Psycholinguistic Morphology in Semitic

Ling 105: Morphology
December 7, 2012

Announcements

- There are doughnuts.
- Final paper due **December 13th at 5p.m.**
- Options for handing it in:
  - Email it to **MATT** by 5p.m.
  - Turn it in to my mailbox in Stevenson Academic Services.
- Unacceptable hand-in options:
  - Slipping it under my office door.
  - Giving it to someone else in the linguistics department.
- Talk by me Monday at 3:30 in the LCR on clitics in Maltese and Arabic.

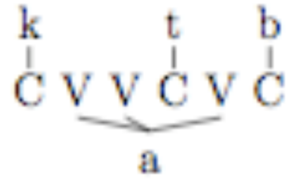
Central Questions

- What are the basic units of analysis in morphological representation/processing?
  - Are these units the same in all languages?
  - Are these units the same for all categories within a language?
- How is the mental lexicon organized?
  - Are all the basic analysis units utilized in lexical organization?
- How is morphology processed in comprehension?
  - Is morphology handled by distinct cognitive/neural systems?
  - What is the time course of morphological and semantic processing?

A Quick Semitic Refresher

- All words in Semitic are morphologically complex and made up of (up to possibly) three elements, all of which are discontinuous and bound:

  1. THE ROOT: 2-4 consonants; appears in many different words with common semantic core; basic unit of lexical meaning.
  2. THE VOCALISM: 2-3 vowels; bearers of tense/aspect/voice information; not really the object of study today.
  3. THE PATTERN: a timing template for arranging the root and vocalism to form an output word; necessarily abstract; maybe prosodic.



The Papers

1. Frost, Forster & Deutsch (1997). "What Can We Learn From the Morphology of Hebrew? A Masked Priming Investigation of Morphological Representation."
   - Visual masked priming study of Hebrew nouns.
   - Shows priming of **root** but not **pattern**.

2. Boudelaa, Pulvermüller, Hauk, Shtyrov, and Marslen-Wilson (2009). "Arabic Morphology in the Neural Language System."
   - Mismatch negativity study of Arabic nouns.
   - Shows differential neural activation for **root** and **pattern**, but clear neurological correlates of the processing of both.

Frost, Forster & Deutsch (1997)

"What Can We Learn From the Morphology of Hebrew? A Masked-Priming Investigation of Morphological Representation"

Visual Masked Priming: Subliminal Mind Control for the Working Psycholinguist

- The first article uses the paradigm of VISUAL MASKED PRIMING.
- PRIMING: In this paradigm, subjects see a PRIME very briefly, followed by a TARGET.
- VISUAL: all the stimuli (both prime and target) are presented on a computer and read by participants.
- FORWARD AND BACKWARD MASKING: the subject sees:
  1. FORWARD MASK (500 ms): ########
  2. PRIME (50 ms): nature
  3. TARGET (500 ms): MATURE
- The subject is not consciously aware of the existence of the prime.

Interpreting Priming Studies

- PRIMING: the difference in reaction time to a LEXICAL DECISION or NAMING task after exposure to a prime.
- LEXICAL DECISION: The subject is asked to decide if a presented word is a word of their language or not, as quickly as possible.
  - Reaction time (RT) and accuracy are usually measured.
- NAMING: The subject is asked to read the target word aloud as quickly as possible.
  - Reaction time (RT) and accuracy are usually measured.
- Priming is always relative to a CONTROL in which the prime is unrelated to the target along the relevant dimension.
- Negative results == facilitation/priming; positive results == inhibition
- Negative results are interpreted as evidence for common processing substrata for the prime and target.

The Hallmarks of Visual Masked Priming

- Visual masked priming allows for examining transient effects that are harder to pick up in longer time-course paradigms.
- The effects on RT in this paradigm are usually conditioned by ORTHOGRAPHIC and MORPHOLOGICAL factors, but not SEMANTIC ones.
- Strongest facilitation usually obtained for IDENTITY PRIMING (*e.g.*, nature-NATURE).
  - RELATED PRIMING usually gives numbers in between Identity and Control conditions.
- Form Priming is also seen (*e.g.*, matune-MAZUNE), and this is modulated by NEIGHBORHOOD DENSITY.
- None of these effects are typically seen for nonwords, meaning they're contingent upon lexical contact.

The Hebrew Nominal System (*mishkalim)*

- The Hebrew nominal system has the familiar root-and-pattern properties.
- Number of templates is high; possibly in the hundreds.
- No clear meaning association with individual templates.
- Same root can create many different nominal forms.
- *e.g.*, √zmr forms nouns:
  1. *zamar*, ‘male singer’
  2. *zemer*, ‘a song’
  3. *tizmoret*, ‘an orchestra’
  4. *zamarut*, ‘a singing profession’

The Experiments

1. Priming with Word Patterns
2. Priming with Roots
3. Priming with Nonword Legal Roots
4. Priming with Semantic Associates
5. Priming with Root Derivations
6. Priming with Pseudoroot Derivations

Experiment 1: The Stimuli

	IDENTITY	RELATED	CONTROL
Forward mask	########	########	########
prime	/targil/ (exercise) תרגיל	/taklit/ (record) תקליט	/tadhema/ (amazement) תדהמה
target	TARGIL תרגיל	TARGIL תרגיל	TARGIL תרגיל

Word pattern: T A _ _ I _ (masculine noun, result of an action).

Figure 2. Examples of stimuli used in Experiment 1 in the identity, related, and control conditions. Stimuli were presented in unpointed Hebrew script, and therefore, not all of the word-pattern vowels were necessarily printed. For example, the vowel /a/ of the word pattern *TA__I_* does not appear in print. Note that Hebrew is read from right to left.

IDENTITY	RELATED	CONTROL
/targil/	/taklit/	/tadhema/
'exercise'	'record'	'amazement'

TARGET

/TARGIL/

Experiment 1: The Results

Table 1
Reaction Times (RTs) and Percent Errors for Lexical Decision (Experiment 1A) and RTs for Naming (Experiment 1B) for Target Words and Nonwords in All Conditions

Target and condition	Lexical decision RT (ms)	Lexical decision Error (%)	Naming RT (ms)
Words			
Identity	541	5.2	543
Related	578	9.1	571
Control	579	8.2	574
Nonwords			
Identity	617	8.4	603
Related	627	8.8	632
Control	624	9.6	631

Note. Related targets had the same word patterns as primes.

Experiment 1: Conclusions

- Identity priming shows that the brief presentation of the prime doesn't matter – effects can be seen.
- Lack of difference in the related case means the **pattern does not prime**.
- Primes contained both consonants and explicitly written vowels, so orthography is (putatively) not a concern.
- The same effect in naming shows that phonological computation is launched immediately (explaining identity priming in this condition).
  - *Idea*: Computing the phonological representations of segments in the prime helps you with speaking the target.

Experiment 2: The Stimuli

	IDENTITY	RELATED	CONTROL
Forward mask	########	########	&&&&&&&&
prime	tizmoret תזמורת	zmr זמר	tmr תמר
target	TIZMORET תזמורת	TIZMORET תזמורת	TIZMORET תזמורת

ROOT: Z M R- זמר (anything to do with singing)
tizmoret [orchestra]
Tmr [date]

Figure 3. Examples of stimuli used in Experiment 2 in the identity and control conditions.

IDENTITY	RELATED	CONTROL
/tizmoret/	/zmr/	/tmr/
‘orchestra’	‘singer/ song’	‘date’

TARGET

/TIZMORET/

Experiment 2: The Results

Table 2
Reaction Times (RTs) and Percent Errors for Lexical Decisions and RTs for Naming of Target Words and Nonwords in All Conditions in Experiment 2

Target and condition	Lexical decision RT (ms)	Lexical decision Error (%)	Naming RT (ms)
Words			
Identity	566	6.2	583
Related	578	6.7	594
Control	591	6.4	607
Nonwords			
Identity	640	8.9	653
Related	642	9.8	663
Control	639	8.3	661

Note. Related targets had the same roots as primes.

Experiment 2: Conclusions

- Roots prime regardless of positional realization in word.
- Controls had some letter overlap, so could it be inhibition in those cases?
  - Form priming occurs regardless, so the idea is to measure *additive* contributions of overlaps in root morphemes.
- Related condition > Identity condition: the hallmark of visual masked priming.
- No priming effects with nonwords, meaning that these roots help organize *lexical* information/access.

Experiment 3: The Stimuli

- *Problem*: how can we be sure it's not word-to-word activation in Experiments 1 and 2?
- *Idea*: Use nonwords formed of legal roots in illegal patterns.
  - *e.g.*, √rdm exists, as evidenced by *tardemah*, 'deep sleep,' but **radam* does not.
- Controls are "three letters that appeared in the targets, but could not be read as a meaningful word" (p.838).

Experiment 3: The Results

Table 3
Reaction Times (RTs) and Percent Errors for Lexical Decisions and RTs for Naming of Target Words and Nonwords in All Conditions of Experiment 3

Target and condition	Lexical decision RT (ms)	Lexical decision Error (%)	Naming RT (ms)
Words			
Identity	558	5.1	550
Related	565	5.1	565
Control	579	5.5	576
Nonwords			
Identity	643	6.8	598
Related	652	6.9	616
Control	648	7.1	621

Note. Related targets had the same roots as primes, but roots are nonwords.

Experiment 3: The Conclusions

- Since we see priming even when the root (== prime) isn't an independent word, we know this is about *morphological* transfer.
- Prime does not need to be an actual word to facilitate access.
- Thus, we cannot rely on word-to-word linkings to organize the lexicon.

Experiment 4: The Stimuli

- Up until now, we've only considered primes that have a clear semantic relationship to the target *and* a morphological relationship.
- *Idea*: Use primes with *only* semantic similarity to the target. If we do not see priming, we know that this is about Morphology and not orthography/phonology.
- Instead of *zamar*, 'singing' priming TIMZORET (√zmr), use *nagan*, 'instrument playing.'
- Controls had same consonants but no semantic relationship.

Experiment 4: The Results

Table 4
Reaction Times (RTs) and Percent Errors for Lexical Decisions to Target Words in All Conditions in Experiment 4

	Identity	Related	Control
RT (ms)	532	567	564
Error (%)	5.3	6.2	9.8

Note. Targets are semantically but not morphologically related to the primes.

Experiment 4: Conclusions

- No priming implies that semantics is not the relevant notion for this effect.
- Thus, the previous experiments were about form priming, not semantic priming.

Experiment 5: The Stimuli

IDENTITY	M+S+	M+S-	CONTROL
/taklit/	/haklata/	/klita/	/takala/
'a record'	'a recording'	'subscription'	'malfunction'

TARGET

/TAKLIT/

	IDENTITY	M+S+	M+S-	CONTROL
Forward mask	########	########	########	########
Prime	taklit [a record] תקליט	haklata [a recording] הקלטה	klita [absorption] קליטה	takala [malfunction] תקלה
Target	TAKLIT תקליט	TAKLIT תקליט	TAKLIT תקליט	TAKLIT תקליט

ROOT: KLT - קלט (anything to do with receiving).

Figure 4. Examples of stimuli used in Experiment 5. Stimuli were presented in unpointed Hebrew script, and therefore, not all of the word vowels were printed. For example, the middle vowel /a/ does not appear in print. M+S+ = morphologically and semantically related; M+S− = morphologically related and semantically unrelated.

Experiment 5: The Results

Table 5
Reaction Times (RTs) and Percent Errors for Lexical Decisions to Target Words in All Conditions in Experiment 5

	Identity	M+S+	M+S−	Control
RT (ms)	546	568	572	583
Error (%)	3.1	6.3	6.6	7.3
Priming (ms)	37	15	11	

Note. Priming times were calculated by subtracting the RT for each condition from the RT for the control condition. M+S+ = morphologically and semantically related; M+S− = morphologically related and semantically unrelated.

Experiment 5: The Conclusions

- Priming in both the [+M, +S] and [+M, -S] suggests that priming occurs regardless of semantic overlap.
- Suggests a mandatory process of root extraction, even when the word-level evidence suggests that is not needed.
- Interesting divergence from English where [+M, -S] doesn't prime. Two possibilities:
  1. Genuine difference between languages
  2. Previous studies were cross-modal – maybe a task effect?

Experiment 6: The Stimuli

- Just like experiment 3, except here the illegal derivations are in forms other than /paʔal/.
  - *e.g.*, **tazmera* doesn't exist even though the pattern and √zmr exist.
- Control condition includes letter overlap, but not in the root.

Experiment 6: The Results

Table 6
Reaction Times (RTs) and Percent Errors for Lexical Decisions to Target Words in All Conditions of Experiment 6

	Identity	Related	Control
RT (ms)	530	555	559
Error (%)	4.5	6.6	8.4

Note. Primes are nonwords composed of illegal combinations of legal roots and word patterns.

Experiment 6: The Conclusions

- Pseudoroot derivations do not prime.

General Conclusions

- Masked priming is a transfer effect: activation of form is carried over the short INTER-STIMULUS INTERVAL to facilitate the target.
- Morphological units in Hebrew, though abstract and always bound, are an organizing force in the lexicon.
- However, the role of root and word pattern are not equivalent in lexical access.
- We see the characteristics of visual masked priming all throughout the experiments where we see priming.
- We never see similar priming for nonwords.

General Conclusions

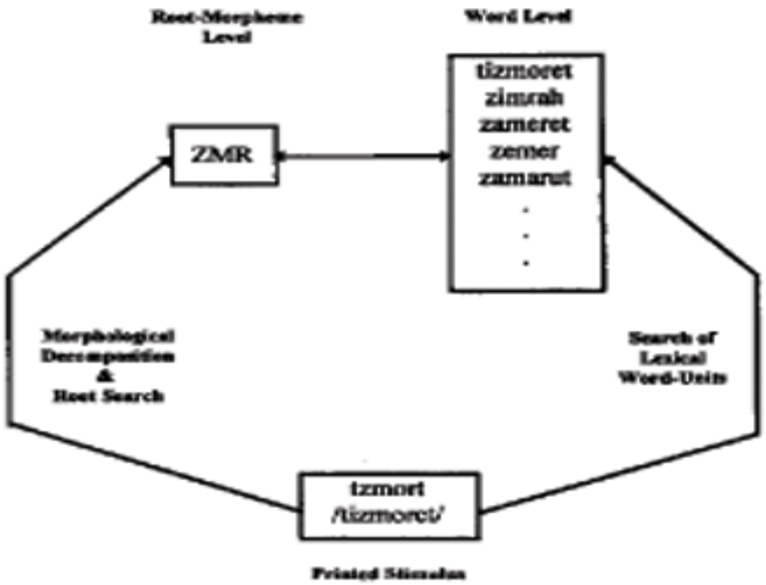


Figure 5. The internal structure of the Hebrew lexicon and the processes involved in printed word recognition.

Remaining Questions:

- The verbal system has far fewer patterns; perhaps the lack of priming in patterns is a function of their number in a particular categorial domain?
- Are these results better described in activation or entry-opening models of the lexicon?
- What impact, if any, does the short-vowel eschewing orthography have on visual masked priming?

Boudelaa, Pulvermüller, Hauk, Shtyrov & Marslen-Wilson (2009)

"Arabic Morphology in the Neural Language System"

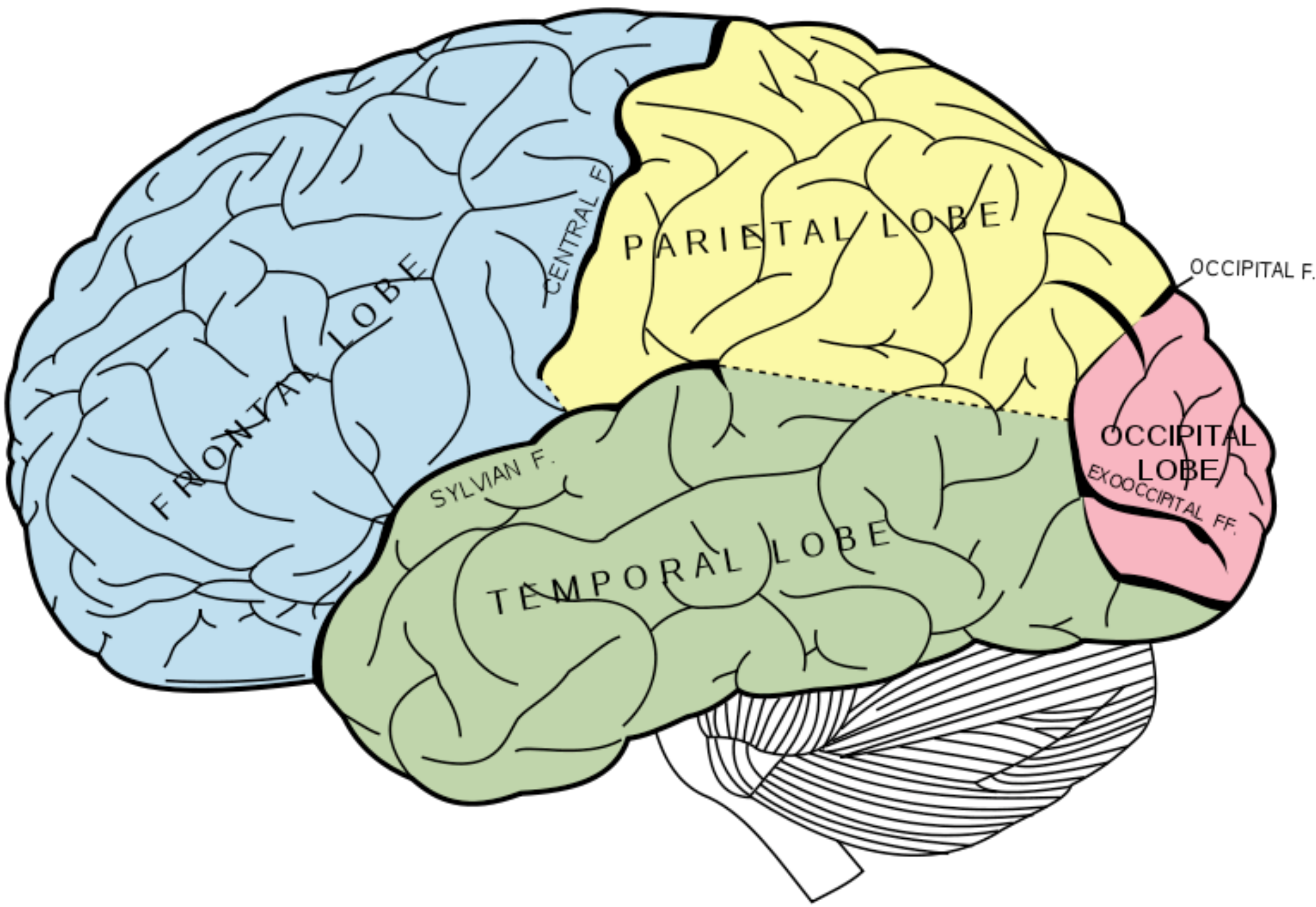
Electroencephalography: Scanning Brains for SCIENCE!

- Basic idea: place electrodes all over the head; measure latent electrical activity over the scalp.
- Since it's electrical activity, it's definitely not conscious.
- MISMATCH NEGATIVITY (MMN): unfortunately, both the name of the paradigm *and* the result.
- Paradigm: Play someone a sequence of identical *standard* sounds and a random occasional *deviant sound.*

EEG Data is Messy

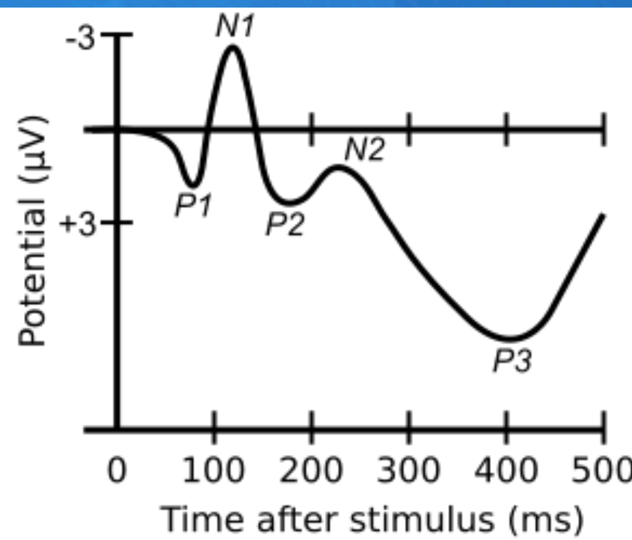
- Usually data is pooled over subjects to form a Grand Average.
  - This helps filter out most of the noise.
  - Outliers are usually trimmed based on some predefined metric.
- In MMN studies, we're interested in the *difference* between the *deviant* and *standard* waveforms.
- Then: *t*-tests on the means of MMN for successive time windows estimates the time-course.

The Human Brain



Event-Related Potentials

- ERPs are EEG correlates of stimuli.
- How to read most: {P,N}XXX where P = Positive, N = Negative and XXX is the latency in ms.
- The big three from neurolinguistics:



1. E(ARLY) L(EFT) A(NTERIOR) N(EGATIVITY): ~200ms; triggered by morphology or syntax violations.
2. N400: localized to the centro-parietal areas, triggered by semantics, but also affected by frequency.
3. P600: mostly centro-parietal, but also sometimes frontal; long duration, usually seen in syntax/grammatical errors.

Some Caveats

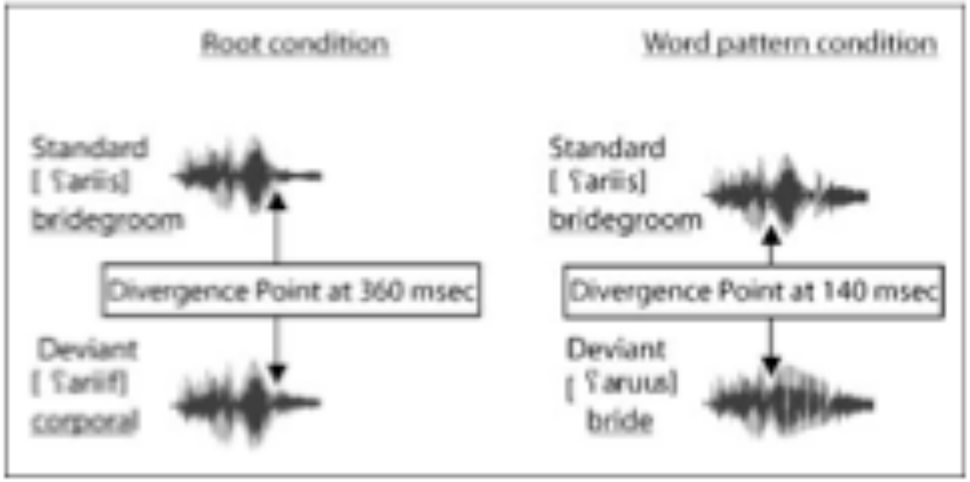
- We can project this data back onto a topographic map generated by fMRI data.
  - However, EEG is still not great in the spatial domain, and not as good as magnetoencephalography (MEG).
- EEG can only get data from the superficial layers of the cortex and a few other places.
- Can’t really get deep cortices or currents running tangential to the skull.
- We can only ever reconstruct the current source for a given signal with modeling.

With All That in Mind…

- **Question**: what are the neural correlates of root and pattern processing in Arabic?
- MMNs are sensitive to expectations of morphological structure. Do we see MMNs when we vary the root and pattern in deviant stimuli?
- Based on English, we expect:

1. Root to pattern like monomorphemic content words (fronto-central MMN early and not lateralized).
2. Pattern to pattern like grammatical morphemes (later fronto-parietal MMN lateralized to the left).

The Stimuli



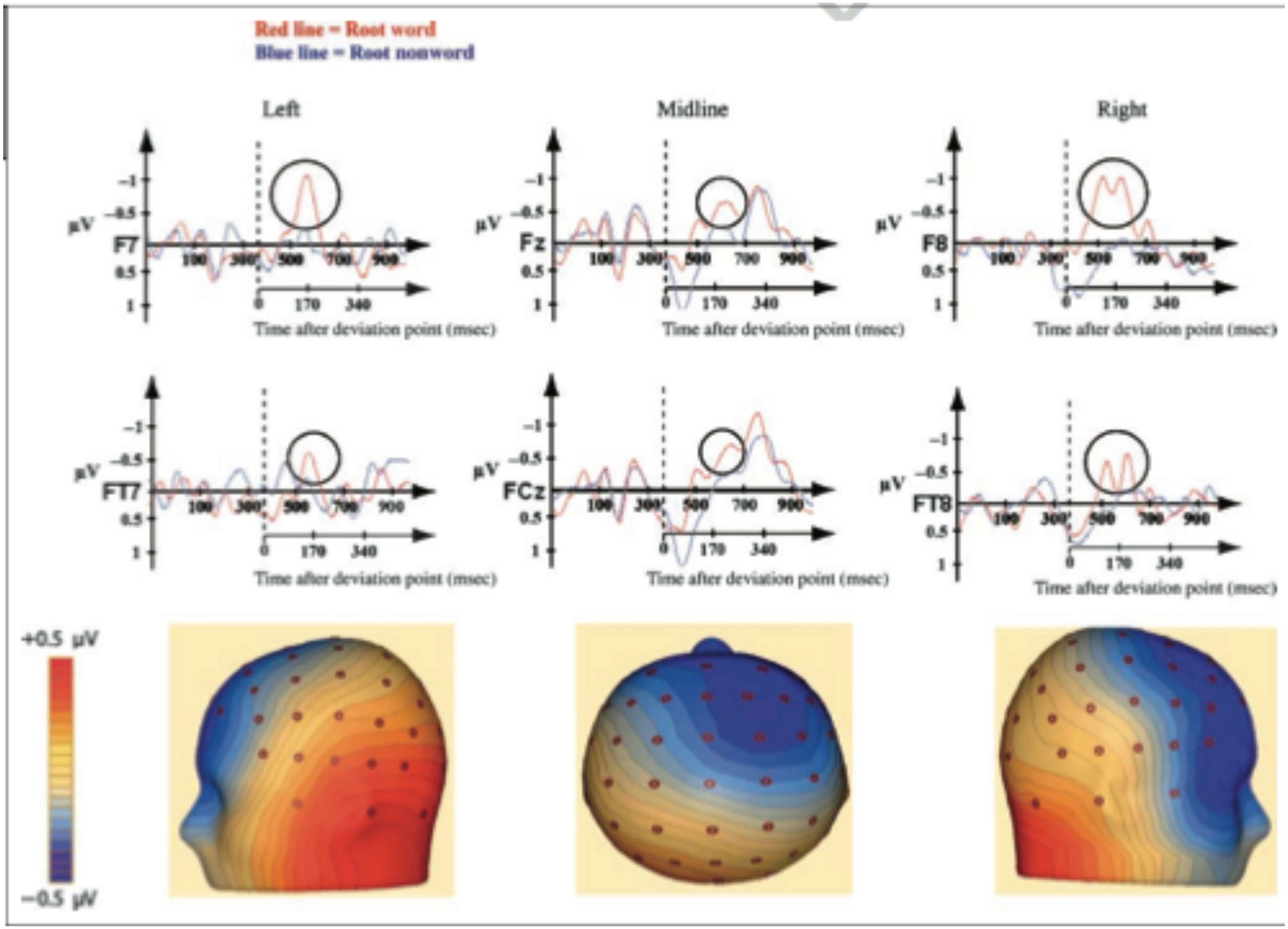
Root Condition

ʕariis
`groom'
ʕariif
`corporal'

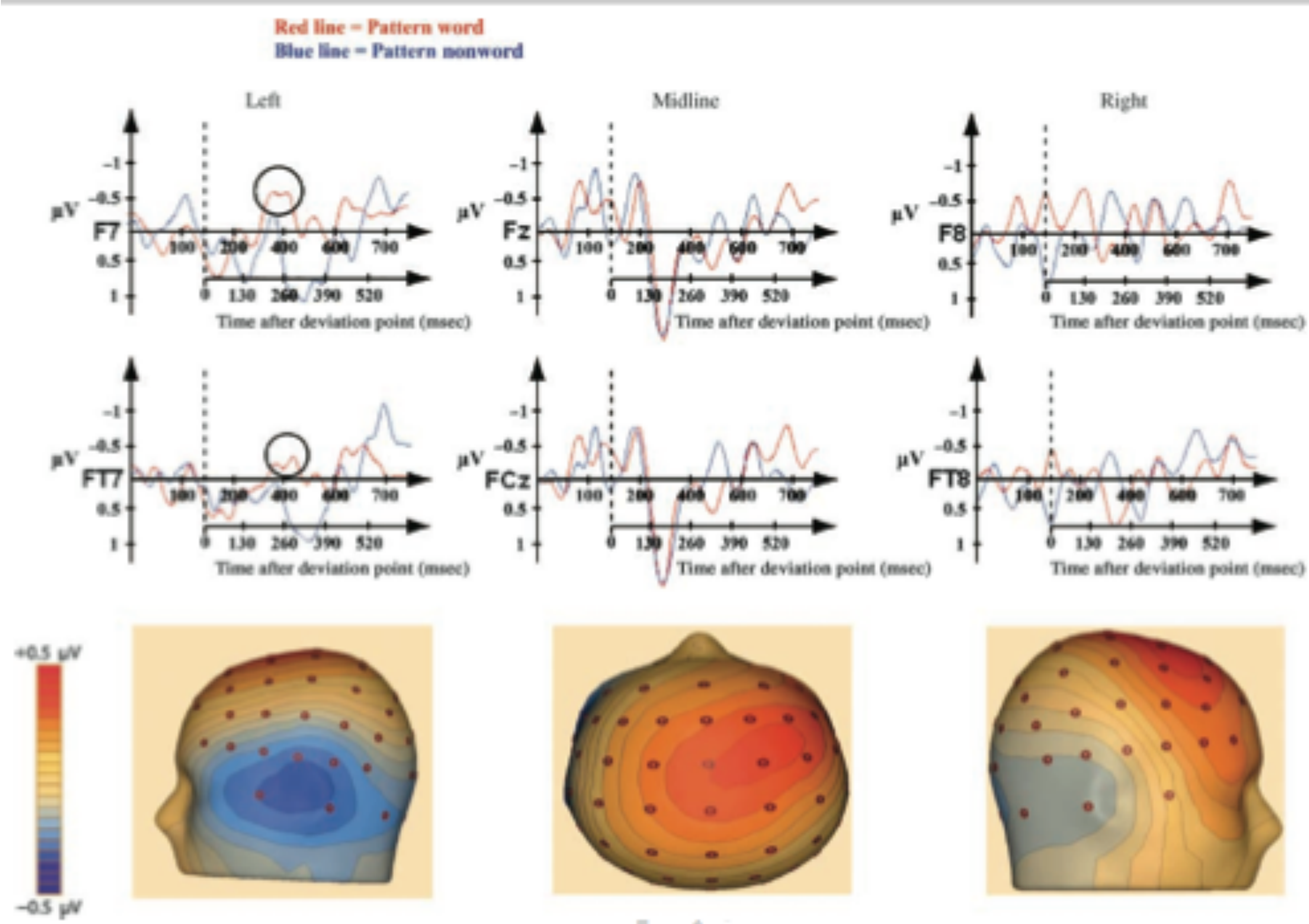
Pattern Condition

ʕariis
`groom'
ʕaruus
`bride'

- Acoustically identical except that the deviant stimuli differ in ROOT or PATTERN.
- Splicing done to ensure acoustic identity.
- Nonwords constructed along similar logic.



Red line = Root word
Blue line = Root nonword
Left
Midline
Right
μV
F7
Fz
F8
FT7
FCz
FT8
Time after deviation point (msec)
+0.5 μV
−0.5 μV



Red line = Pattern word
Blue line = Pattern nonword
Left
Midline
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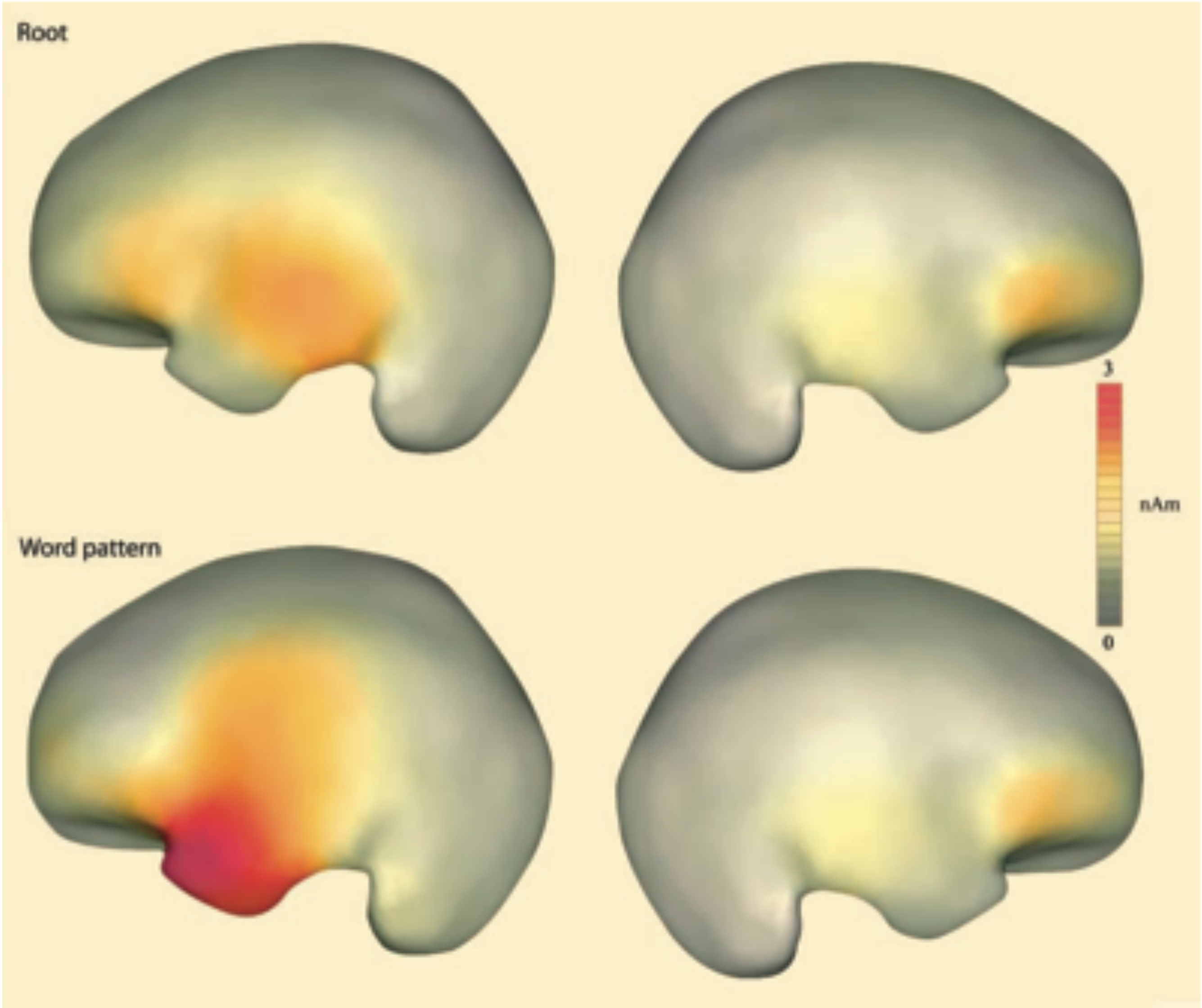
μV
F7
Fz
F8
FT7
FCz
FT8
Time after deviation point (msec)
+0.5 μV
−0.5 μV


Root
Word pattern
3
nAm
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Discussion

- Root and pattern have different neural correlates in comprehension, both in time and space.
- These ERPs look vaguely like early correlates of the N400.
- An ANCOVA shows that the morphological interpretation is robust even after correcting for semantic relatedness.
- Word-based approaches to Arabic are downright screwed here.
- Stem-based approaches are also going to struggle on the root data.

Discussion (cont.)

- The MMN seen with deviant roots looks like the MMN seen with deviant monomorphemic content words for English.
- The MMN seen with deviant patterns looks like the MMN seen for deviant grammatical morphemes in English.
- **Question**: But why the different timecourse? Note that both ERPs are after the WORD RECOGNITION POINT.
- **But…**at any rate, we see here some concrete neurological correlates of the processing of abstract, bound, nonconcatenative morphemes.

مع سلام!

(The End)