to' more often in the 'go' context and hearing 'the' more often in the 'gold' context, indicating the effect of syntactic category assignment on word identification in the presence of perceptual ambiguity.

Context cues in L2 sentence comprehension

- What information do L2 users attend to when comprehending their non-native language?
  - L2 learning/processing shows well-attested age effects
  - L2 learning/processing shows well-attested proficiency effects
  - L2 learners rely on the same higher-order processing mechanisms as in L1, but these mechanisms are slower, less efficient, less automatic and more taxing
  - These constraints might fundamentally alter or limit the types of information used by L2 speakers during comprehension

✓	**Broad sentential context, discourse**	L2 listeners rely on the constructed schema of the conversation which guides their processing of incomplete bottom-up information [Akimi, 1999; Field, 2004]
✓		Semantic contexts help identify words more easily across all noise l… …akers show a higher …Cutler et al., …0 effect
?	**Syntact…**	…e more …ne, 2001; Hanne &… …]
?	**Morphological**	Shallow morphosyntactic parsing predominates in L2 processing [Clahsen & Felser , 2006a, 2006b]

→ L2 comprehension relies primarily on semantic & pragmatic heuristics, coupled with lexical semantic information. Morphosyntactic and inflectional information are under-used during L2 comprehension

Research Questions

- **RQ 1:** What are the consequences of L2 phonolexical ambiguity for auditory sentence comprehension?
- **RQ 2:** Do L2 listeners utilize contextual information for meaning resolution in online auditory sentence comprehension?
- **RQ 3:** Do L2 listeners utilize different kinds of contextual information, such as semantic, morphological and syntactic, for meaning resolution to the same degree?
- **RQ 4:** What is the time course of integration of phonological information with higher-order contextual information in L2?
- **RQ 5:** How does auditory sentence processing compare in L1 and L2 in terms of the use of contextual information and the temporal aspects of context effects?

Exp.5. Lexical decision task in context

- L1: n = 24 (M age 32, range 23-58; 20 F)
- L2: n = 34 (M age 29.5, range 21-50; 20 F)

	Mean	SD
Age when started learning Russian	17.67	2.79
Length of living in Russia (years)	2.72	2.28
Formal instruction in Russian (years)	6.03	1.56
Self-rated pronunciation	7.15	1.46
Self-rated oral proficiency	7.03	1.09
Self-rated listening proficiency	7.76	1.13
Self-rated reading proficiency	7.56	1.35
Self-rated writing proficiency	6.65	1.45
Self-rated knowledge of grammar	7.24	1.30
Cloze test (Proficiency measure)	21.74	1.80

Objective

- to examine if perceptual ambiguity in the L2 has consequences for word recognition during sentence comprehension;
- to investigate context effects (semantic, morphological, syntactic) on spoken word recognition in L2 and L1 listeners.

Task

- Is the last word in the sentence a real word or a non-existing word?
- Answer comprehension questions.

Russians drink much ...

Russians drink much **tea**.

500 ms

Do Russians drink much tea?

Materials and Design

1. Context type:

- constraining:

  Russians drink much **tea**.

- unconstraining/ neutral:

  Now you will hear the word **tea**.

Materials and Design

2. Context condition:

- semantic:

  Russians drink much **tea/*coke**.

- morphological:

  Russians drink much **tea/*teas**.

- syntactic:

  Russians drink much **tea/*quickly**.

Materials and Design

3. Target type:

- congruent:

  Russians drink a lot of **tea**.

- confusable:

  Russians drink a lot of **bee**.

- unrelated:

  Russians drink a lot of **gas**.

- nonce:

  Russians drink a lot of **tib**.

Materials and Design

4. Block:

- critical:

perceptually ambiguous for L2, [± soft] consonants

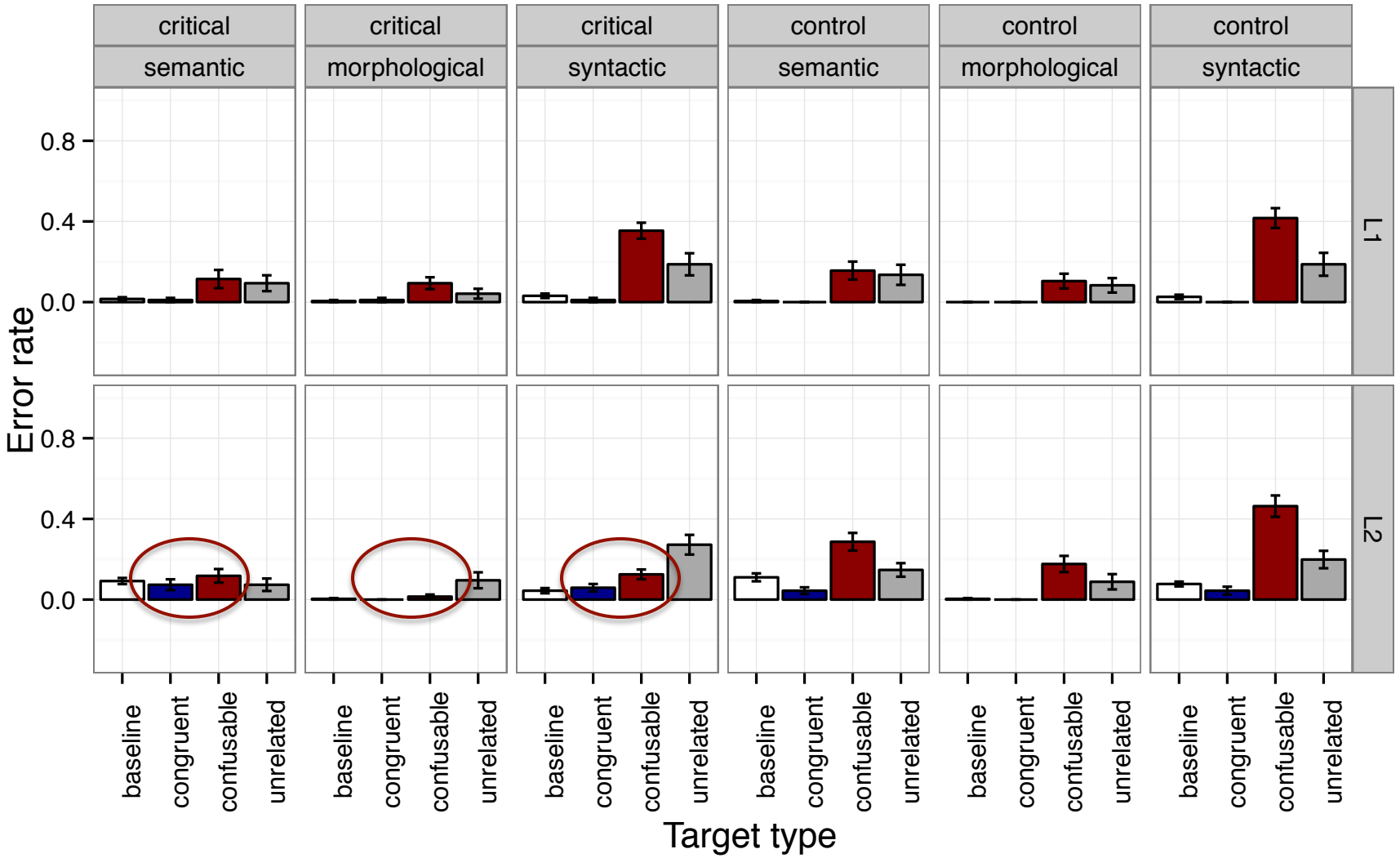
- control:

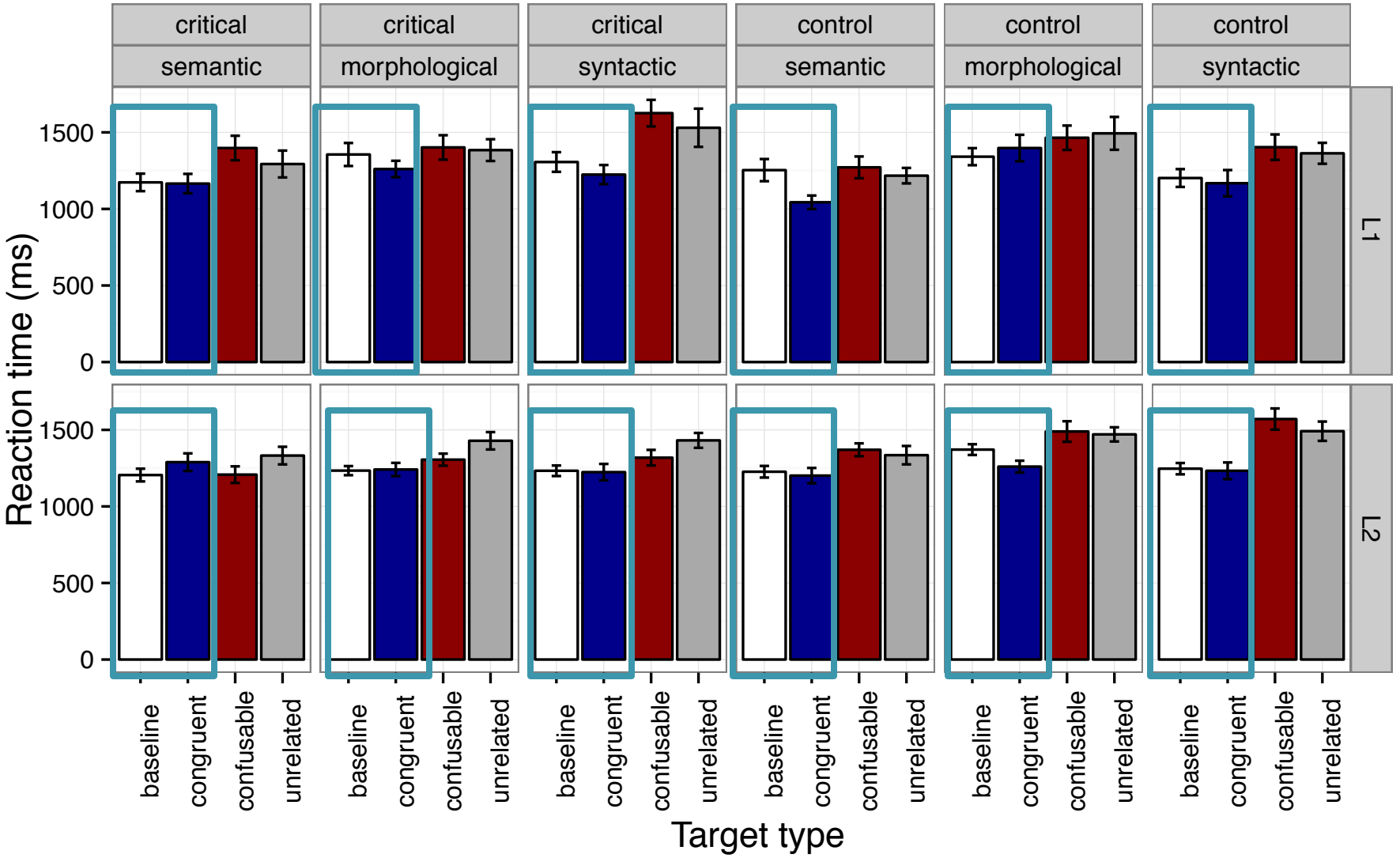
perceptually unambiguous

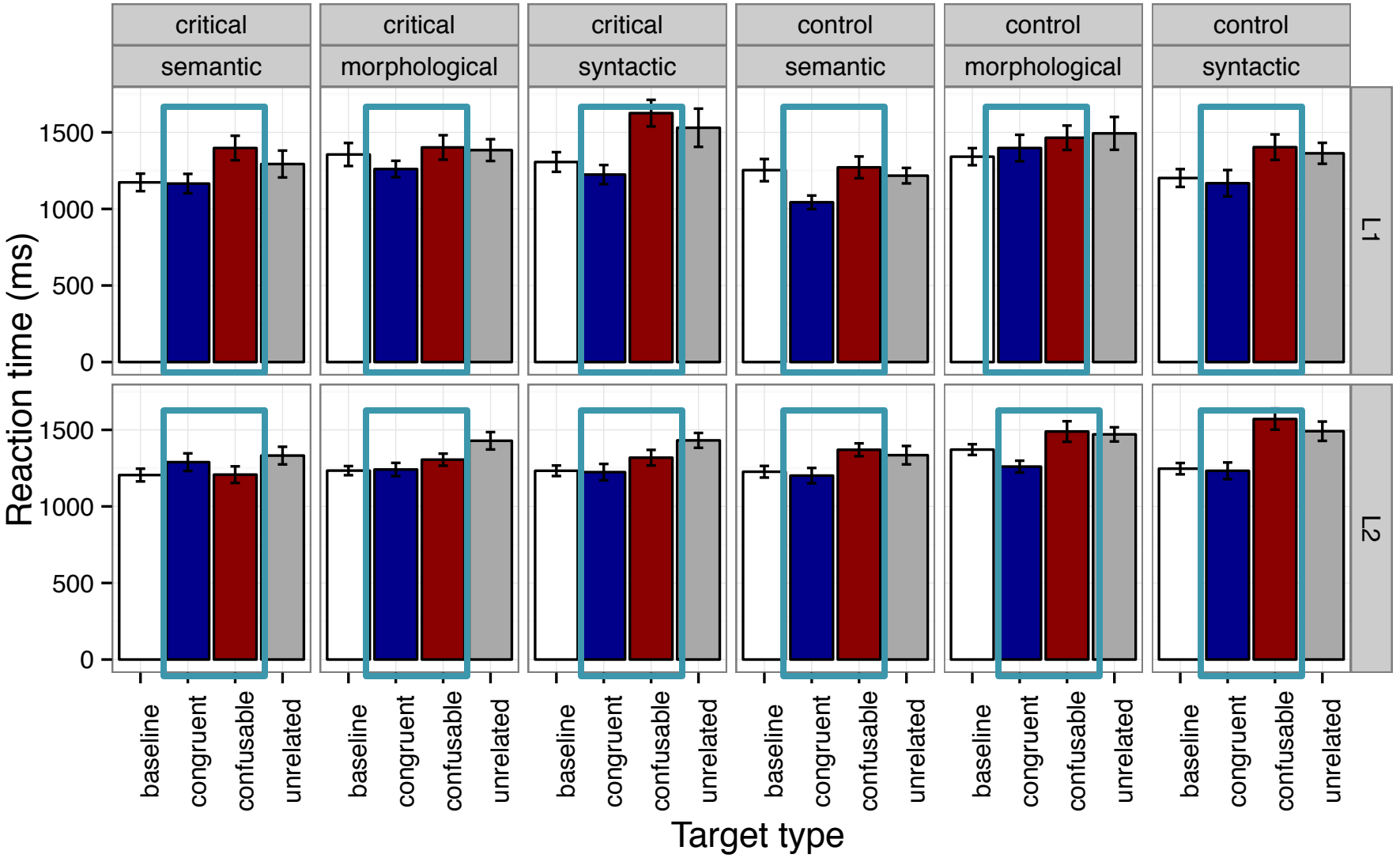
4 lists x 240 items (120 of each context, 32 of each condition, 24 fillers)

Materials design and targets' properties in the lexical decision task.

Block	Condition	Target type	Example	Translation	Number of phonemes		Lemma frequency		Surface frequency	
					M	*SD*	*M*	*SD*	*M*	*SD*
Critical	Semantic	Congr	мать	mother	3.5	*0.5*	66.8	*93.3*	31.9	*52.6*
		Conf	мат	checkmate	3.5	*0.5*	66.8	*93.3*	31.9	*52.6*
		Unrel	газ	gas	3.5	*0.5*	86.3	*46.7*	25.9	*12.6*
		Nonce	маф	na	na	*na*	na	*na*	na	*na*
	Syntactic	Congr	брать	to take	4.1	*1.1*	260.4	*428.6*	58.6	*111.9*
		Conf	брат	brother	4.1	*1.1*	260.4	*428 6*	58.6	*111.9*
		Unrel	вниз	downward	4.1	*1.1*	73.7	*69.1*	73.5	*69.1*
		Nonce	брам	na	na	*na*	na	*na*	na	*na*
	Morphological	Congr	говорить	to speak	6.2	*0.5*	361	*690.6*	361	*128.2*
		Conf	говорит	speaks	6.2	*0.5*	361	*690.6*	361	*128.2*
		Unrel	говорим	we speak	6.2	*0.5*	361	*714.8*	4.4	*7.1*
		Nonce	говорик	na	na	*na*	na	*na*	na	*na*
Control	Semantic	Congr	храм	temple	3.6	*0.5*	88	*62.5*	25.4	*19.9*
		Conf	храп	a snore	3.6	*0.5*	88	*62.5*	25.4	*19.9*
		Unrel	долг	debt	3.6	*0.5*	68.1	*28.3*	22	*9.6*
		Nonce	храк	na	na	*na*	na	*Na*	na	*na*
	Syntactic	Congr	жир	grease	3.6	*0.7*	202.9	*298*	35.6	*40.4*
		Conf	жил	lived	3.6	*0.7*	202.9	*298*	35.6	*40.4*
		Unrel	зря	in vain	3.7	*0.7*	61.1	*37.7*	61	*37.7*
		Nonce	жих	na	na	*na*	na	*na*	na	*na*
	Morphological	Congr	любим	we love	6.5	*1.5*	918.1	*686.1*	21.6	*20.3*
		Conf	любишь	you love	6.5	*1.5*	918.1	*686.1*	21.6	*20.3*
		Unrel	любит	loves	6.5	*1.5*	918.1	*710.2*	20.6	*19.7*
		Nonce	любик	na	na	*na*	na	*na*	na	*na*


critical
semantic
critical
morphological
critical
syntactic
control
semantic
control
morphological
control
syntactic
L1
L2
Error rate
0.8
0.4
0.0
baseline
congruent
confusable
unrelated
Target type


critical
semantic
critical
morphological
critical
syntactic
control
semantic
control
morphological
control
syntactic
L1
L2
Reaction time (ms)
1500
1000
500
0
baseline
congruent
confusable
unrelated
Target type


critical
semantic
critical
morphological
critical
syntactic
control
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L1
L2
Reaction time (ms)
1500
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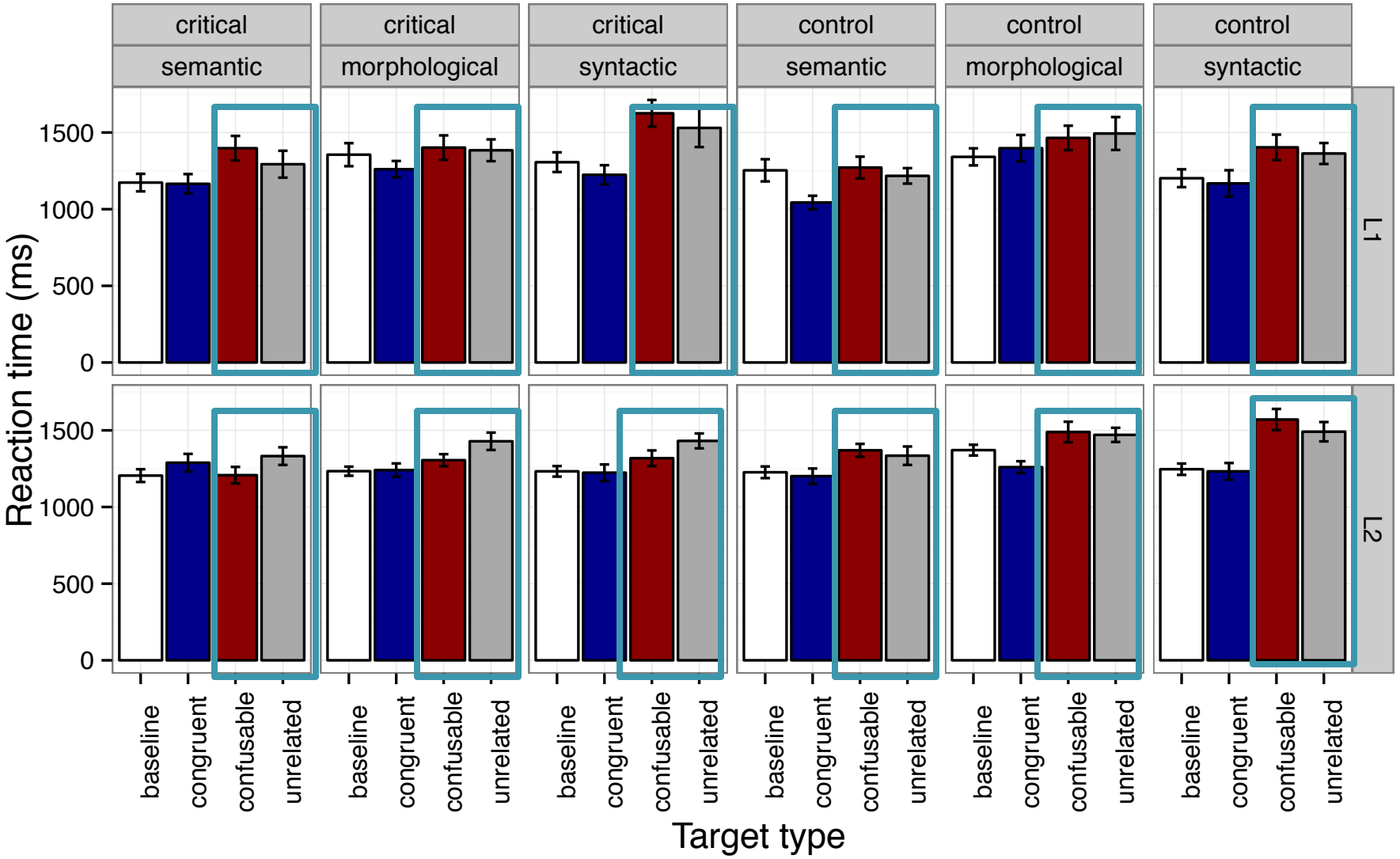
baseline
congruent
confusable
unrelated
Target type


critical
semantic
critical
morphological
critical
syntactic
control
semantic
control
morphological
control
syntactic
L1
L2
Reaction time (ms)
1500
1000
500
0
baseline
congruent
confusable
unrelated
Target type

Interim summary

- Mismatching phonological information (confusable and unrelated targets) disrupts comprehension flow creating a conflict in expectations → longer RT and higher ER (inhibition);
- Inhibition most likely reflects sentence integration costs at post-lexical stage of processing;
- L2ers, unlike L1ers, do not show inhibition for confusable targets → L2 speakers' perceptual difficulty with the consonantal hardness and softness in Russian has consequences for lexical processing in sentence comprehension;
- Context effects are greatest in the syntactic condition and weakest in the morphological condition.

Exp.6. Self-paced listening task

Objective

- to examine the time course of context effects (semantic, morphological, syntactic) on word integration during auditory comprehension.

Task

- Listen to the sentences and answer comprehension checks.

Russians

Russians drink

Russians drink much

Russians drink much **tea**

Russians drink much **tea** even

Russians drink much **tea** even in the summer.

Do Russians drink tea in the summer?

Russians drink much **tea** even in the summer.

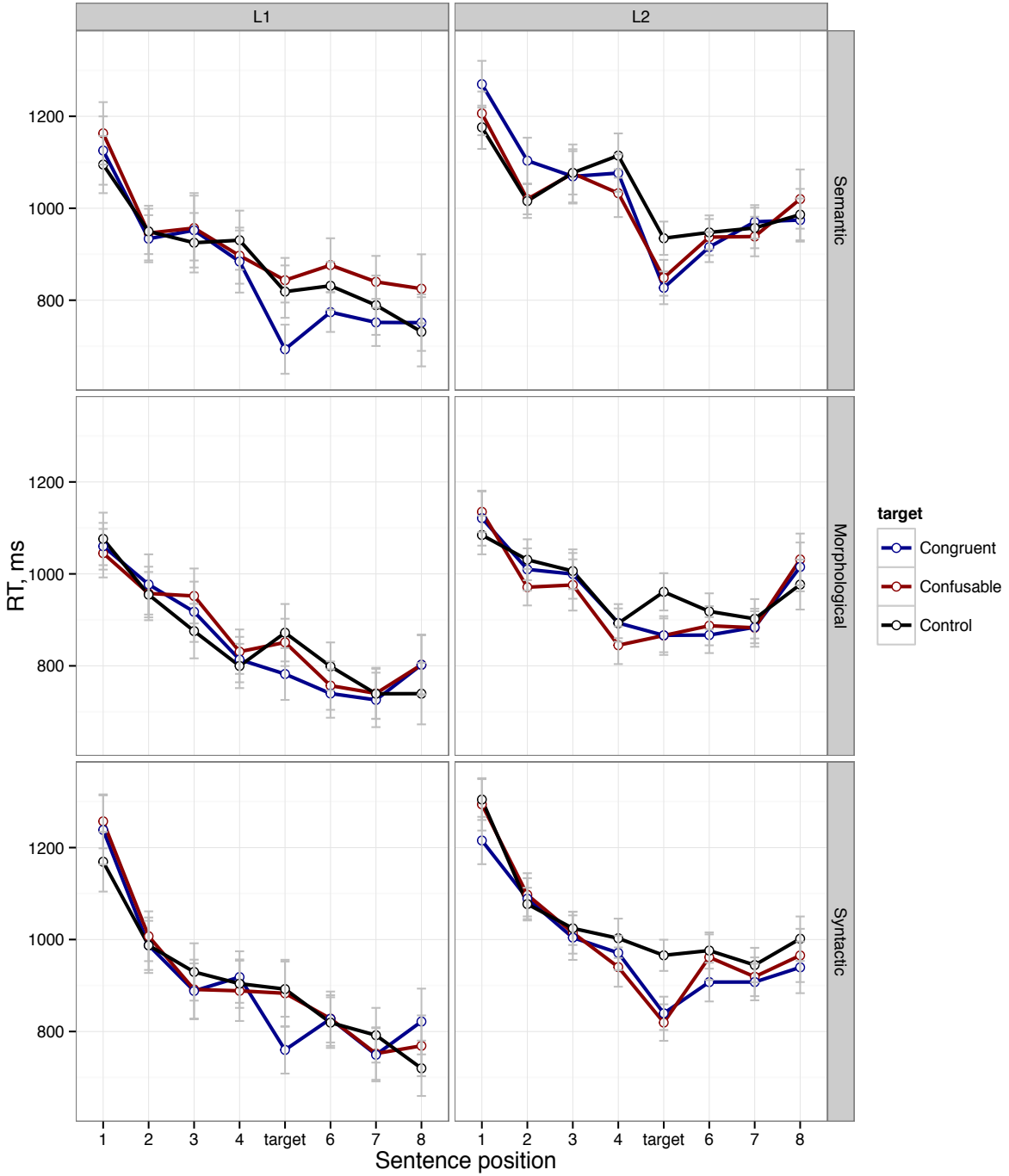
bee ⇦ confusable

gas ⇦ control

Materials design and targets' properties in the self-paced listening task.

Condition	Target type	Example	Translation	Number of phonemes		Log surface frequency	
				Mean	SD	Mean	SD
Semantic	Congruent/ Confusable	мать/ мат	mother/ checkmate	3.50	0.52	0.99	0.70
	Control	газ	gas	3.50	0.53	1.34	0.31
Syntactic	Congruent/ Confusable	брать/ брат	to take/ brother	4.13	1.09	1.21	0.79
	Control	вниз	downward	4.13	1.13	1.70	0.42
Morphological	Congruent/ Confusable	говорить/ говорит	to speak/ speaks	6.25	0.45	1.28	0.60
	Control	говорим	we speak	6.25	0.46	0.27	0.60

Participants' mean listening latencies across all experimental conditions in the self-paced listening task.



Context effects

Condition	Target	L1				L2			
		Mean	SE	RT difference	SE difference	Mean	SE	RT difference	SE difference
Semantic	Congruent	693.3	53.4	na	na	827	35.6	na	na
	Confusable	843.5	48.5	150.1	72.1	848.7	39	21.8	52.8
	Control	818.7	56.9	125.3	78.1	934.8	36.2	107.8	50.8
Morphological	Congruent	782.2	56.3	na	na	866.4	36.7	na	na
	Confusable	851	51.4	68.8	76.3	866	42.2	-0.4	55.9
	Control	872	62.5	89.8	84.1	961	40.5	94.6	54.7
Syntactic	Congruent	759.9	51.5	na	na	839.5	36.2	na	na
	Confusable	883.1	72.8	123.2	89.2	819.4	39.7	-20.1	53.7
	Control	892.2	60	132.2	79.1	965.6	33.9	126.1	49.6

Interim summary

- L1 listeners experience equal difficulty integrating confusable (phonologically similar) and control (dissimilar) words into context causing temporary processing breakdown, but L2 listeners experienced processing difficulty only with control targets → phonolexical ambiguity.
- L1 and L2 listeners experience the strongest context effects in the syntactic and semantic conditions followed by the morphological condition.
- L2 speakers draw on similar (albeit slower) mechanisms during sentence comprehension and utilize contextual information to build expectations about the upcoming auditory input.
- L2 listeners' vague and fuzzy phonological representations make them completely dependent on contextual information for meaning resolution if the words are phonologically ambiguous.

Discussion

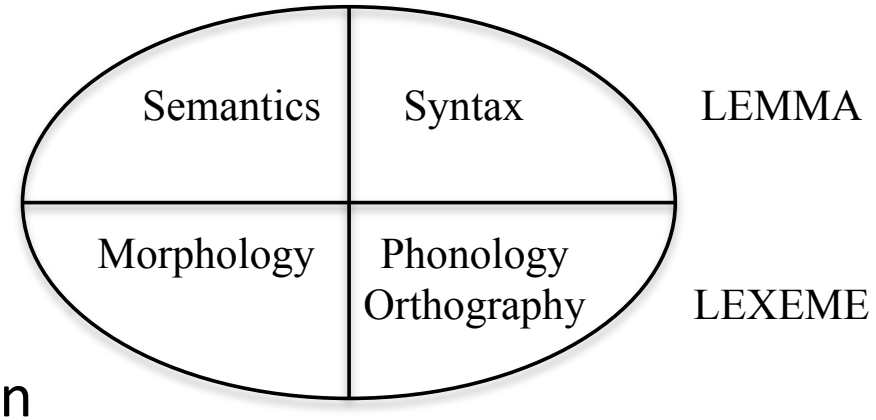
A. Phonolexical ambiguity in L2

Phonological ambiguity → Lexical ambiguity:

- choose a translation of a similar-sounding word instead of the target word (e.g., *брать* (/brɑtʲ/, "to take") for *брат* (/brɑt/, "brother");
- accept nonwords created by substituting the hard and soft consonants as real Russian words;
- the effects of phonolexical ambiguity are asymmetric, with the feature of consonant hardness being the dominant one → no complete homophony (markedness? category-goodness assimilation pattern?).

Discussion

- L2 listeners don't notice and don't show inhibition or processing difficulty when they encounter context-incongruent ambiguous words in sentences → access the intended lexical candidate despite low-resolution phonological information.
- Use semantic, morphological and syntactic specifications to access meaning.
- An exact match between a lexical item and its phonological properties is not required when L2 listeners can take advantage of the information gleaned at the contextual level.



Discussion

B. Context effects

– L2 listeners akin to L1 listeners experience the strongest context effects in the syntactic and semantic conditions followed by the morphological condition.

a. syntactic and semantic properties of words are closely connected in the lemma component and are associated with word meaning → stronger effect on the parser;

b. semantic constraints are more specific while syntactic constraints are more general [Lee and Federmeier, 2009];

c. syntactic information is deterministic and definitive (and thus quite constraining) in a way that semantic information cannot be [Friederici, Pfeifer, and Hahne, 1999; Friederici, 2002], e.g., "*Mary got soaked to the skin because she forgot the …*";

d. contextual constraints operate differently for different classes of words → words within the same grammatical class should compete for lexical selection more than words belonging to different grammatical categories [Dell, Oppenheim, & Kittredge, 2008; Levelt, Roelofs, & Meyer, 1999; Pechmann & Zerbst, 2002] → more competition and uncertainty in the semantic condition, which included violations within the same grammatical class.

Exp.7. Event related potentials (ERP) experiment

Objective

- to investigate the electrophysiological aspects and temporal parameters of morpho-phonological processing in L1 and L2 listeners;
- to examine whether the ERP response may be modulated by the level of perceptual difficulty of the morpho-phonological contrast.

Task

- Listen to the sentences and evaluate sentence goodness.

Participants

- L1: n = 21 (M age 29.8, range 19-58; 14 F)
- L2: n = 15 (M age 29.8, range 24-51; 7 F)

	Mean	SD
Age when started learning Russian	17.00	2.75
Age when first traveled to Russia	18.93	5.44
Length of living in Russia (years)	2.83	1.61
Formal instruction in Russian (years)	2.77	0.67
Self-rated pronunciation	7.27	1.49
Self-rated oral proficiency	7.13	1.64
Self-rated listening proficiency	7.27	1.33
Self-rated reading proficiency	7.67	1.59
Self-rated writing proficiency	6.47	1.81
Self-rated knowledge of grammar	7.40	1.64
Cloze test (Proficiency measure)	22.27	2.40

Materials and Design

Condition

(90 each)

- critical, control, filler

Congruency

(30 each)

- congruent, incongruent

3 lists x 270 items

Condition	Congruency	Example	Mean TW duration, ms	Mean TW lemma frequency, ipm
Critical	congruent	Личный помощник президента хочет ОТВЕТИТЬ$_{INF}$ на провокационный вопрос журналиста. *President's personal assistant wants to ANSWER$_{INF}$ the journalist's provocative question.*	0.78	60.95
	incongruent future *(phonologically ambiguous)*	Личный помощник президента хочет *ОТВЕТИТ$_{FUTURE}$ на провокационный вопрос журналиста. *President's personal assistant wants to *ANSWER$_{FUTURE}$ the journalist's provocative question.*	0.78	60.95
	incongruent past *(phonologically unambiguous)*	Личный помощник президента хочет *ОТВЕТИЛ$_{PAST}$ на провокационный вопрос журналиста. *President's personal assistant wants to *ANSWER$_{PAST}$ the journalist's provocative question.*	0.78	60.95
Control	congruent	Школьники начинают изучать иностранный ЯЗЫК$_{ACCUSATIVE}$ с первого класса. *Students start learning a foreign LANGUAGE$_{ACCUSATIVE}$ in the first grade.*	0.65	126.29
	incongruent case	Школьники начинают изучать иностранный ЯЗЫКУ$_{DATIVE}$ с первого класса. *Students start learning a foreign LANGUAGE$_{DATIVE}$ in the first grade.*	0.77	126.29
	incongruent semantic	Школьники начинают изучать иностранный ОВОЩ с первого класса. *Students start learning a foreign VEGETABLE in the first grade.*	0.65	139.46

EEG Recording

- 29 Ag/AgCl scalp electrodes
- recording with Neuroscan and SynAmps amplifier at a 1000-Hz sampling rate with a bandpass filter of 0.1-100 Hz
- right mastoid reference
- impedances kept below 5kΩ
- epoched (−200 to 1400 ms) and baseline corrected (−200 ms to 0ms).

EEG Analysis

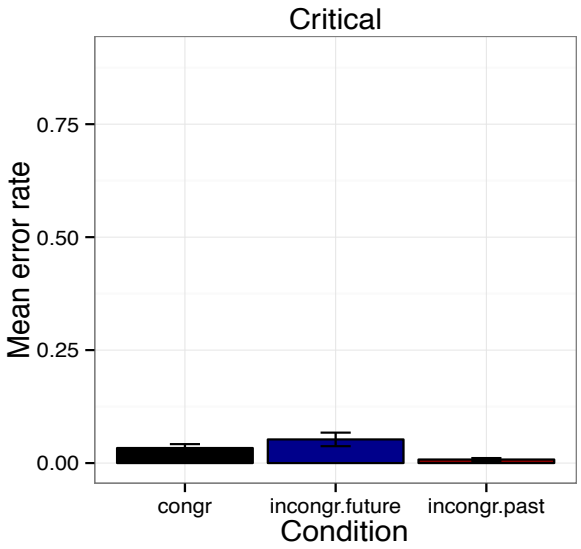
- independent component analysis (ICA) with the runica Infomax algorithm
- peak-to-peak artifact rejection, rejection level ±100 µV) resulting in 5.11% (L1) and 5.24% (L2) of discarded trials
- grand averaged ERPs were filtered off-line with a 20 Hz low-pass filter for plotting purposes
- 200-600 ms for the N400 component; 800-1300 ms for P600 component

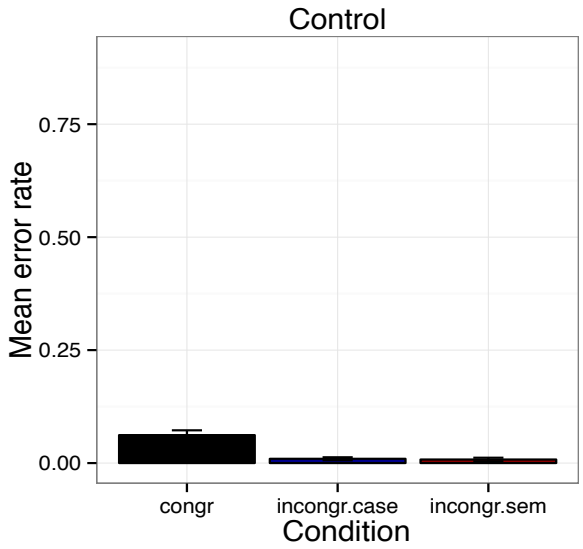
Behavioral results

Condition	Language group			
	L1		L2	
	Error rate	RT	Error rate	RT
Critical	0.031 *(0.007)*	1026.36 *(101.32)*	0.315 *(0.015)*	1516.64 *(249.10)*
Control	0.026 *(0.004)*	1038.37 *(106.62)*	0.145 *(0.018)*	1395.12 *(267.72)*
Filler	0.019 *(0.004)*	1051.1 *(108.65)*	0.222 *(0.021)*	1779.62 *(406.61)*

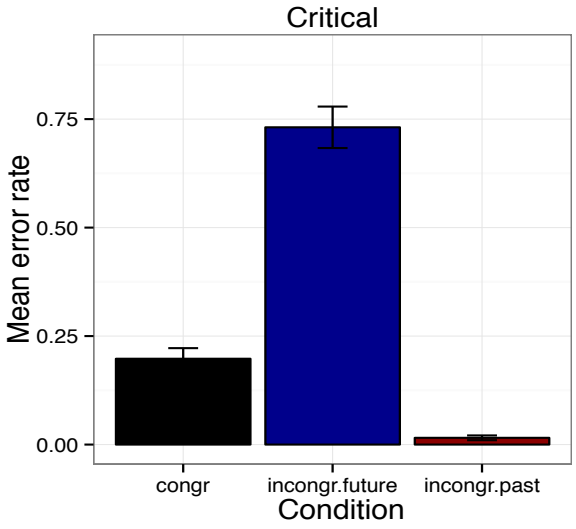
Mean error rate in the critical and the control conditions in the L1 group and the L2 group.

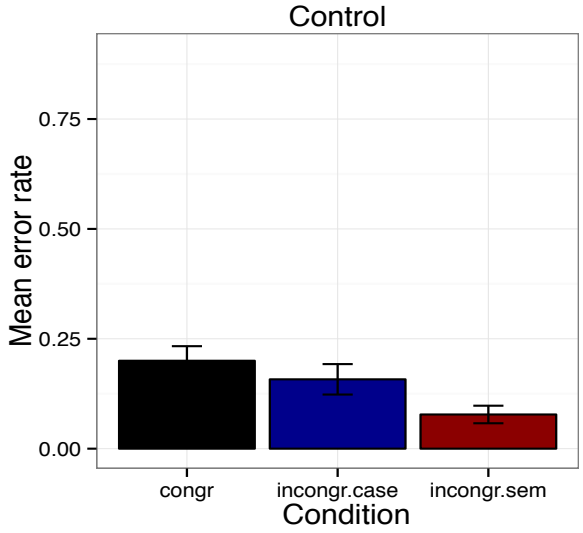
L1





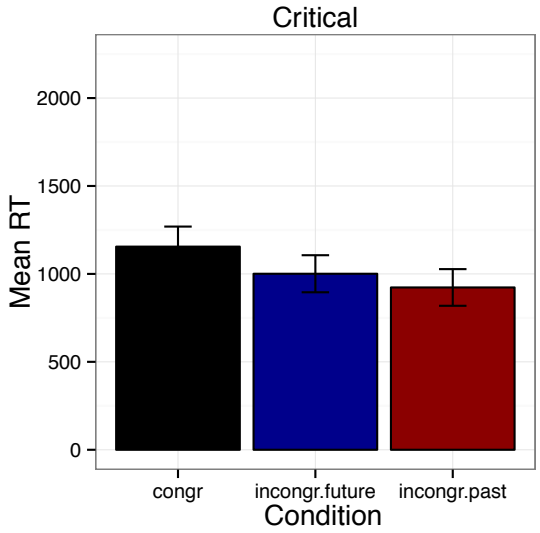
L2

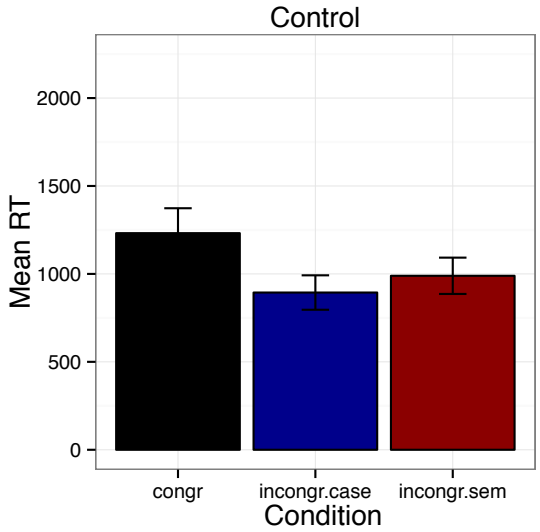




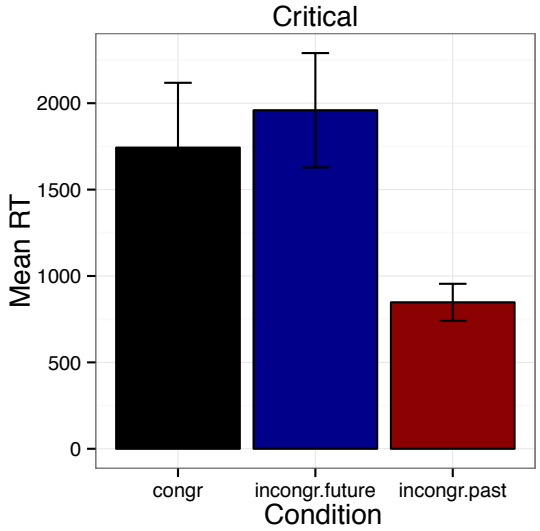
Mean RT in the critical and the control conditions in the L1 group and the L2 group.

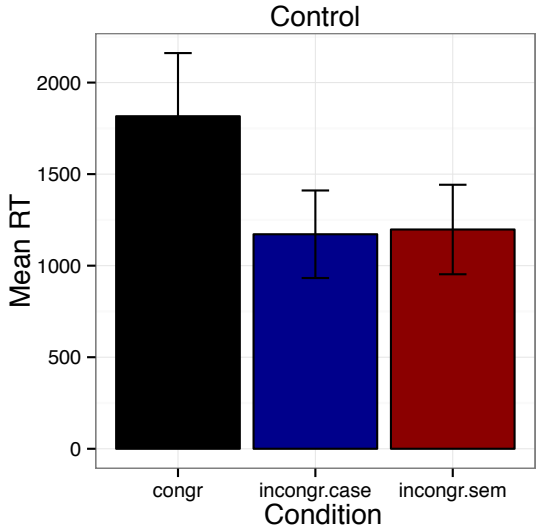
L1





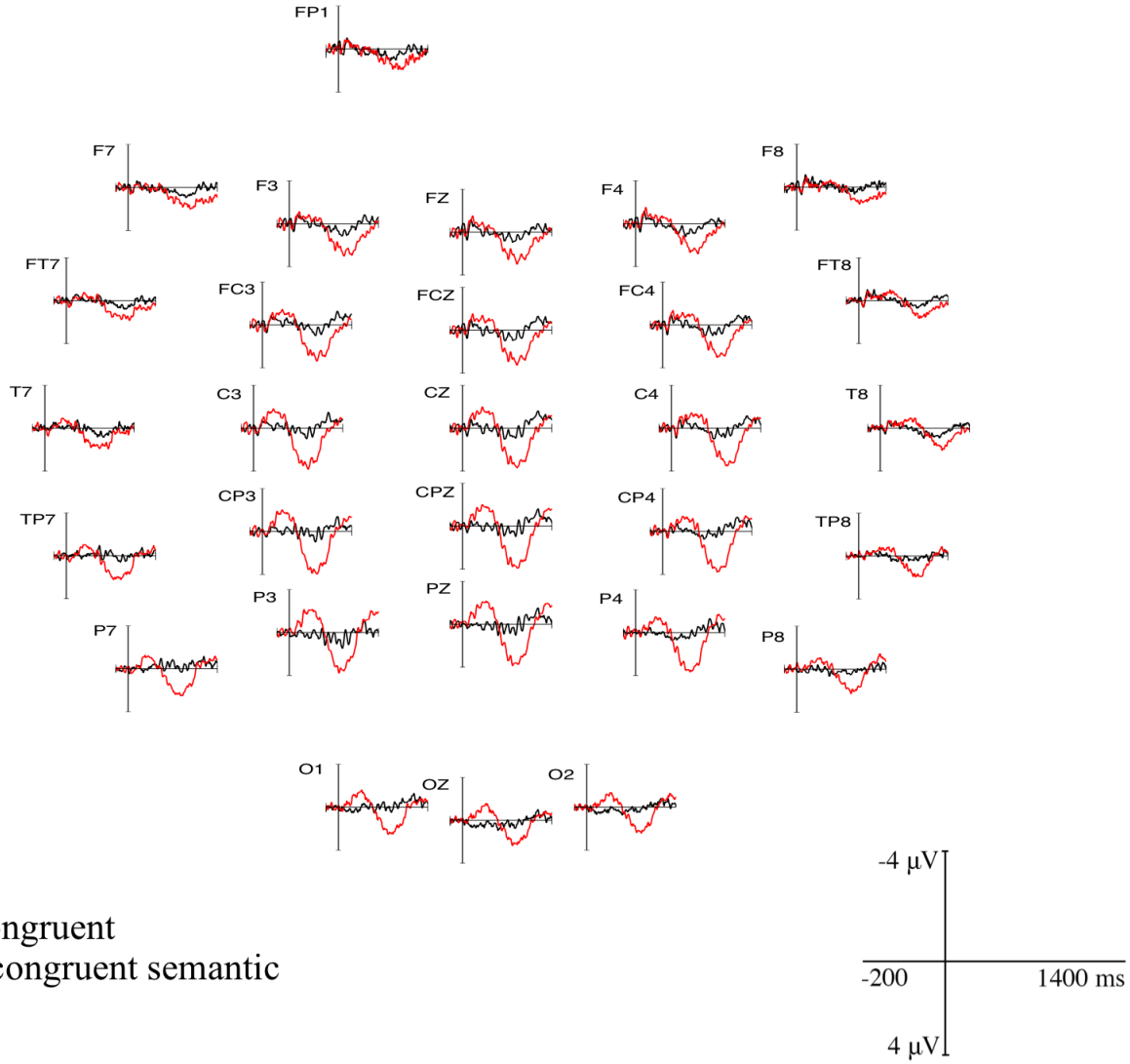
L2





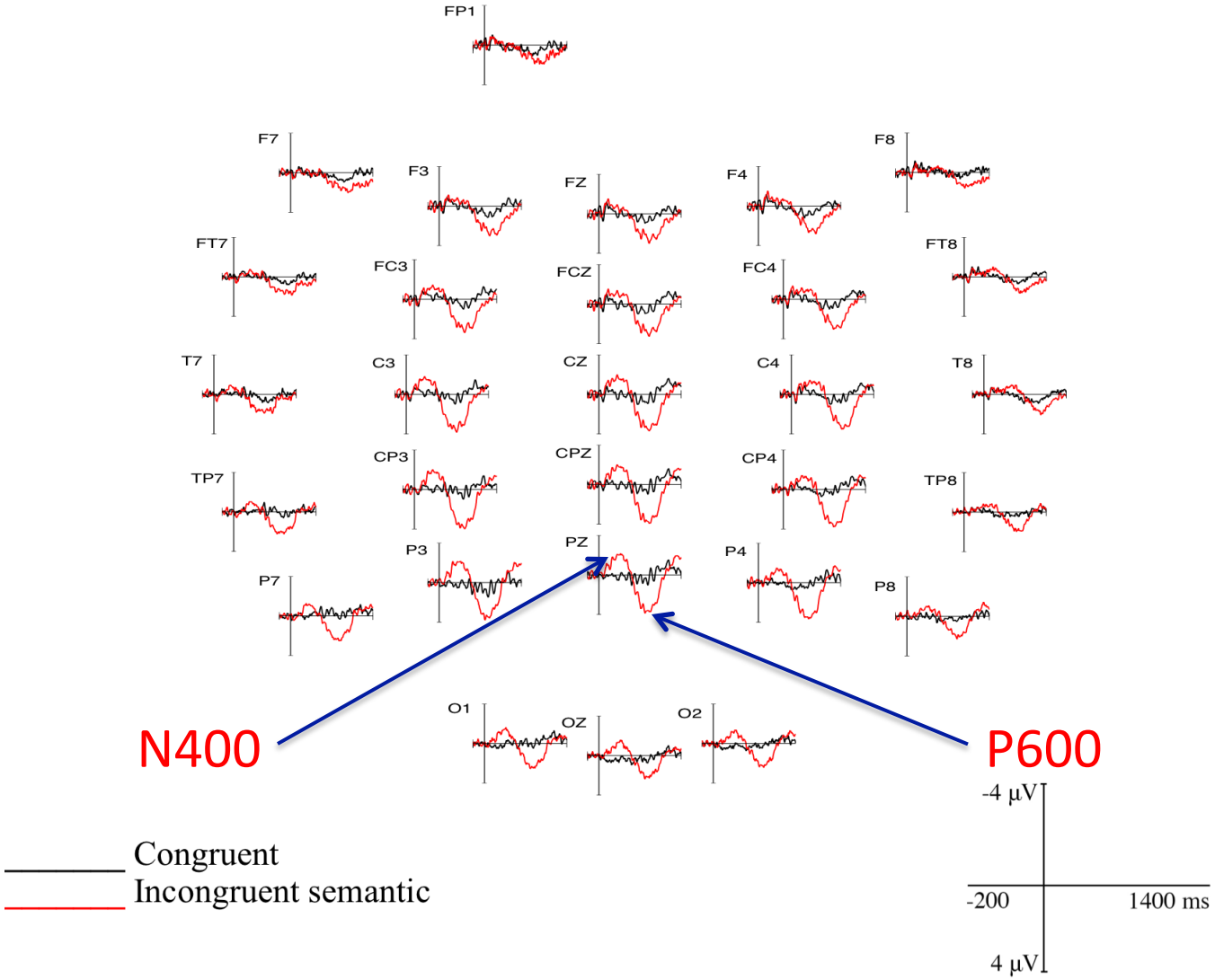
ERP results: Control semantic

L1



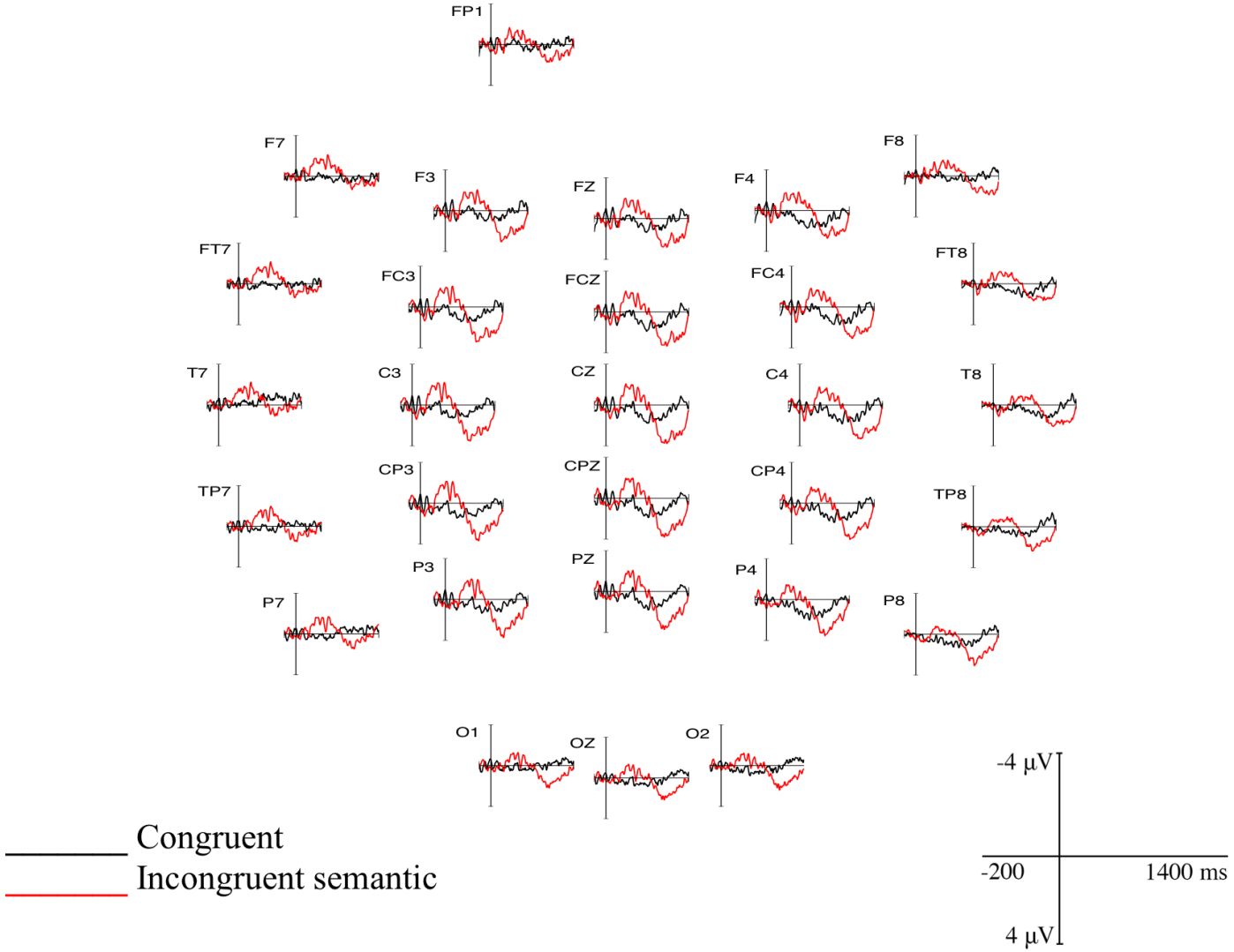
ERP results: Control semantic

L1



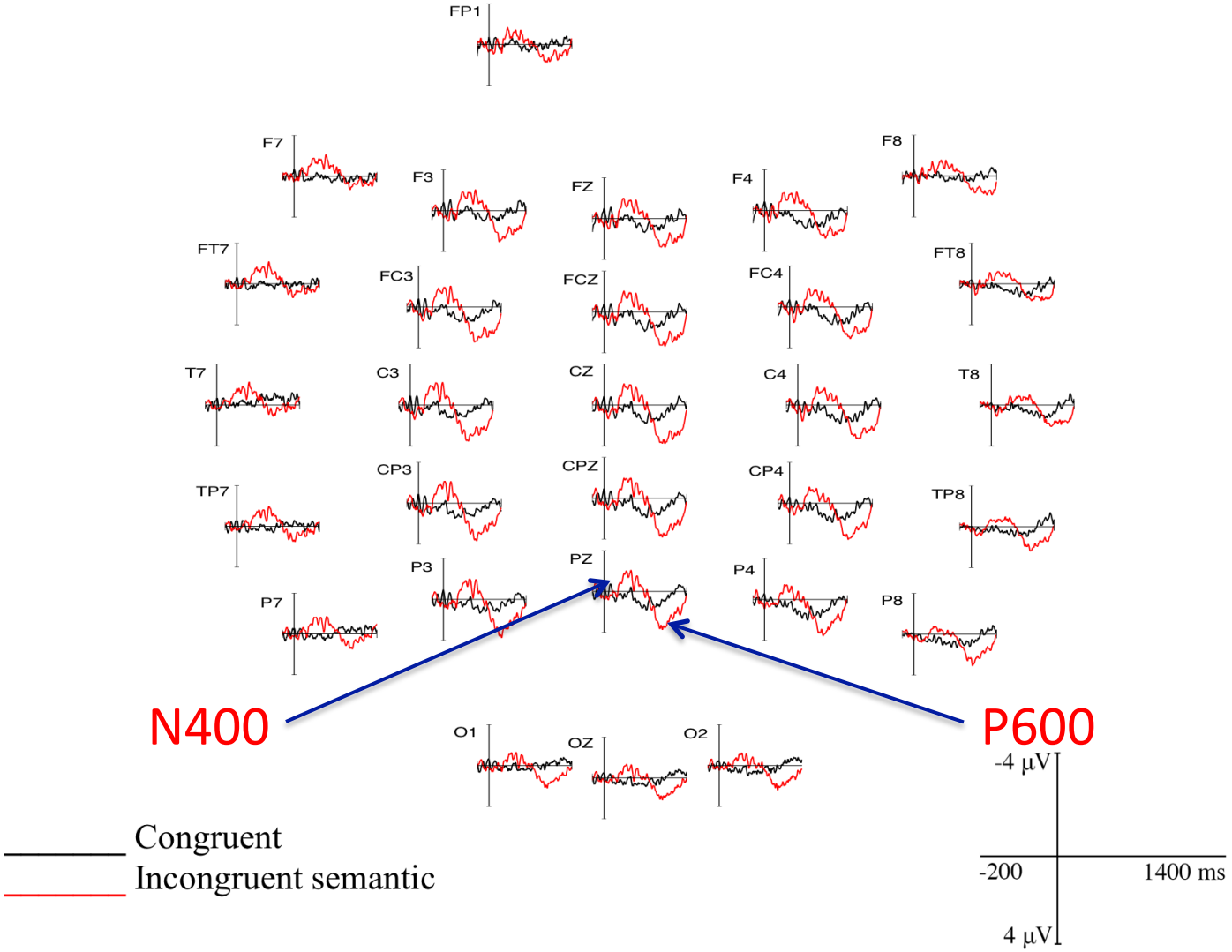
ERP results: Control semantic

L2



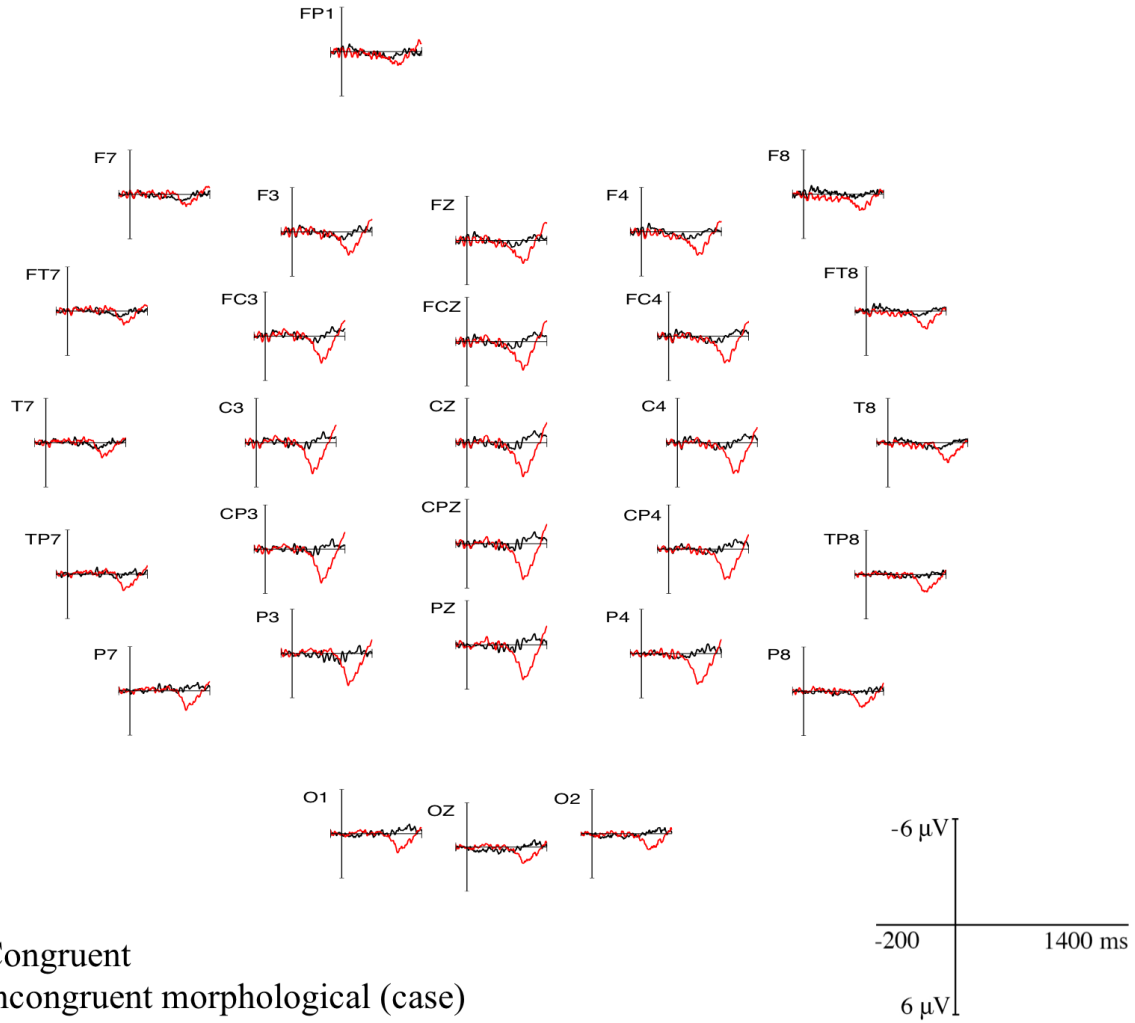
ERP results: Control semantic

L2



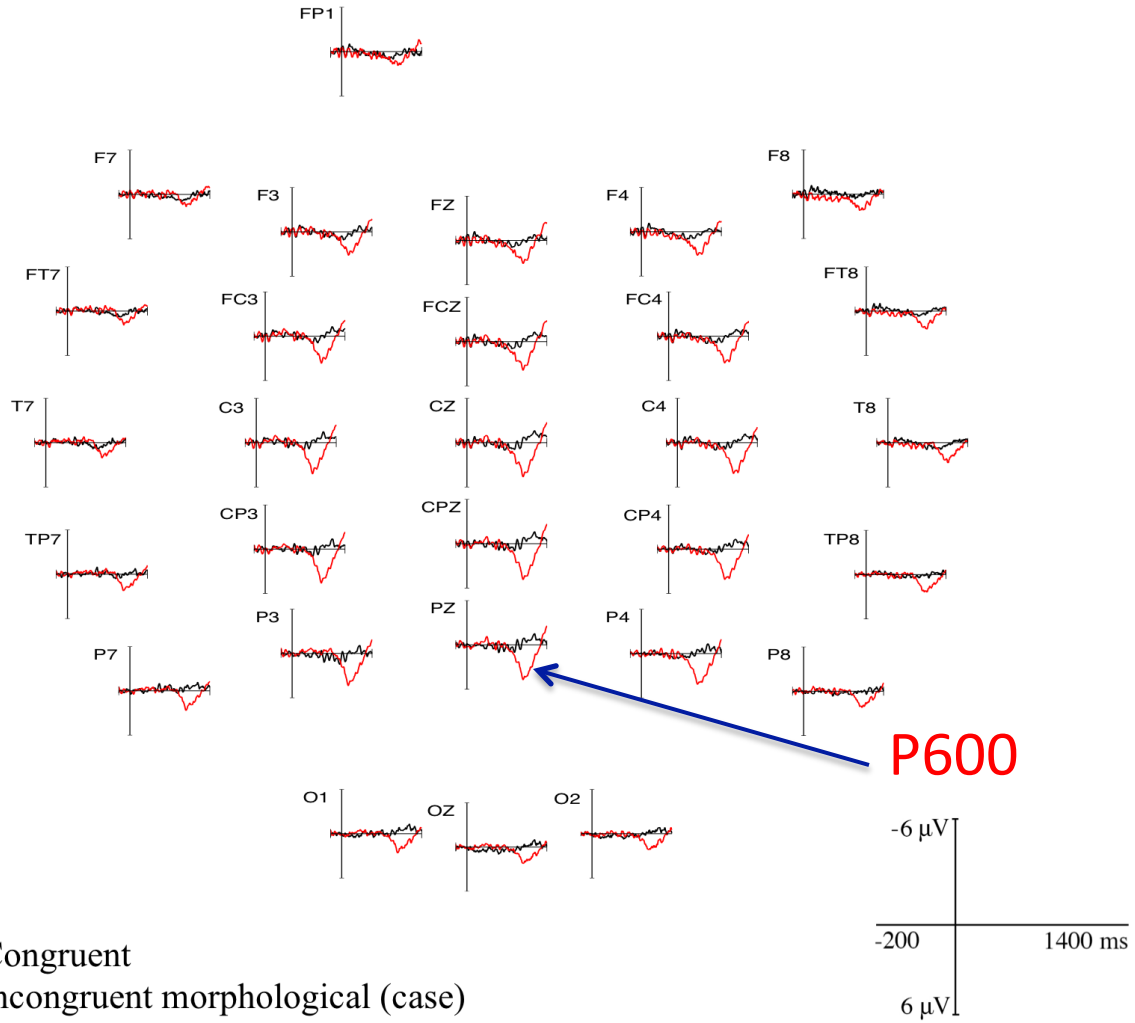
ERP results: Control morphological (case)

L1



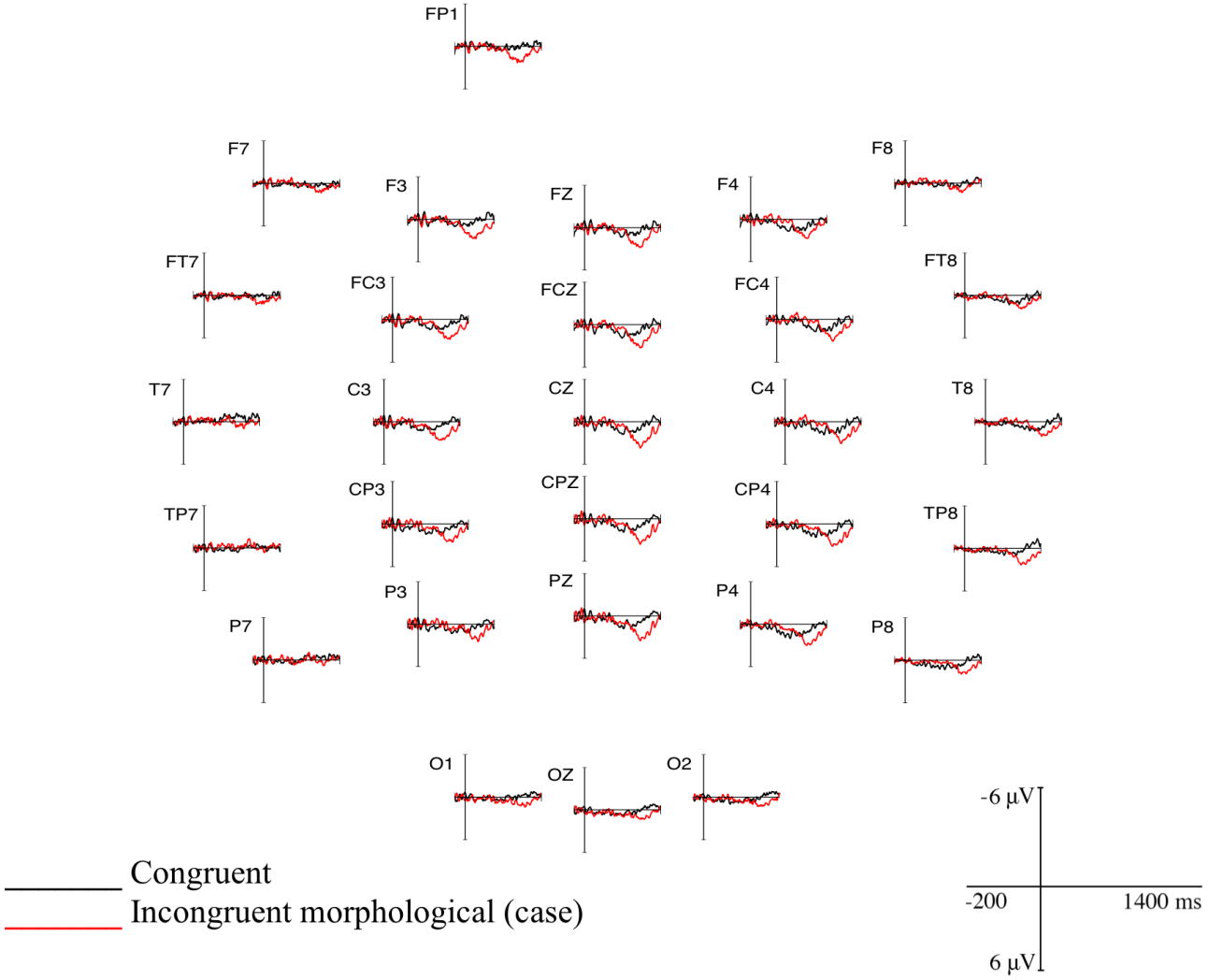
ERP results: Control morphological (case)

L1



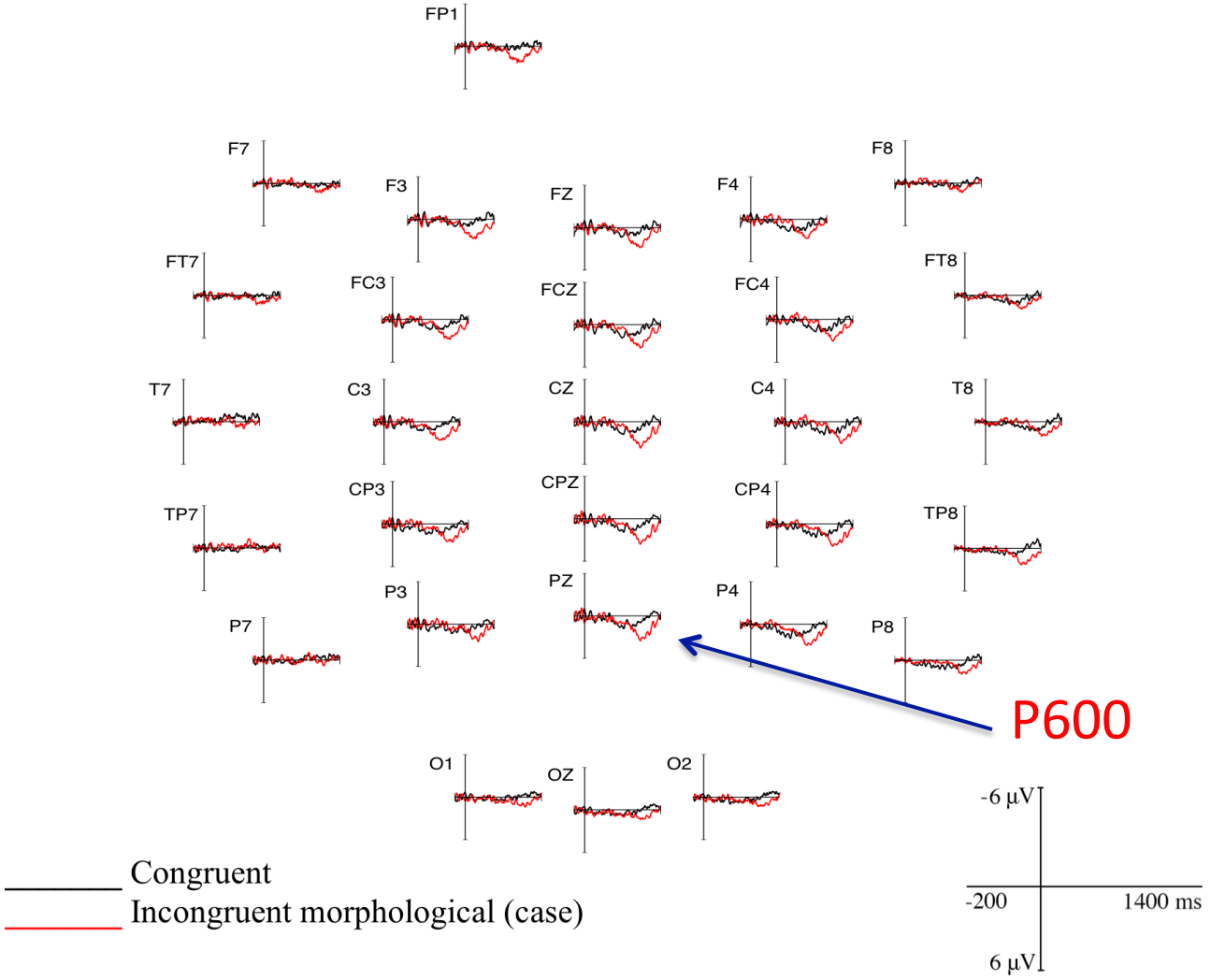
ERP results: Control morphological (case)

L2

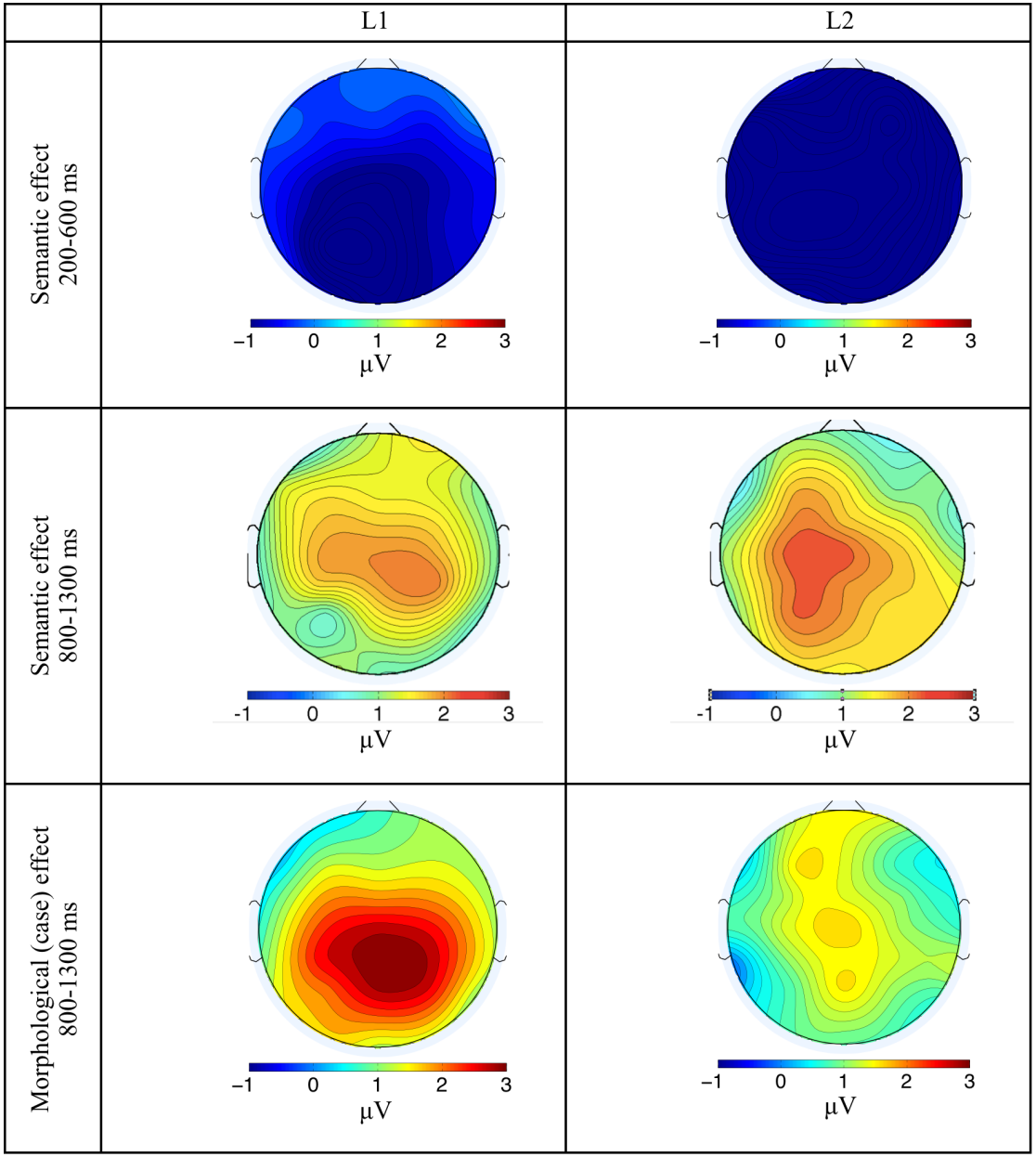


ERP results: Control morphological (case)

L2

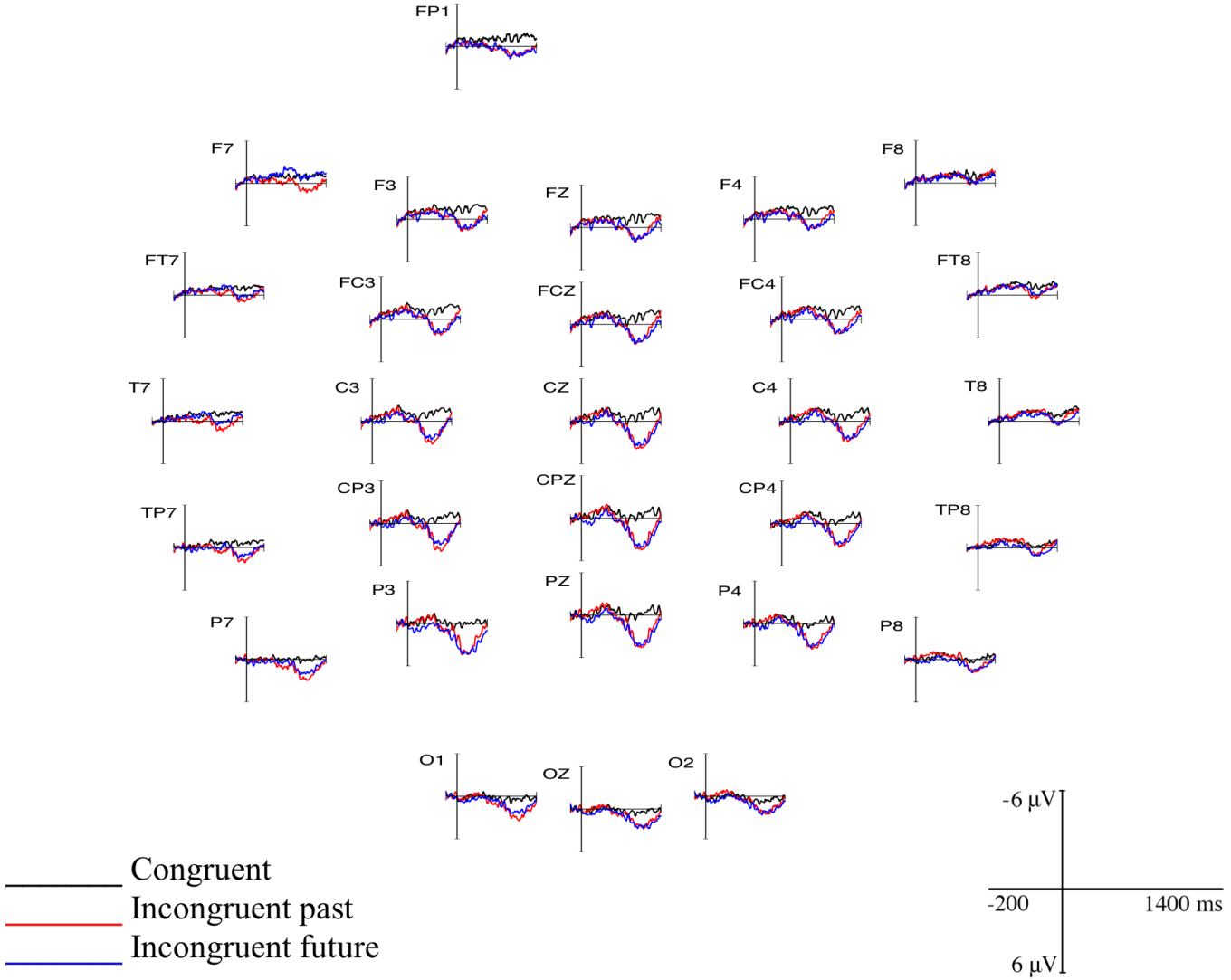


Topographic distribution of the ERP effects in the control semantic condition and in the control morphological (case) condition for L1 and L2 groups.



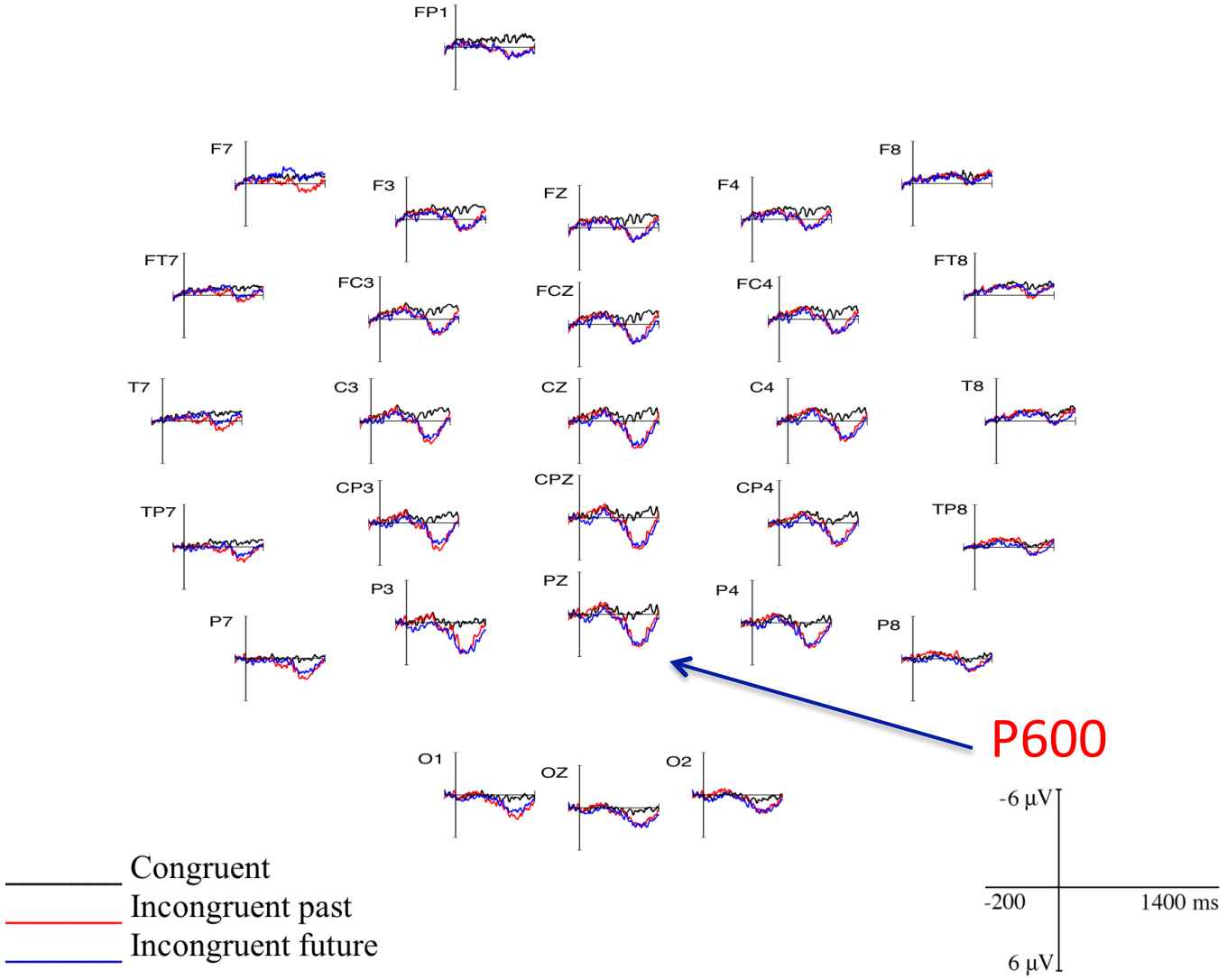
ERP results: Critical (onset-locked)

L1



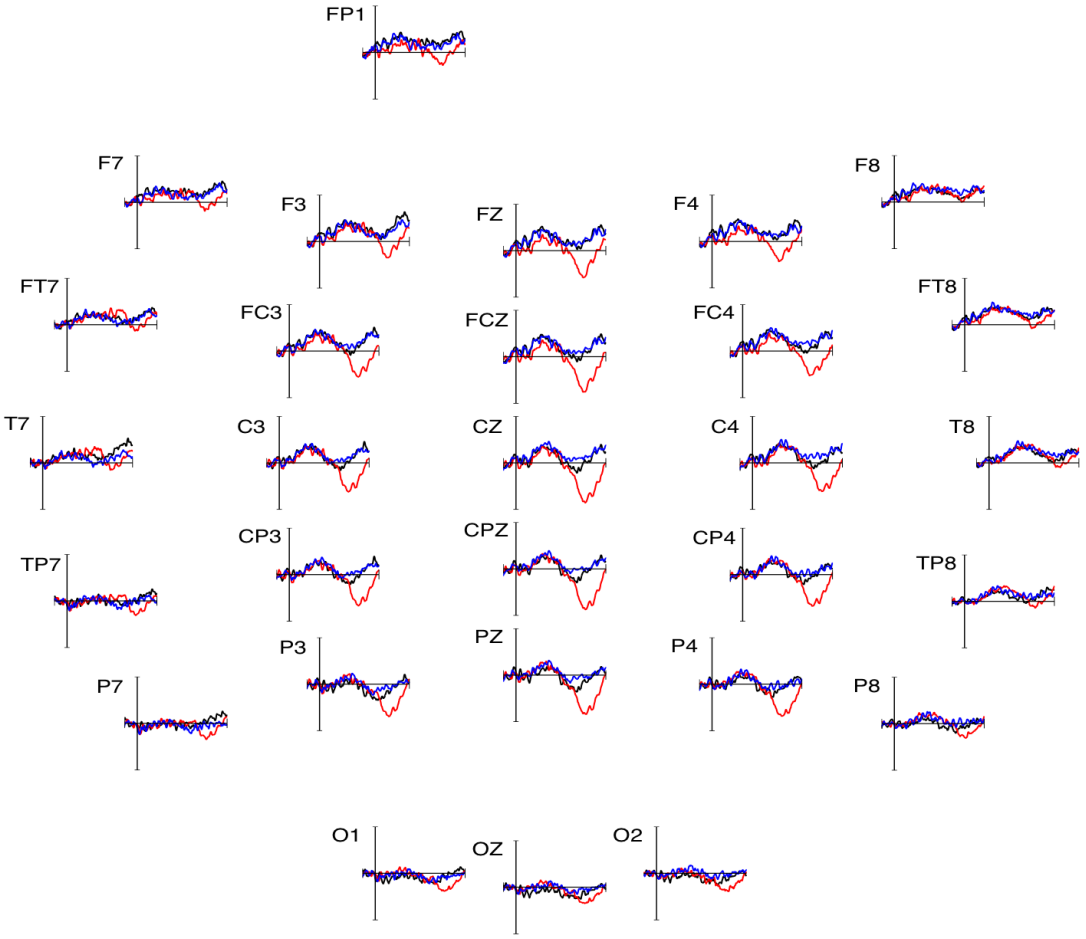
ERP results: Critical (onset-locked)

L1



ERP results: Critical (onset-locked)

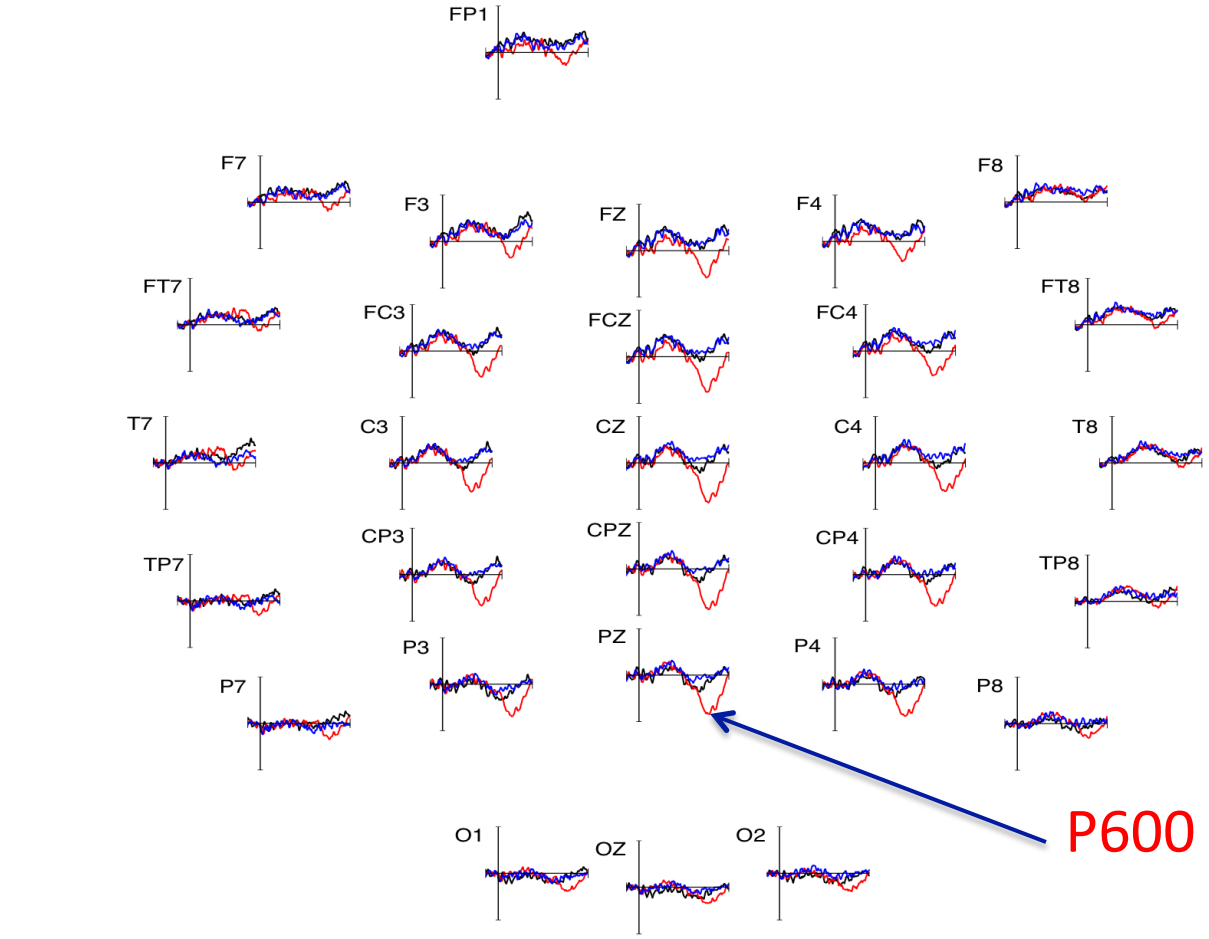
L2



Congruent
Incongruent past
Incongruent future

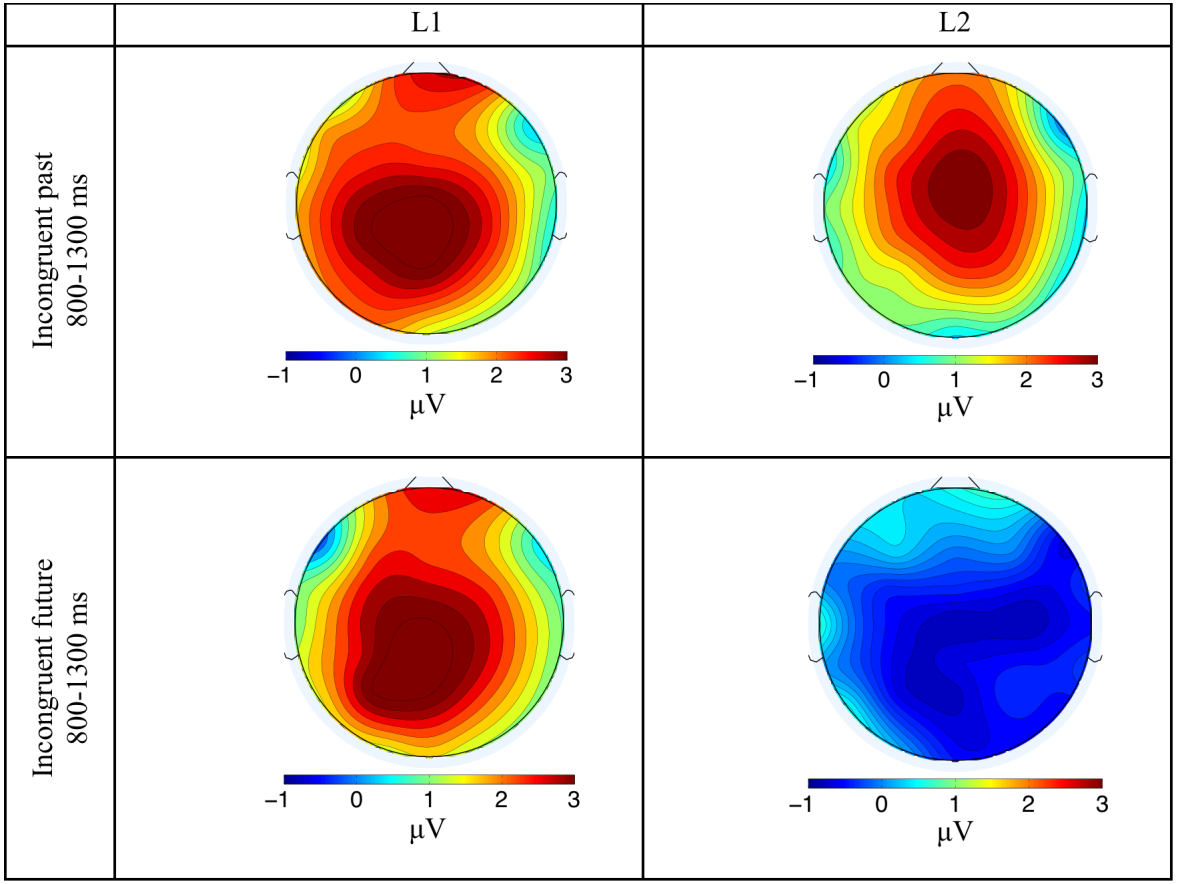
ERP results: Critical (onset-locked)

L2



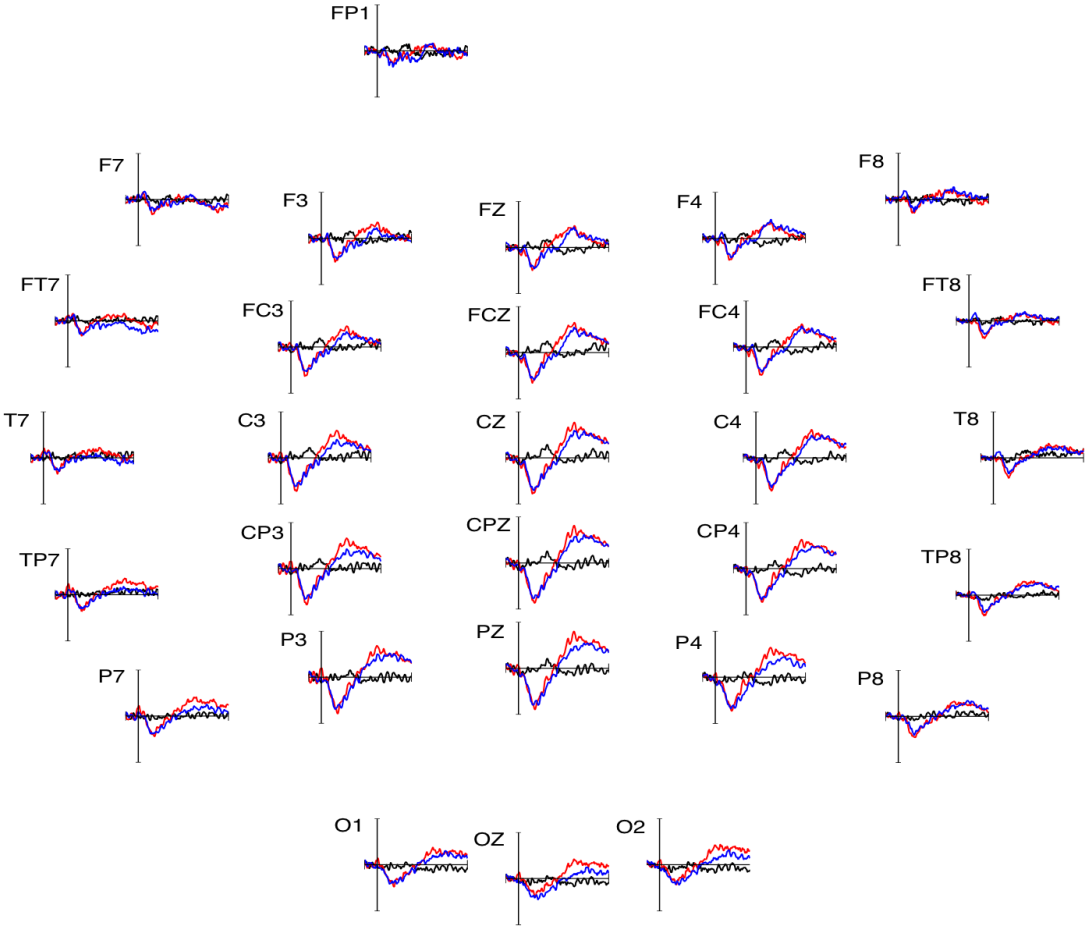
Congruent
Incongruent past
Incongruent future

Topographic distribution of the ERP effects in the 800-1300 ms latency windows for the critical incongruent past (top) and critical incongruent future (bottom) conditions for L1 and L2 groups.



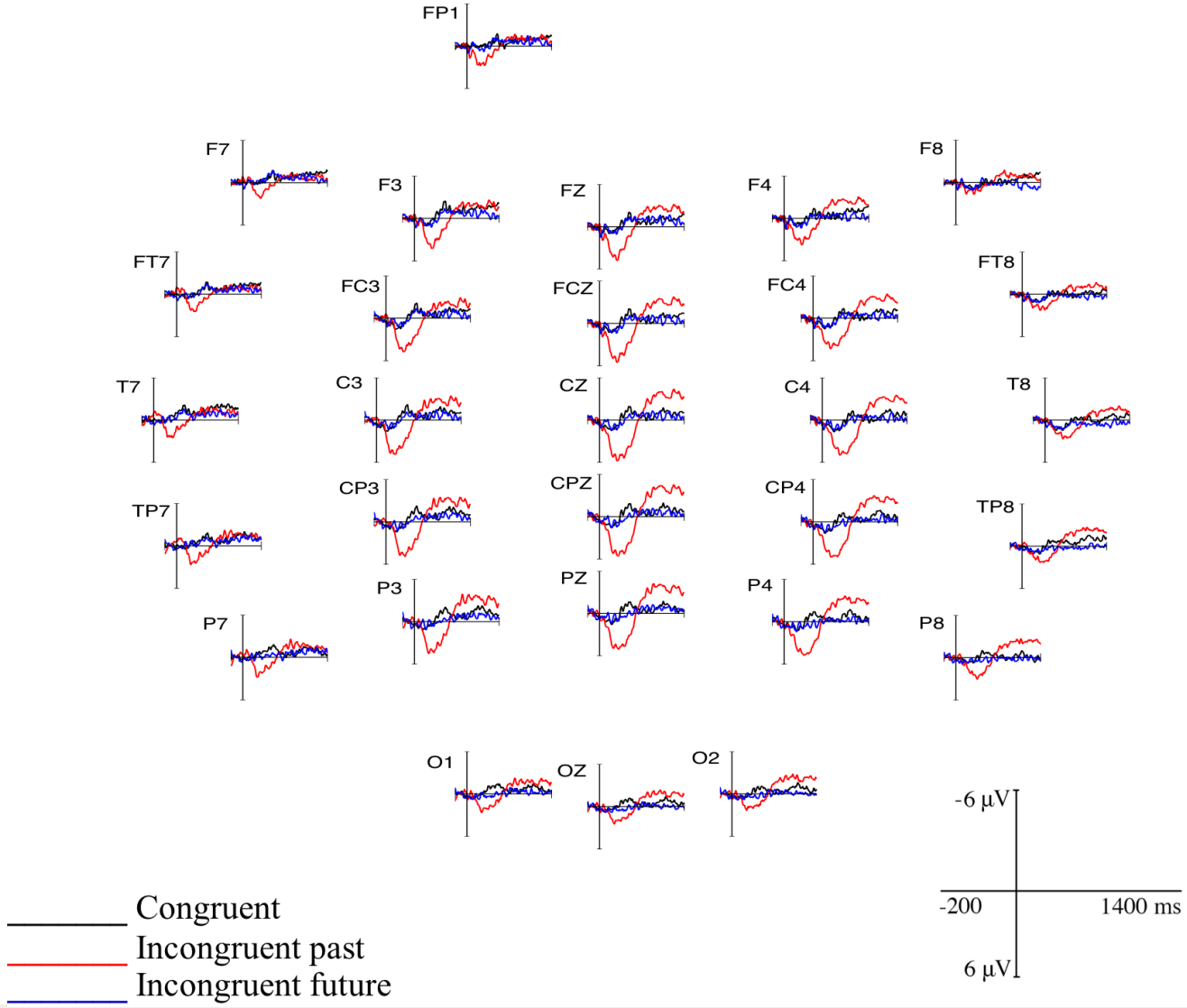
ERP results: Critical (offset-locked)

L1

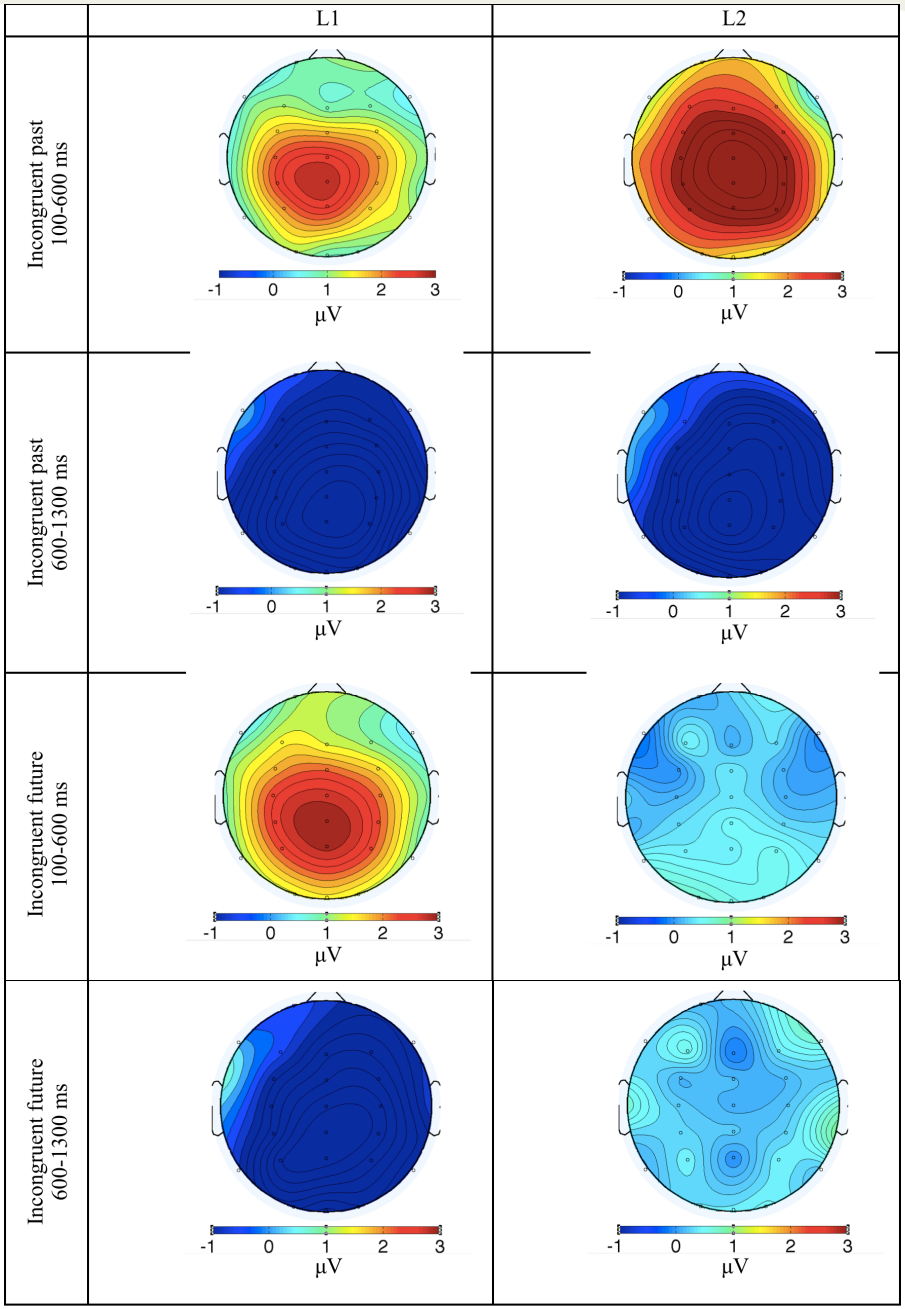


ERP results: Critical (offset-locked)

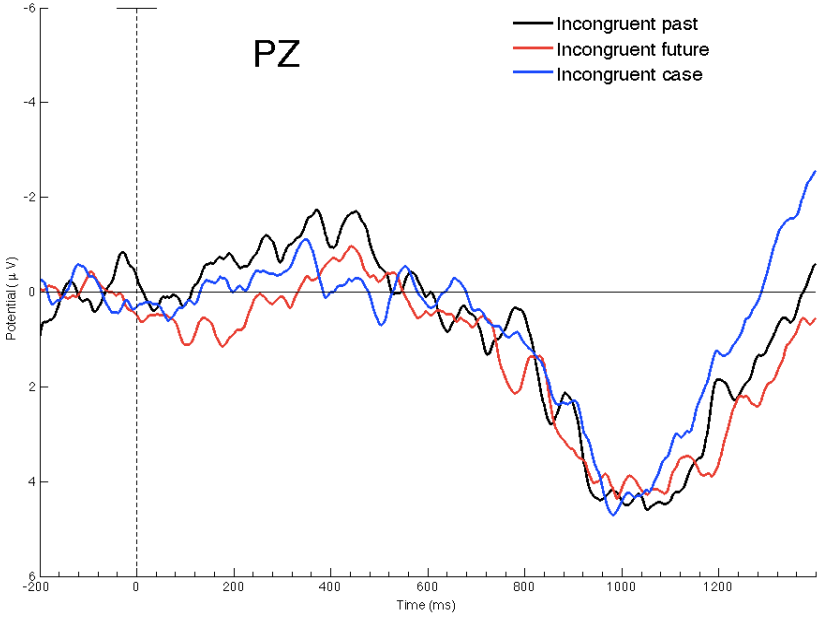
L2

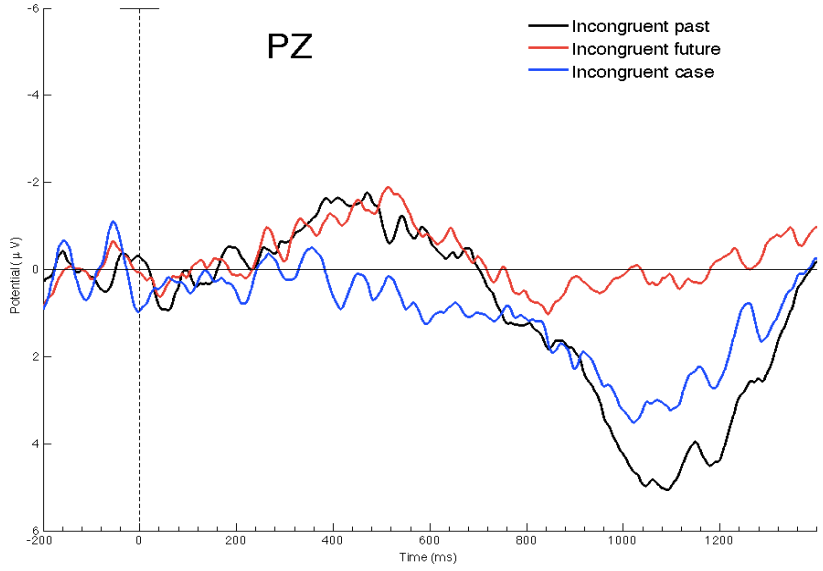


Topographic distribution of the ERP effects in the incongruent past and incongruent future conditions in the 100-600 ms and 600-1300 ms latency windows for L1 and L2 groups.



Grand average ERPs for a representative (PZ) electrode at the onset of the target word across all morphologically incongruent conditions in the L1 and L2 groups.





Discussion

Control condition

A. Semantic violation

- N400 and late P600 elicited in L1 and L2;
- P600 could reflect a more general language-related reanalysis processes
- similar distribution and temporal characteristics of the ERP components suggest similarities between L1 and L2 lexical–semantic processing.

Discussion

Control condition

A. Morphological (case) violation

- late P600 elicited in L1 and L2;
- English speakers of L2 Russian are sensitive to violations in the nominal case use, even though English does not have a comparably complex nominal case system;
- Contrary to predictions, L2 listeners repair and reanalyze incorrectly inflected word forms before integrating them with the rest of the context.

Discussion

Critical condition

- L2 comprehenders incorrectly accepted sentences with incongruent future-tense forms (73%) as correct → phonolexical ambiguity;
- P600 in both incongruent conditions in the L1 group; P600 only to past-tense forms in the L2 group;
- Contrary to predictions, L2 listeners are sensitive to morphological cues during sentence comprehension, but their morphological processing is modulated by the level of perceptual difficulty of the phonological contrast involved in the distinction of the two morphological forms.

Discussion

On the nature of timing of the P600

- delayed timing of the P600 could be due to the auditory modality of stimuli presentation [Leinonen et al., 2009; Lück et al., 2006],
- or to the greater computational load of processing of inflected words [Allen et al., 2003; Baayen et al., 1997; Lehtonen et al., 2007],
- or because critical comparisons occurred word-finally.

Conclusions

RQ 1: *What are the consequences of L2 phonolexical ambiguity for auditory sentence comprehension?*

- When L2 comprehenders encounter phonolexically unambiguous incongruent words during auditory speech comprehension, they experience processing difficulty trying to integrate them with the sentential context.
- Phonolexically ambiguous words, on the other hand, do not incur processing costs associated with contextual integration, as evidenced by i) negligible reaction time differences in the self-paced listening task, ii) a lack of inhibition effect in the lexical decision task, and iii) the absence of the P600 response in the ERP study.

Conclusions

RQ 2: *Do L2 listeners utilize contextual information for meaning resolution in online auditory sentence comprehension?*

- Provided that context has enough predictive power, L2 listeners can take advantage of the contextual information, and use it to access and select the intended lexical items through their semantic, syntactic and morphological characteristics despite low-resolution phonological information.

Conclusions

RQ 3: *Do L2 listeners utilize different kinds of contextual information, such as semantic, morphological and syntactic, for meaning resolution to the same degree?*

- L2 listeners utilize different kinds of contextual information to a different extent. L2 listeners, akin to L1 listeners, experience the strongest context effects in the syntactic and semantic conditions followed by the morphological condition, although L2 listeners can successfully generate morphological predictions and rely on them during online speech comprehension, as demonstrated by the ERP experiment.

Conclusions

RQ 4: *What is the time course of integration of phonological information with higher-order contextual information in L2?*

- The average duration of the target words in the critical condition was 780 ms, and the positivity started to emerge around 800 ms. It lasted for about 500 ms, peaking around 1000 ms. When the same waveforms were time-locked to word offsets, a positive deflection emerged as early as 100 ms and also spread over a 500-ms latency window. This suggests that as soon as the listeners reached words' uniqueness point and discovered a phonological mismatch, the parser experienced difficulty integrating the target word with the preceding context and invoked a rechecking procedure, after which meaning resolution was accomplished in about 500 ms.

Conclusions

RQ 5: *How does auditory sentence processing compare in L1 and L2 in terms of the use of contextual information and the temporal aspects of context effects?*

- L2 lexical representations may differ from those in L1 in that they may lack phonological specification and detail. However, we have obtained behavioral and electrophysiological evidence showing that, despite subtle differences, the mechanisms associated with top-down processing and the use of contextual information for meaning resolution in auditory sentence comprehension are essentially the same in the L1 and the L2.

Future research

"Extensive" way:

- using a similar framework, other kinds of contexts, phonological contrasts, and L1-L2 combinations may be examined;
- triangulation: using different methods, examine whether the results are generalizable or task-specific);
- other non-normative populations (heritage, patients with language deficits, etc.).

Future research

"Intensive" way:

- Neural correlates of prediction and integration mechanisms in speech comprehension (e.g., identifying brain networks involved in contextual prediction using VLSM);
- Uncovering the dependent variables of prediction:
  1. frequency
  2. number of cues
  3. earliness
  4. structure complexity

Thank you!

Support

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