

# Un/Re-packing argument and event structure restrictions on prefixation: MEG evidence

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**Linnaea Stockall, Christina Manouilidou, Laura Gwilliams and Alec Marantz**

*Workshop on the syntax of argument structure: empirical  
advancements and theoretical relevance | 38.*

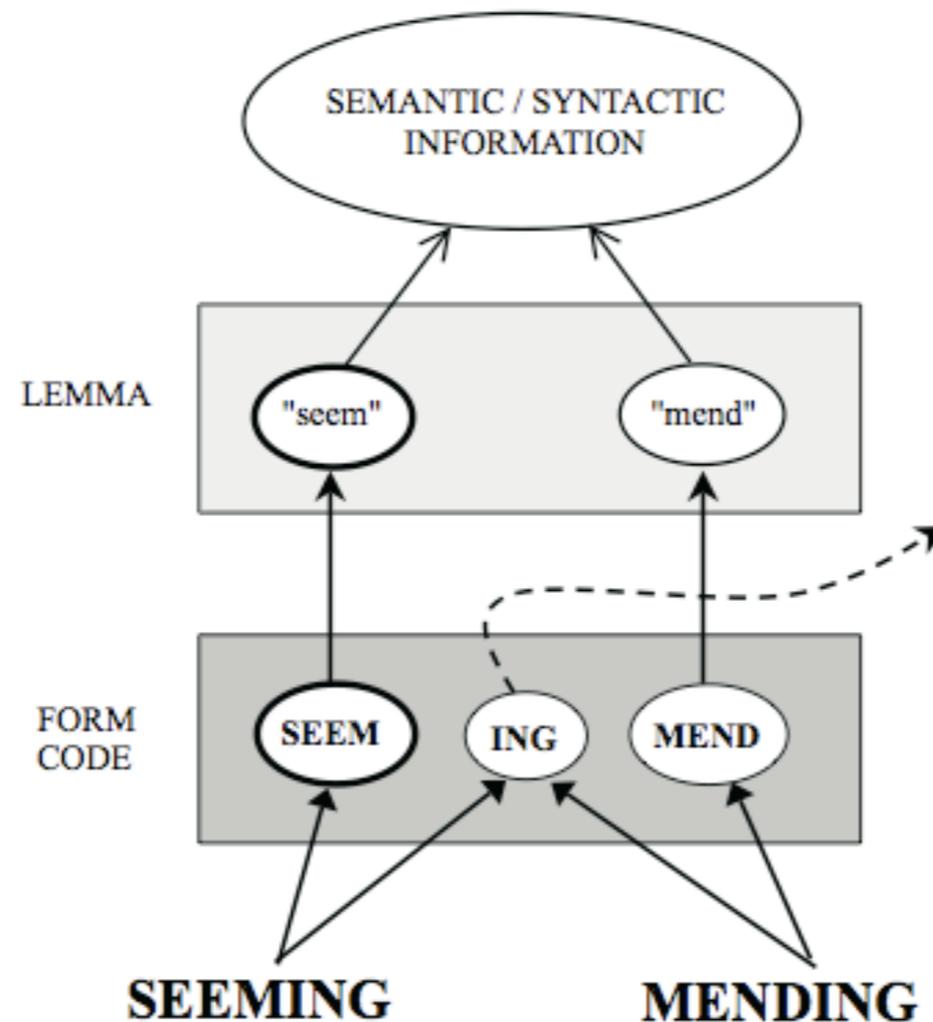
*Jahrestagung der Deutschen Gesellschaft für*

*Sprachwissenschaft*

*February 24-26, 2016*

# Past Decade: Consensus(ish)

There is an early stage of morpho-orthographic processing which involves detecting morphological constituents purely on the basis of their word form characteristics (no effects of semantics). This mechanism operates equally over 'teacher' and 'number'. (Rastle & Davis (2008).)



# Converging Evidence

The broth in my brother's brothel:  
Morpho-orthographic segmentation  
in visual word recognition

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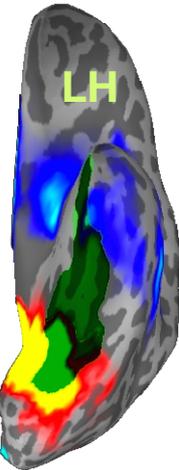
frontiers in  
HUMAN NEUROSCIENCE

ORIGINAL RESEARCH ARTICLE  
published: 22 November 2013  
doi: 10.3389/fnhum.2013.00798

MEG masked priming evidence for form-based  
decomposition of irregular verbs

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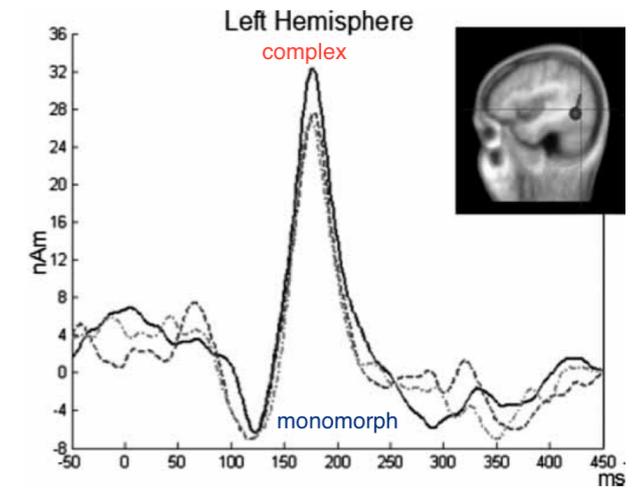
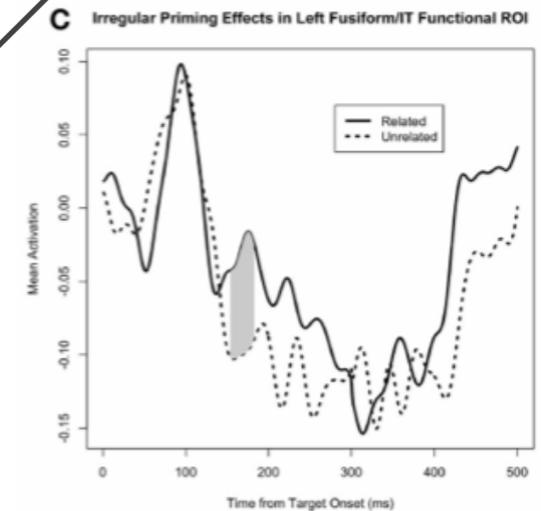
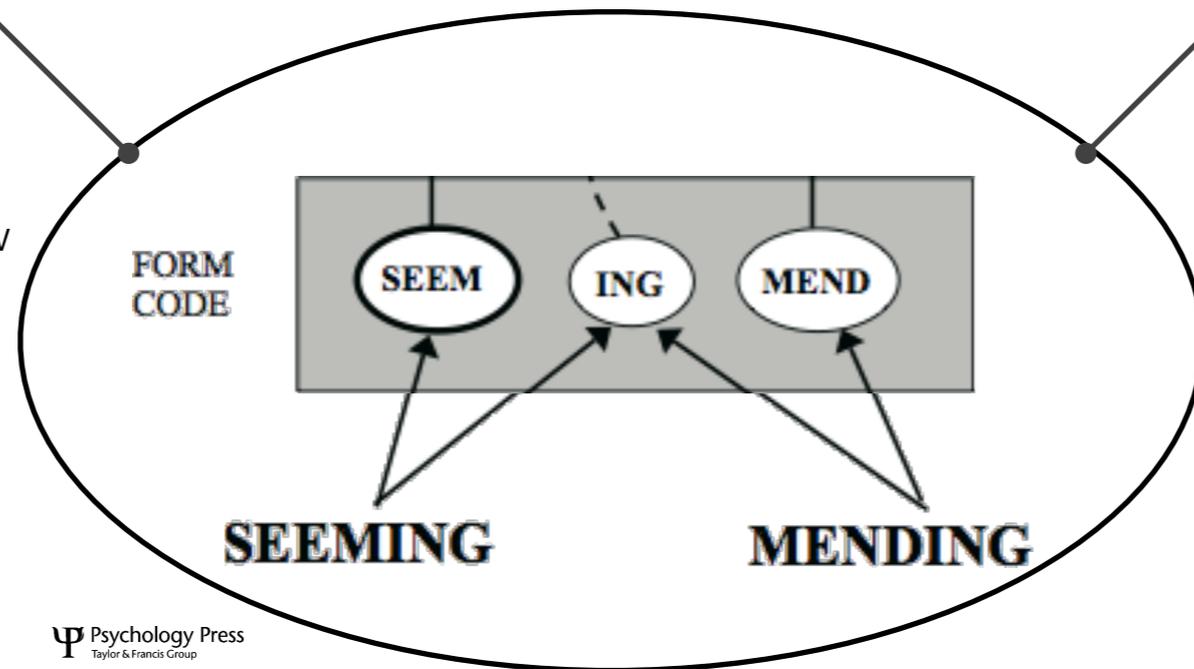


Behavioural Masked  
Priming

EEG and MEG  
Masked Priming

+	####	prime	TARGET
500ms	500ms	33ms	~2500ms

- with ~40ms of prime exposure
- *teacher* primes *teach*
- *brother* primes *broth*
- *brothel* does not prime *broth*
- see Rastle & Davis, 2008 for a review of >20 studies reporting consistent results since 1999



LANGUAGE AND COGNITIVE PROCESSES  
2009, 24 (3), 412–439

Psychology Press  
Taylor & Francis Group

A visual M170 effect of morphological complexity

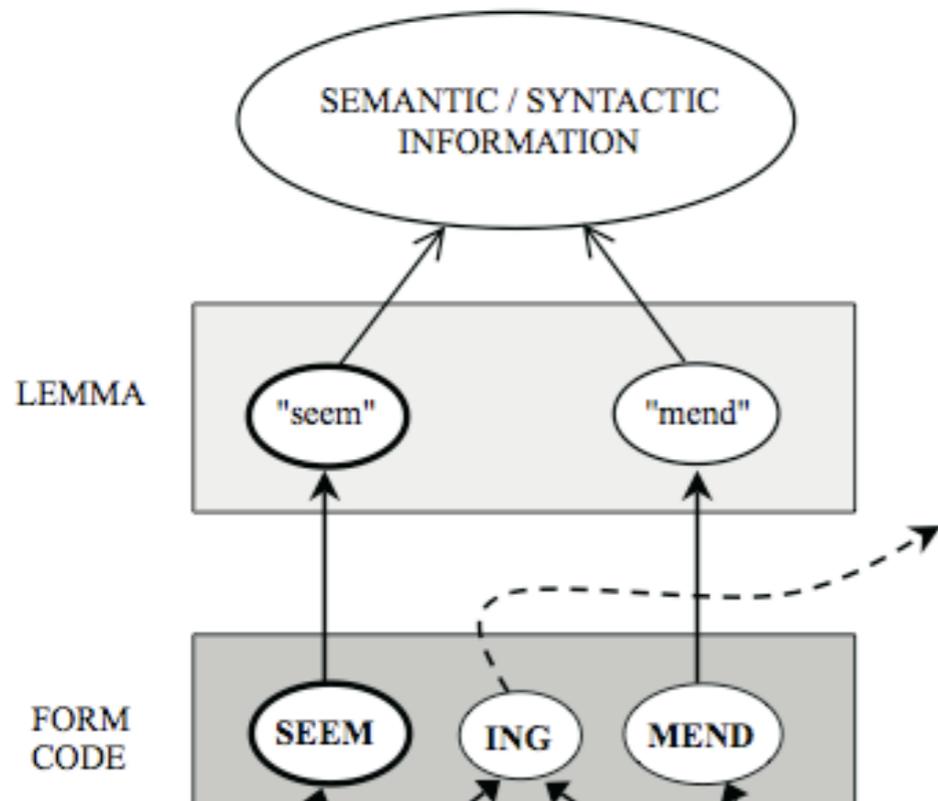
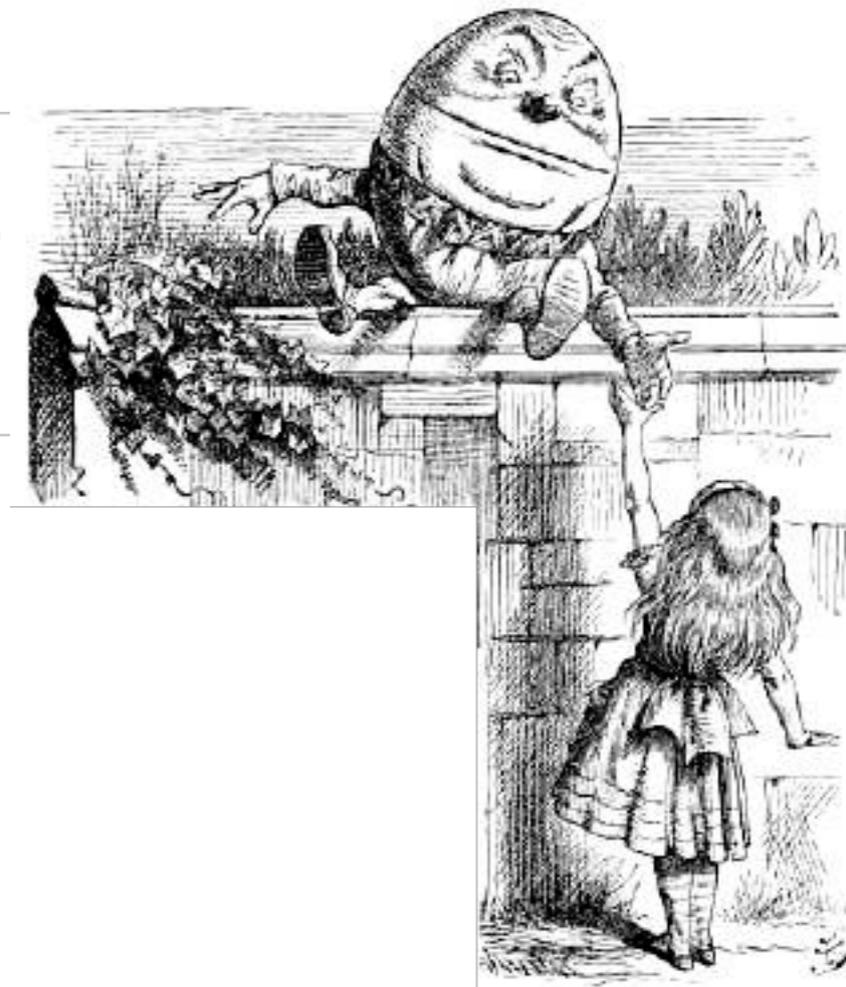
Eytan Zweig  
Department of Language and Linguistic Science, University of York, York, UK

Liina Pykkänen  
Departments of Linguistics and Psychology, New York University, New York, NY, USA

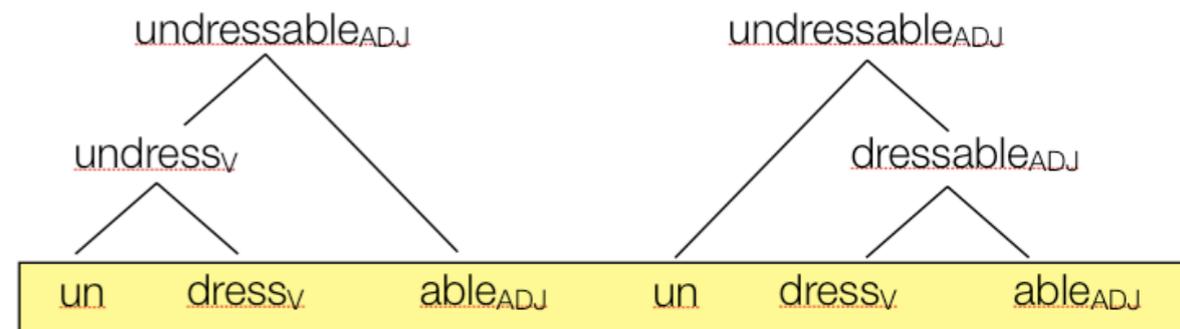
MEG Single  
Word Reading

compared **COMPLEX**: teacher (exp1), refill (exp2); **MONOMORPH**: straight & **PSEUDO-AFFIXED**: winter (exp1), resist (exp2)

# But then what?



- ❖ teacher —> teach | er vs. brother —> broth | er
- ❖ undressable —> un | dress | able



## Decomposition, lookup, and recombination: MEG evidence for the Full Decomposition model of complex visual word recognition

Joseph Fruchter <sup>a,\*</sup>, Alec Marantz <sup>a,b,c</sup>

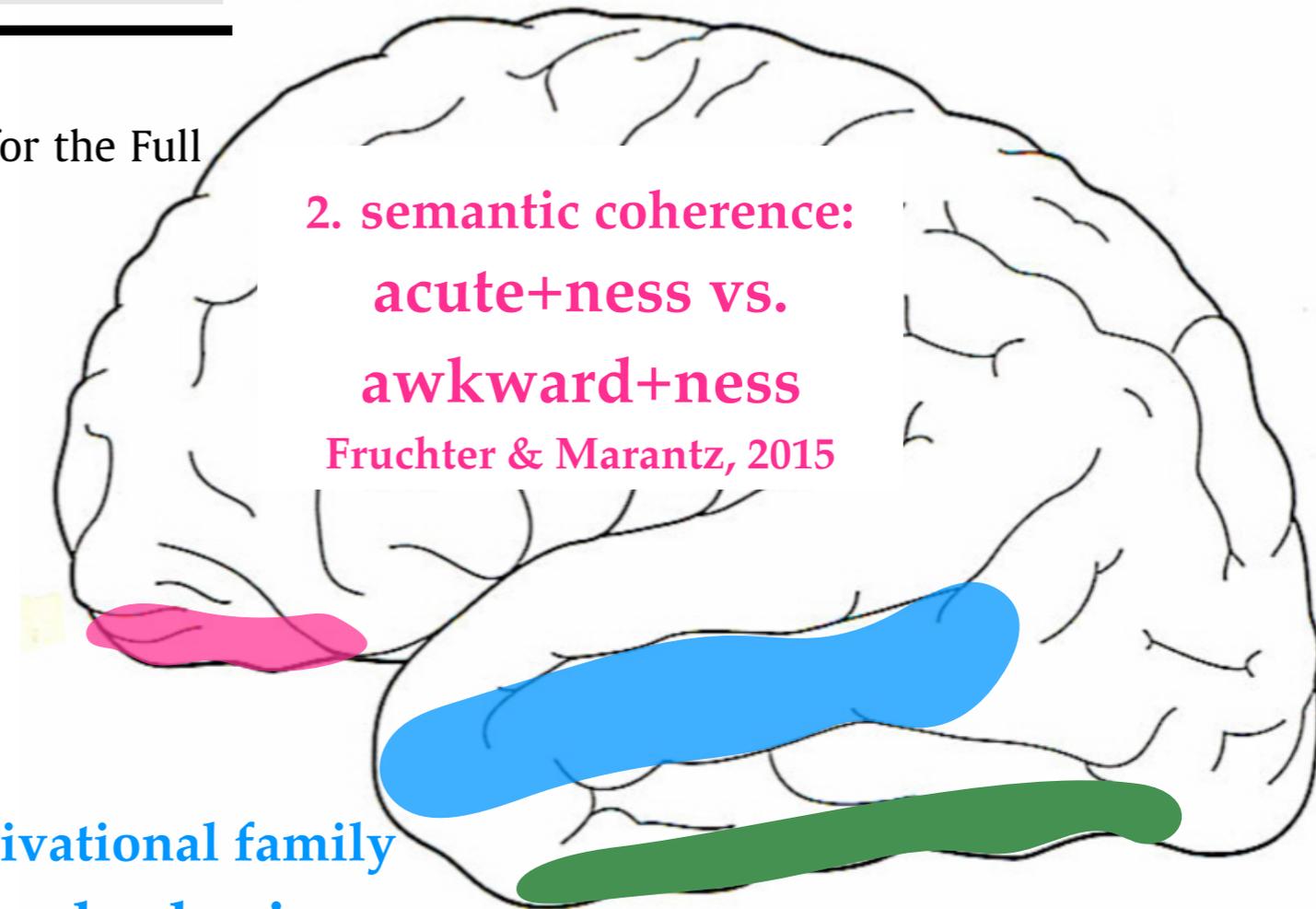
<sup>a</sup> Department of Psychology, New York University, New York, NY, USA

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Schreuder & Baayen (1995):

- **licensing**: the syntactic combinability of the stem and the affix is checked
- **composition**: the meaning of the stem + affix combination is computed.



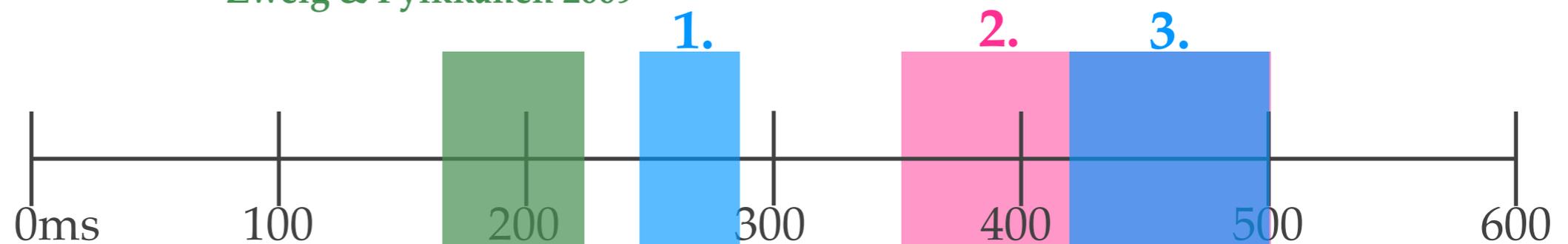
**2. semantic coherence:**  
**acute+ness vs.**  
**awkward+ness**  
Fruchter & Marantz, 2015

**1. derivational family**  
**entropy: barbaric vs.**  
**famous**  
Fruchter & Marantz, 2015

**3. surface frequency:**  
**barbaric vs. famous**  
Fruchter & Marantz, 2015

**re | fill vs. re | sume**

Zweig & Pykkänen 2009



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# Our Project

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- ❖ to investigate the when and how of morphological recombination and interpretation
- ❖ by measuring responses to combinations that systematically violate different wellformedness restrictions on verbal affixation

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# Verbal Affixation Restrictions

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- ❖ **re-** selects internal argument taking accomplishments
  - ❖ reopen (a door) / repaint (a house) / refill (a glass)
  - ❖ \*resmoke / \*relaugh / \*resang / \*renap [*\*unerg / activity*]
  - ❖ \*repet (the dog) / \*repush (the cart) [*\*atelic*]
  - ❖ \*rekick (the ball) / \*rereach (the top) [*\*achievement*]
  - ❖ \*regive (a book)(to Sally) / \*reput (it)(there) [*\*ditrans*]
- ❖ **this is a syntactic restriction, not a conceptual one**
  - ❖ “The pair took the stage to re-dance their famous Pirates of the Caribbean Paso Doble from an earlier week on the show. “

# Re-

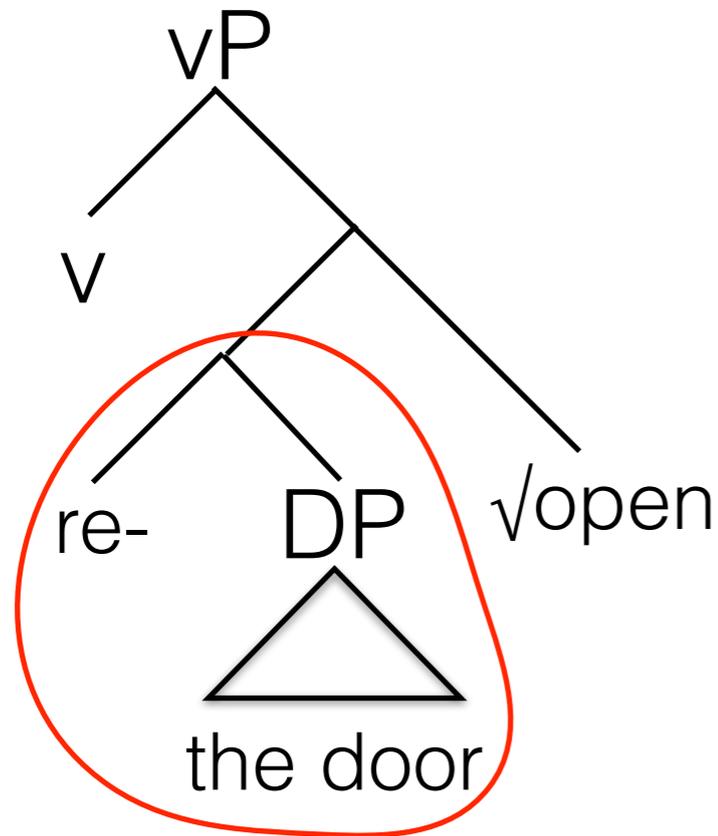
*The door was built open, then the wind blew it closed.*

*I re-opened the door.*

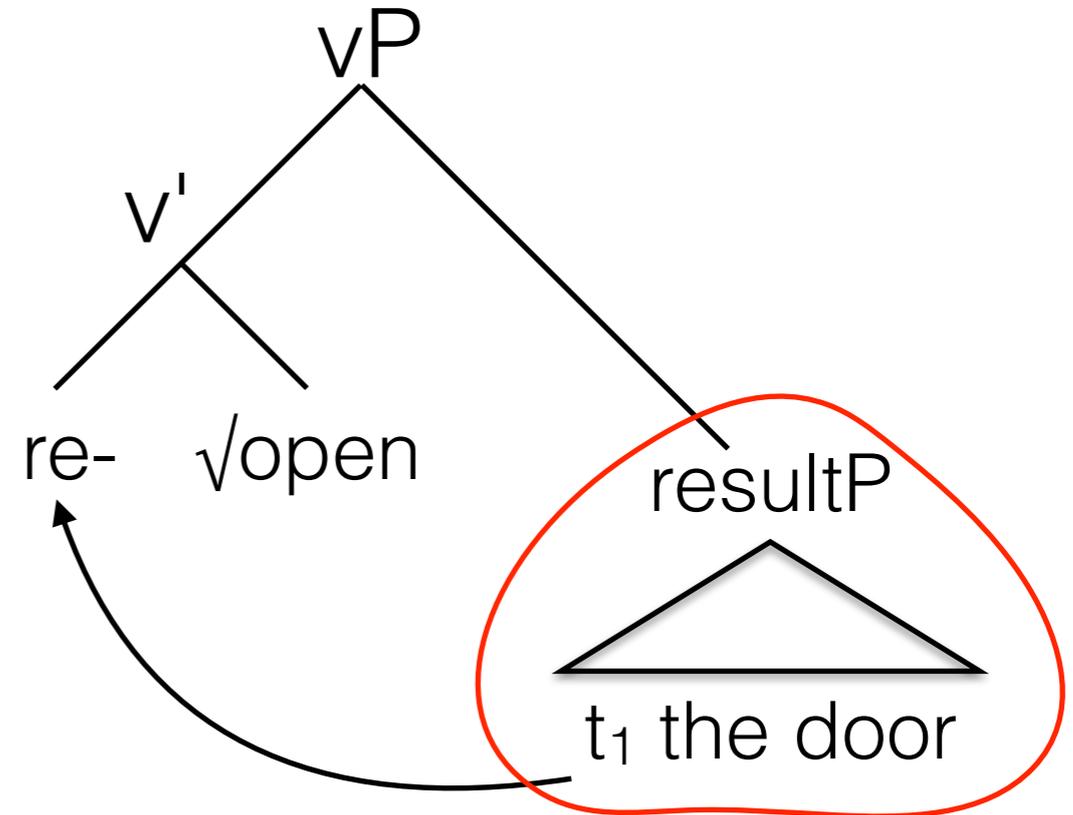
Marantz 2009, p. 4.

- ❖ re- is restitutive; crucially, it says the door was in the state of being open again, but not that the act of opening was performed again. That is, the door was built open but it had not been opened.
- ❖ So the scope of re- appears to be lower than the v that introduces the event semantics

# Re-



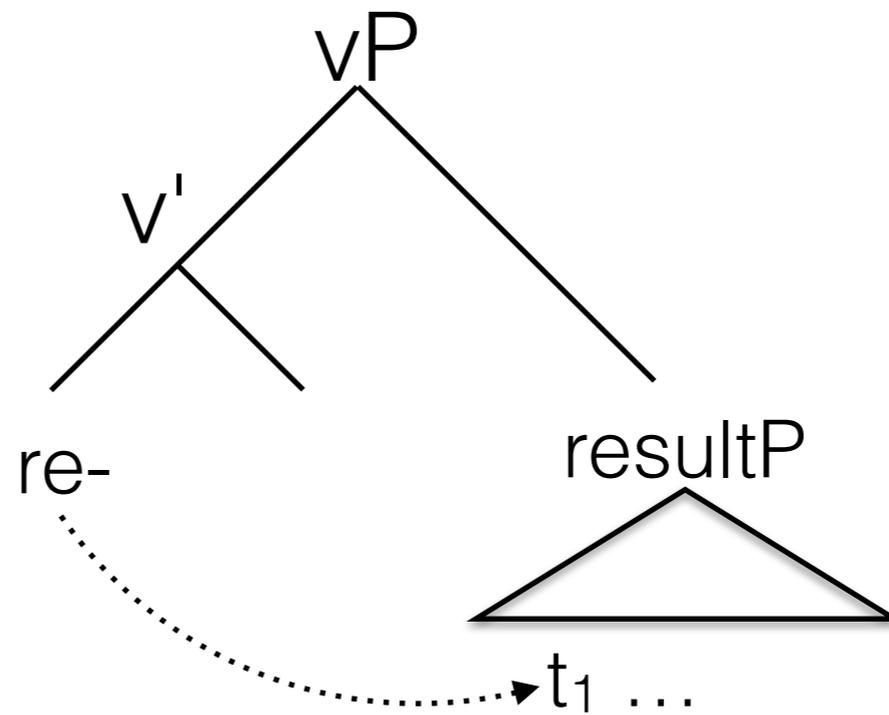
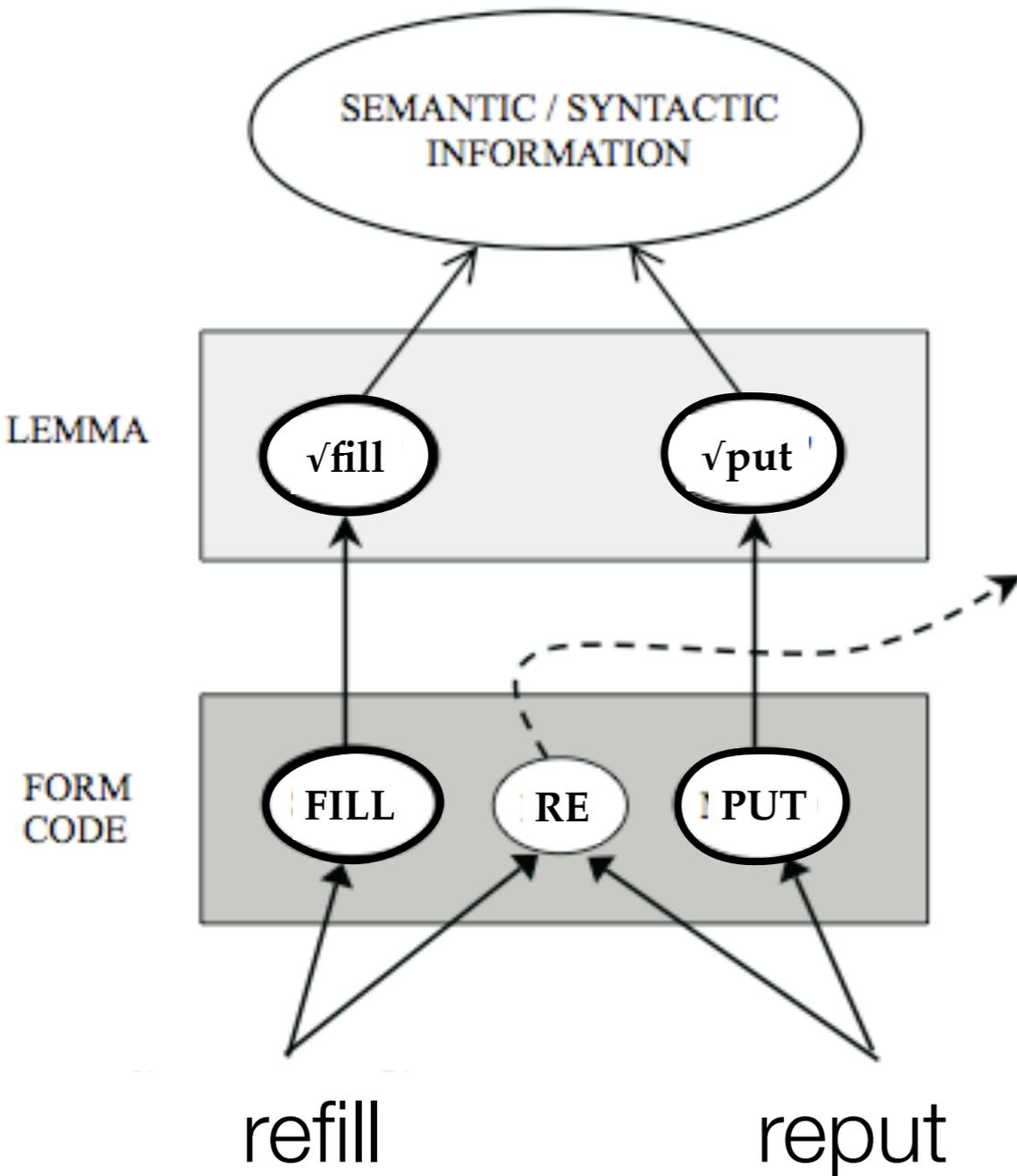
Marantz 2007, 2009



Alexiadou and Schäfer 2014

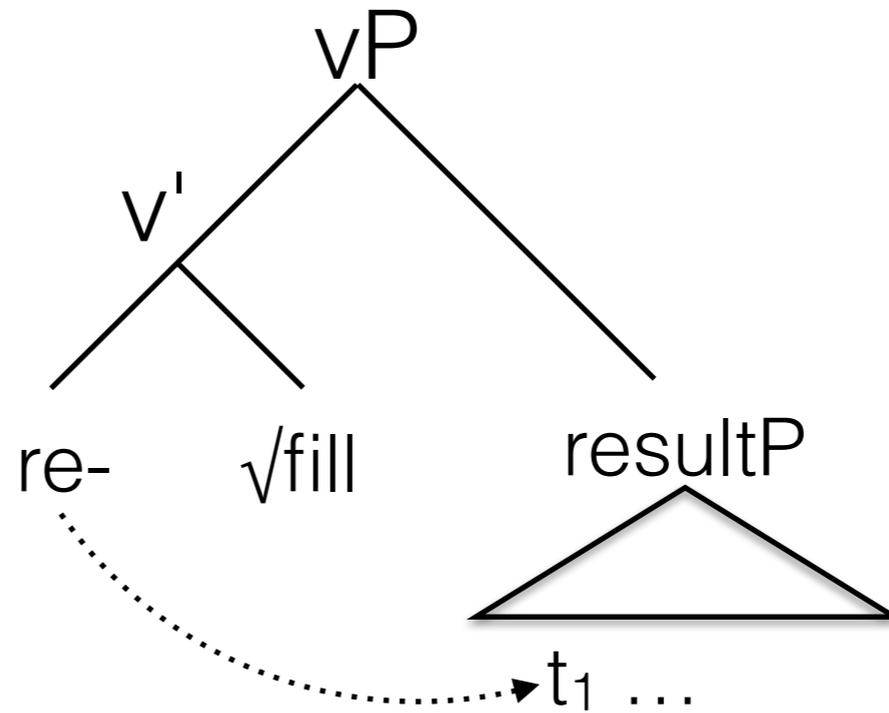
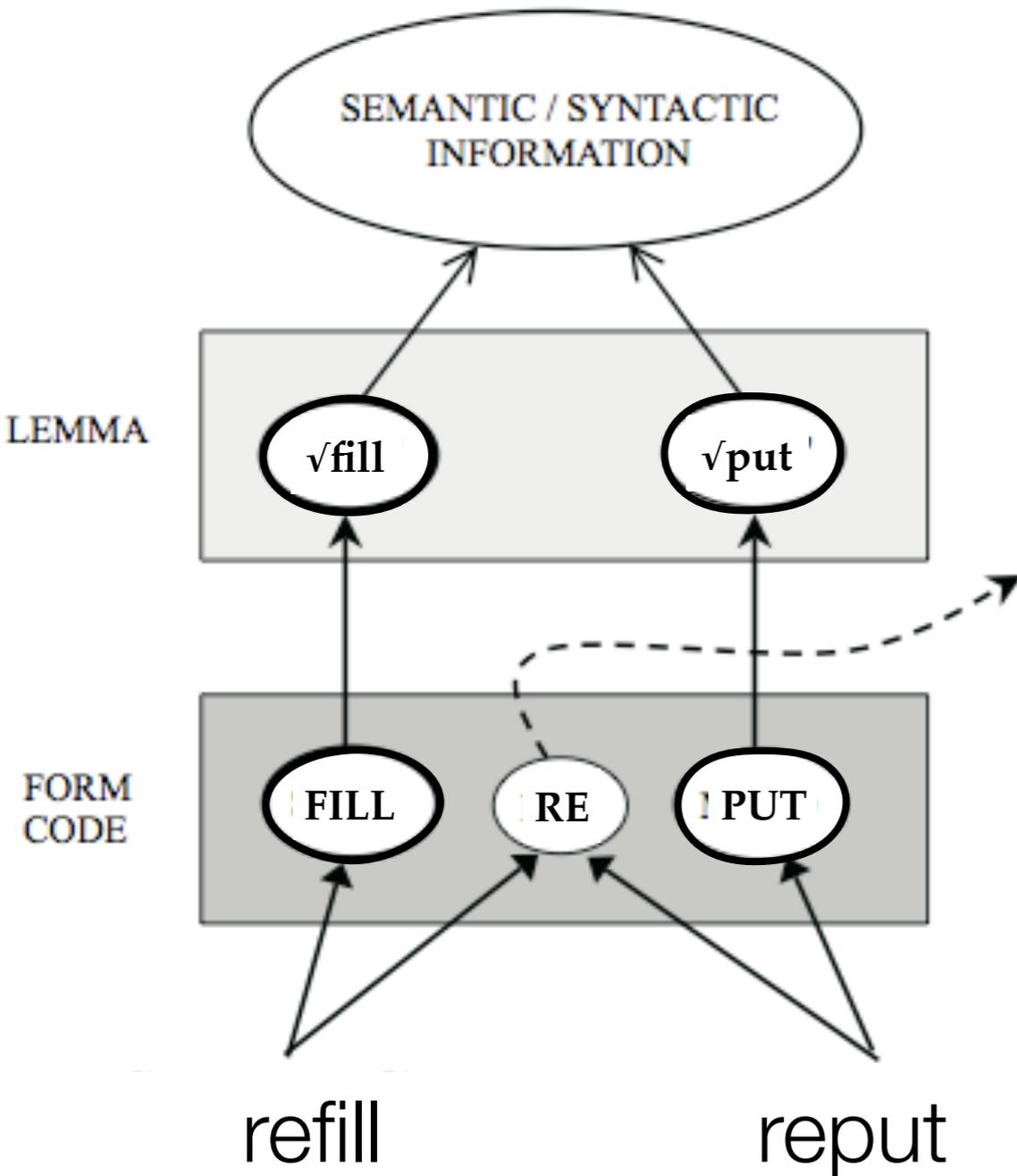
- re- c-selects a DP
- “re- takes scope most narrowly over the change of state DP, and the state in the presupposition re- adds is equated with the end state of the change of state.” (Marantz 2009, p10)

# Re-verse engineering



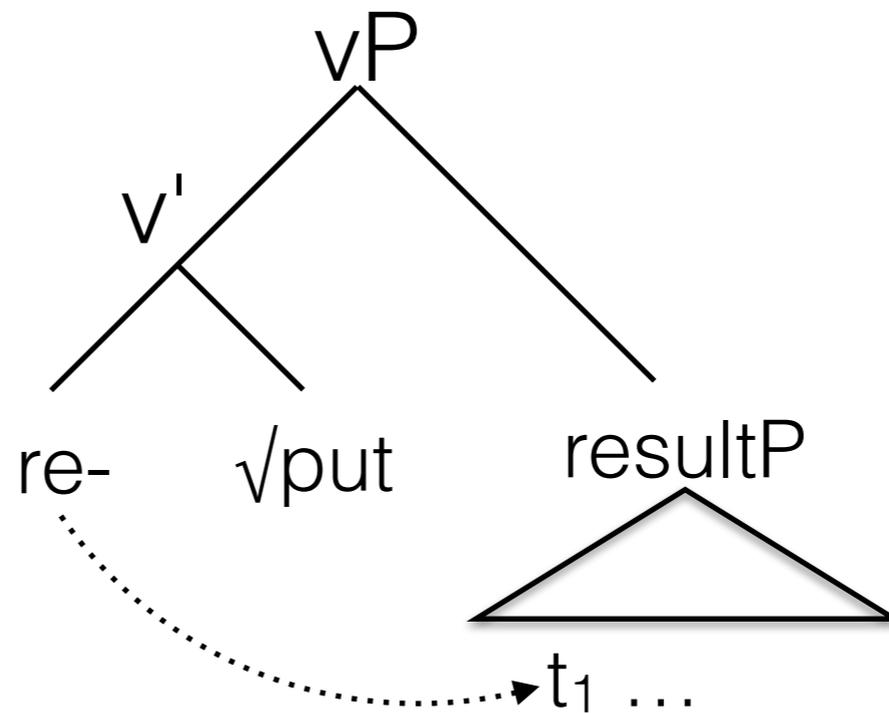
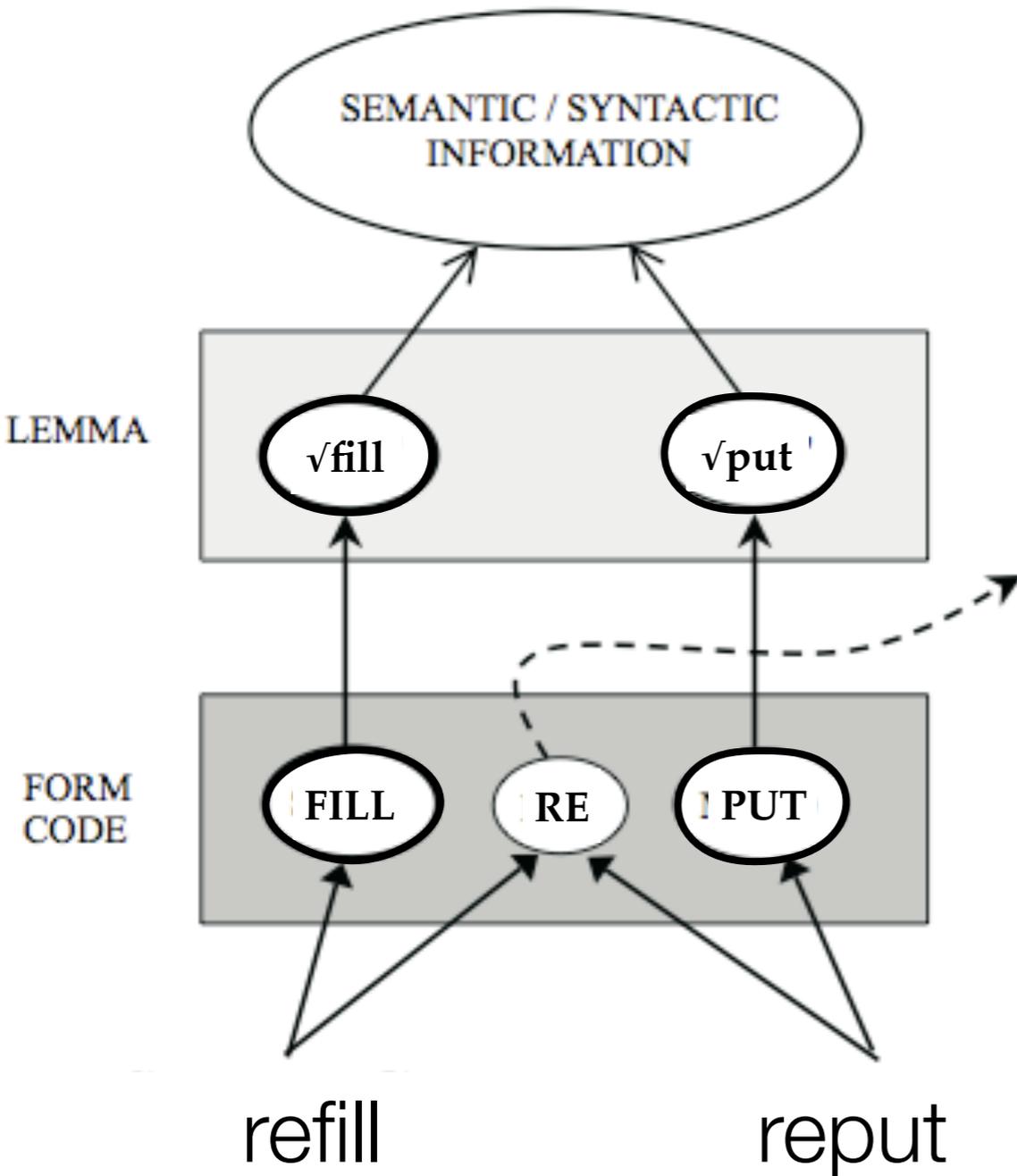
- ❖ is the root associated with the right lexical category?
- ❖ is the root associated with the right eventive meaning?

# Re-verse engineering



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# Re-verse engineering



- ❖ is the root associated with the right lexical category?
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# Manouilidou & Stockall, 2015

## Nonce Word Affixation in English & Greek

NONCE WORD TYPE	ENGLISH	GREEK
category violation	reflat	kareklatís ‘chairer’
argument structure violation	resmile	orimastís ‘maturer’
no violation	rehold	xtypitís ‘hitter’
nw-stem	reclow	kapaktitís ‘kapakter’

- **-tis** requires an activity verb with an agent external argument
  - kolymbó ‘to swim’ → kolymvitís ‘swimmer’
  - ksexnó ‘to forget’ → \*ksexastís ‘forgeter’
- **-(s)imos** requires a transitive verb with an agent external argument
  - ekpedévo ‘to train’ → ekpedéfsimos ‘trainable’
  - tréxo ‘to run’ → \*tréksimos ‘runable’

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# Manouilidou & Stockall, 2015

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## Nonce Word Affixation in English & Greek

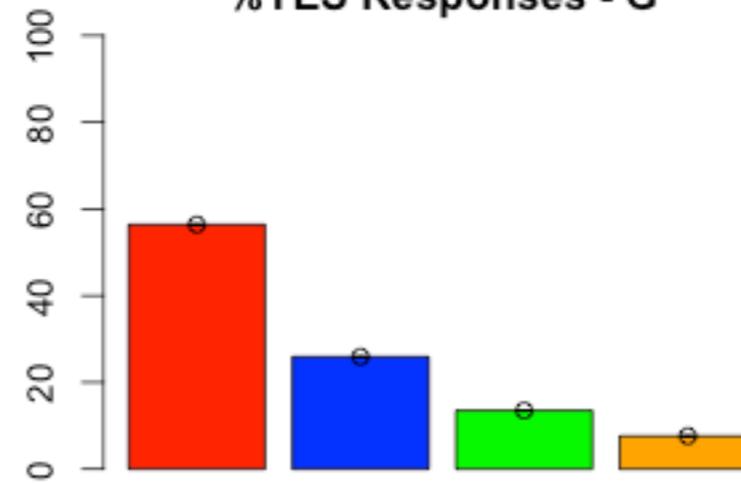
NONCE WORD TYPE	ENGLISH (N=30)	GREEK (N=46)
no violation	rehold	xtypitís 'hitter'
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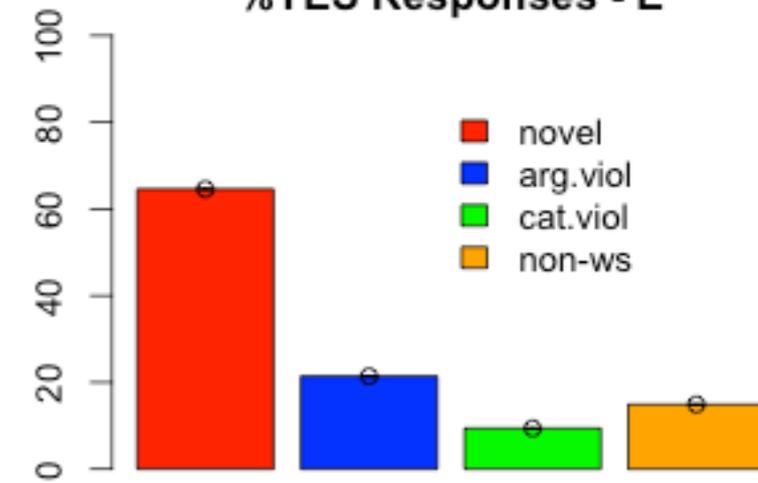
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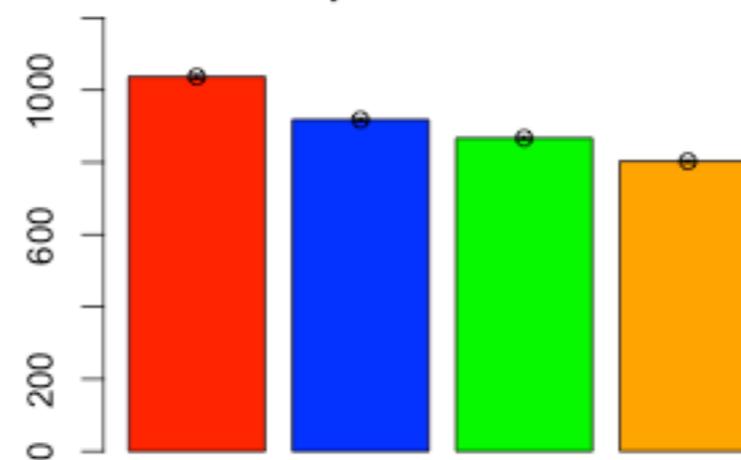
%YES Responses - G



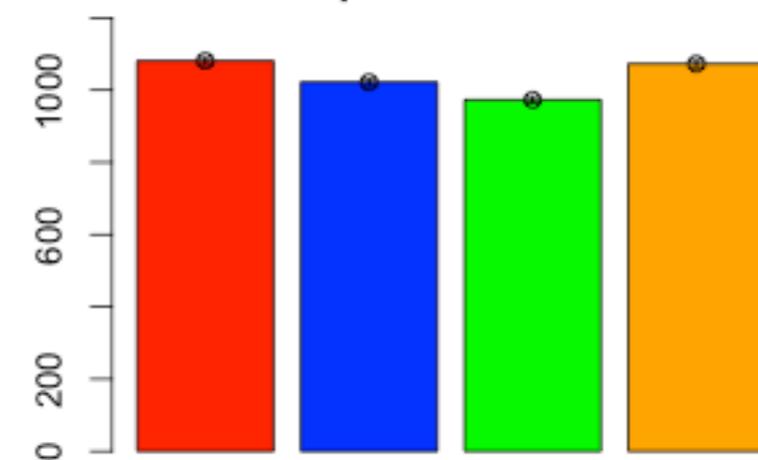
%YES Responses - E



Response Time - G

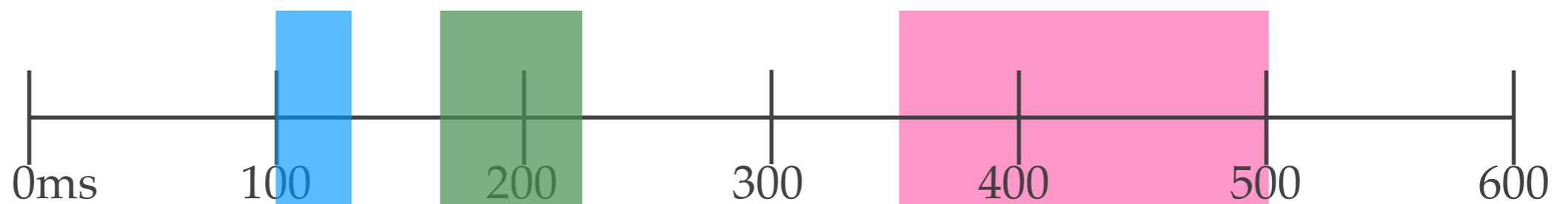


Response Time - E



# Manouilidou & Stockall, 2015

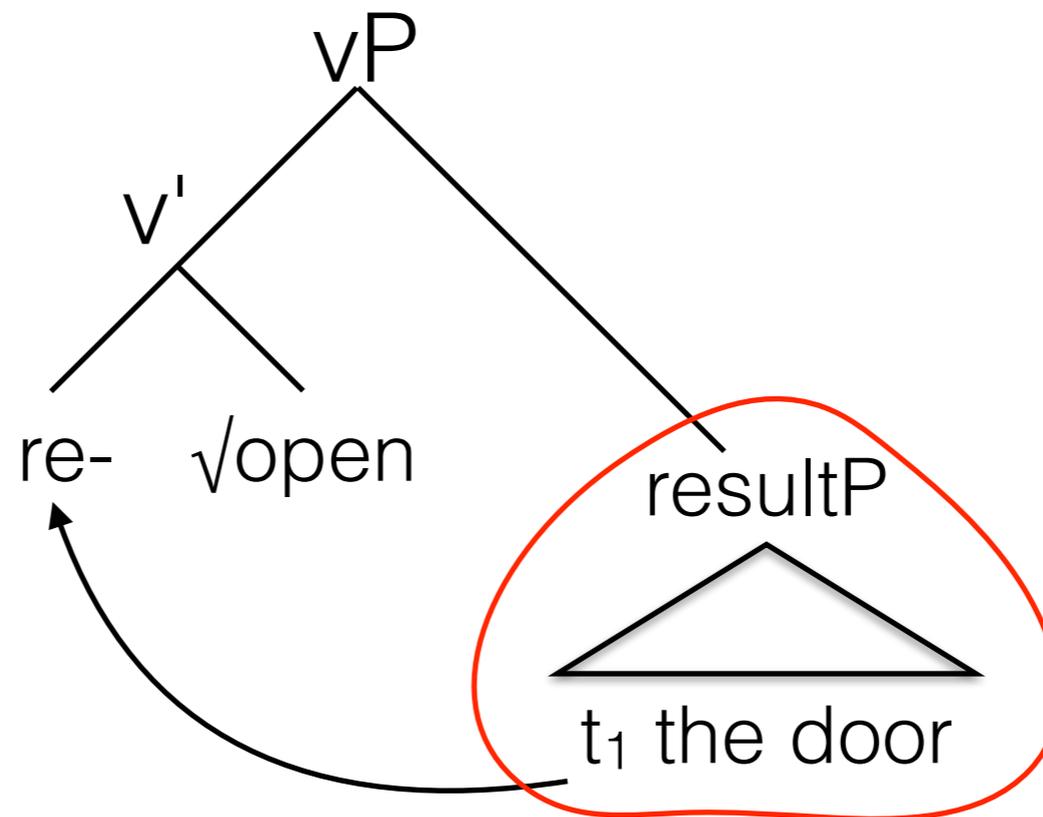
- ❖ it is faster/easier to reject candidates that violate grammatical category restrictions than argument/event structure restrictions
- ❖ consistent with other evidence for early access to grammatical category signalled by a suffix:
  - ❖ **Dikker et al 2008: M100**
- ❖ vs. later effects for semantic well/illformedness of stem+affix:
  - ❖ Pylkkänen et al 2009: vmPFC@290-330ms
  - ❖ **Fruchter et al 2015: lateralOF@354-500ms)**



# Re-Un-Out

- ❖ 3 prefixes: **un-**, **re-** & **out-**
- ❖ compare **category violating** and **event/argument structure violating** complex words
- ❖ use MEG to reveal the time course of processing these distinct sources of information
- ❖ at   **جامعة نيويورك أبوظبي**  
**NYU | ABU DHABI**

# Re-



- ❖ **category violation** effects > **argument structure violation** effects (Manouilidou & Stockall, 2015)

# un-

	un+ADJ	un+VERB
meaning	<b>not ADJ</b> <i>unhappy = not happy</i> (but cf. Horn 2005)	<b>reverse the change of state event</b> <i>unbutton = return to a state of being unbuttoned</i>
semantic restrictions	<b>none</b> (but see Pesetsky 1985, Newell 2005 on bracketing paradoxes)	<b>only works with verbs that denote impermanent changes of state</b> <i>*unthink, *unflush, *unfall</i>

## ❖ **argument/event structure violation:**

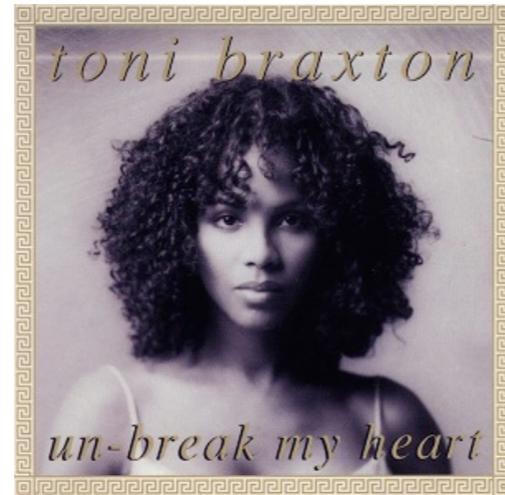
- ❖ does not prevent un+V structure building (Stockall & Pollatsek in prep)
- ❖ does trigger semantic wellformedness costs: Pylkkänen et al 2009:  
vmPFC@290-330ms

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# Unthinkable?

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# Unthinkable?

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## Semantics vs. world knowledge in prefrontal cortex

Liina Pykkänen, Bridget Oliveri, and Andrew J. Smart  
*Department of Linguistics and Department of Psychology, New York  
University, NY, USA*



# Unthinkable?

## Semantics vs. world knowledge in prefrontal cortex

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*Item*    Condition: *Stimulus*

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- 1a    Well-formed: None of the waitresses noticed that the wine was being uncorked for the wedding reception
- 1b    Semantic violation: The experienced waitress firmly ensured that the wine was being unchilled for the next meal
- 1c    World violation: All of the waitresses knew that the thirst was being uncorked for the main course

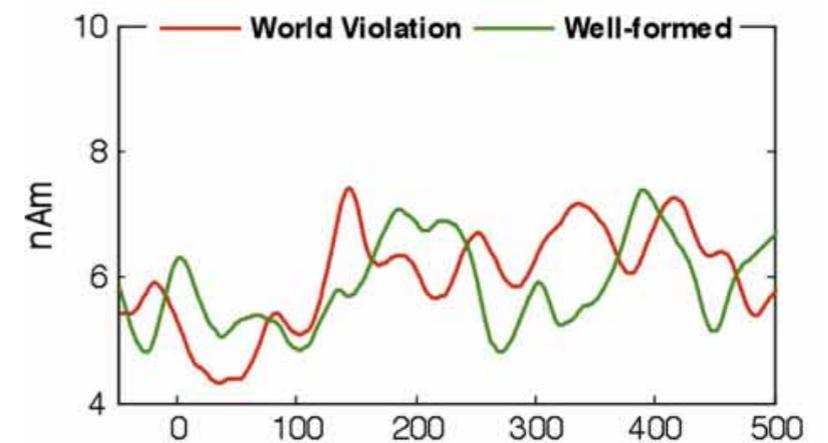
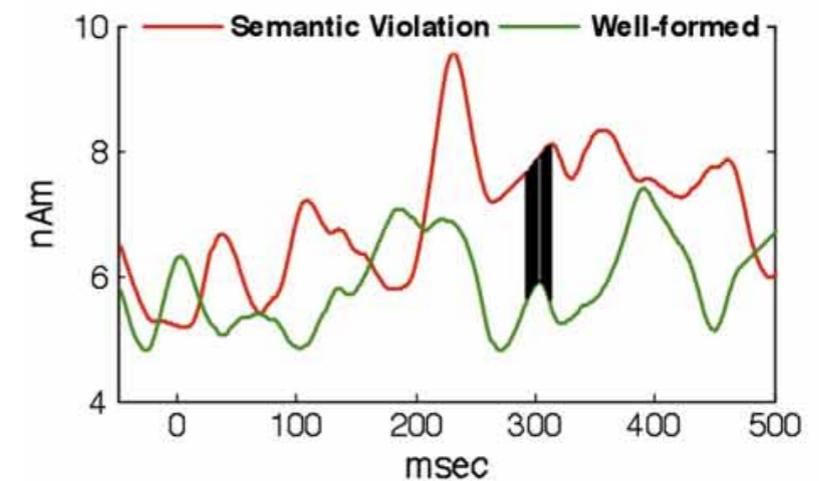
# Unthinkable?

## Semantics vs. world knowledge in prefrontal cortex

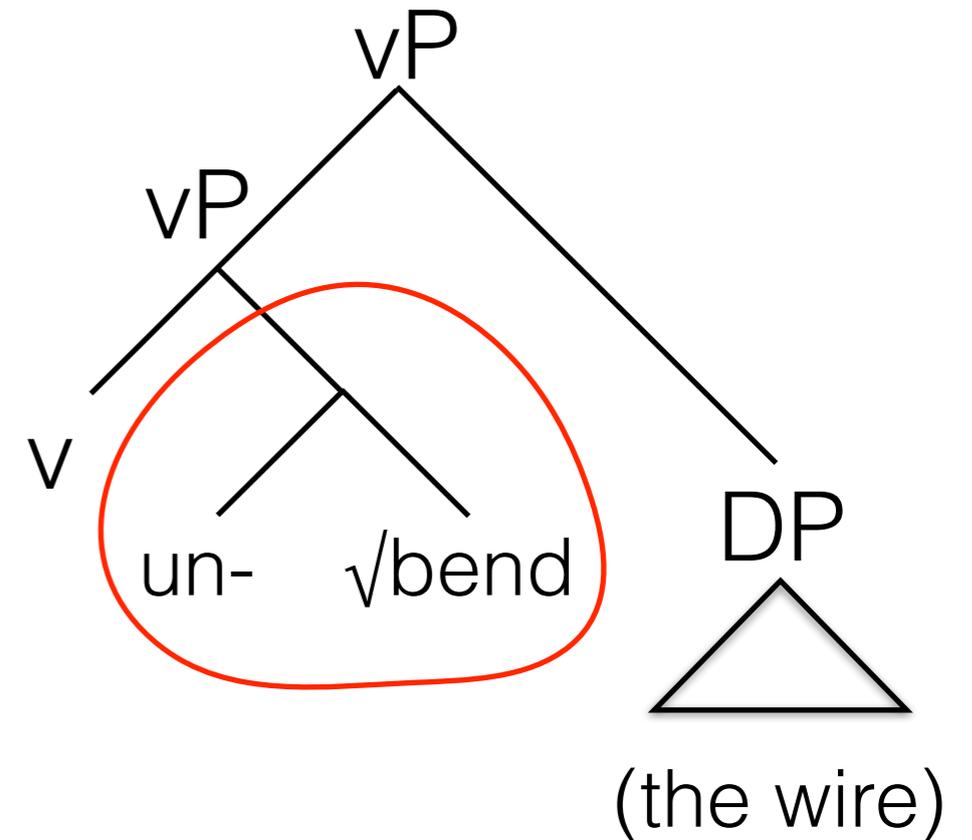
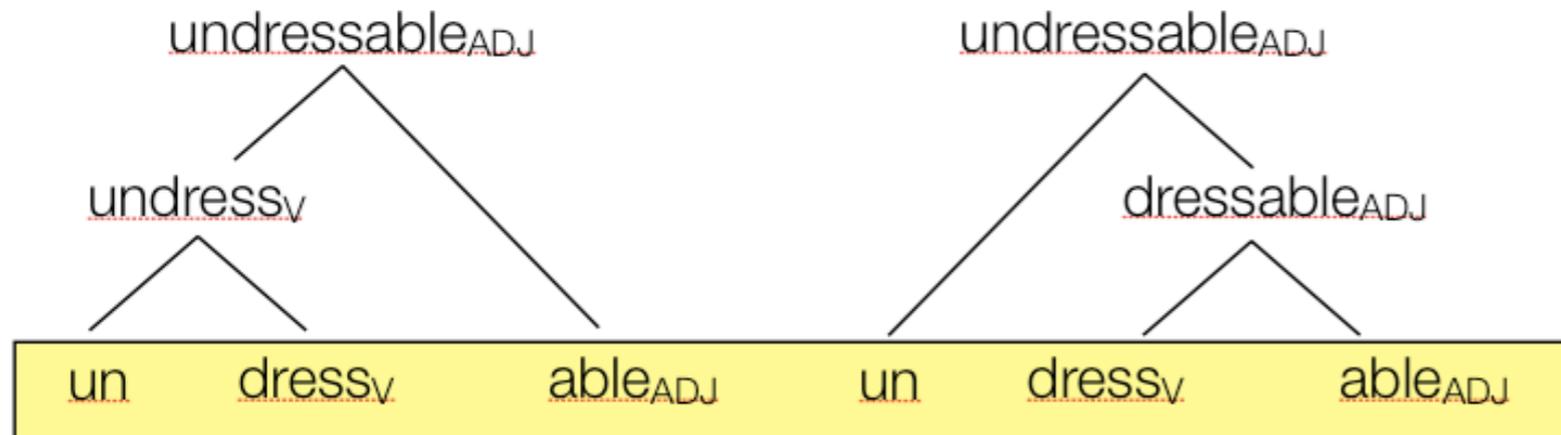
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1c	<u>World violation</u> : All of the waitresses knew that <u>the thirst was being uncorked</u> for the main course

VmPFC



# un-



- ❖ 'verbal' un- actually attaches to many 'nouny' stems: unbutton, unchain, uncork, undress, etc
- ❖ un- s-selects a reversible change of state event

# out-

- ❖ *Mary outspent Pat during the campaign.* (Adamson 2015)
- ❖ **Mary** spent X & **Pat** spent Y &  $|X| > |Y|$  (2 **agents**?)
- ❖ *Google has outdone itself today.* (Ahn 2016)
- ❖ Google did X at  $t_1$  & Google did Y today &  $Y > X$
- ❖ “SUBJECT participated in a VERBing (of something) to a greater/better degree than OBJECT” (Ahn 2016)
- ❖ *John outran the bus.* (Marantz 2009)
- ❖ John ran faster / further than the bus ‘ran’ (traveled)

# out-

- ❖ out- adds an additional argument to unergatives
  - ❖ John stared \*(Bill).
  - ❖ John outstared Bill.
- ❖ out- is obligatorily transitive:
  - ❖ Because she is not rich, Martha cannot outbuy \*(Susan). (Adamson 2015)
  - ❖ \*Ben is so fast he can always outrun \*(the competition).

# out-

❖ No other internal argument(s) can surface with out-

❖ **object of a transitive:**

(1) a. The Iron Man sequel grossed \*(\$625million).

b. Each Marvel sequel has out-grossed its predecessor. (<http://bit.ly/1BqdPH1>)

c. Each Marvel sequel has out-grossed (\*\$625million) its predecessor (\*\$625million).

❖ **optional cognate object of an unergative:**

(2) a. Mike danced (a good dance).

b. Mike outdanced (\*a good dance) Janet (\*a good dance).

(3) a. James weighs (a healthy weight).

b. James outweighs (\*a healthy weight) Josh (\*a healthy weight).

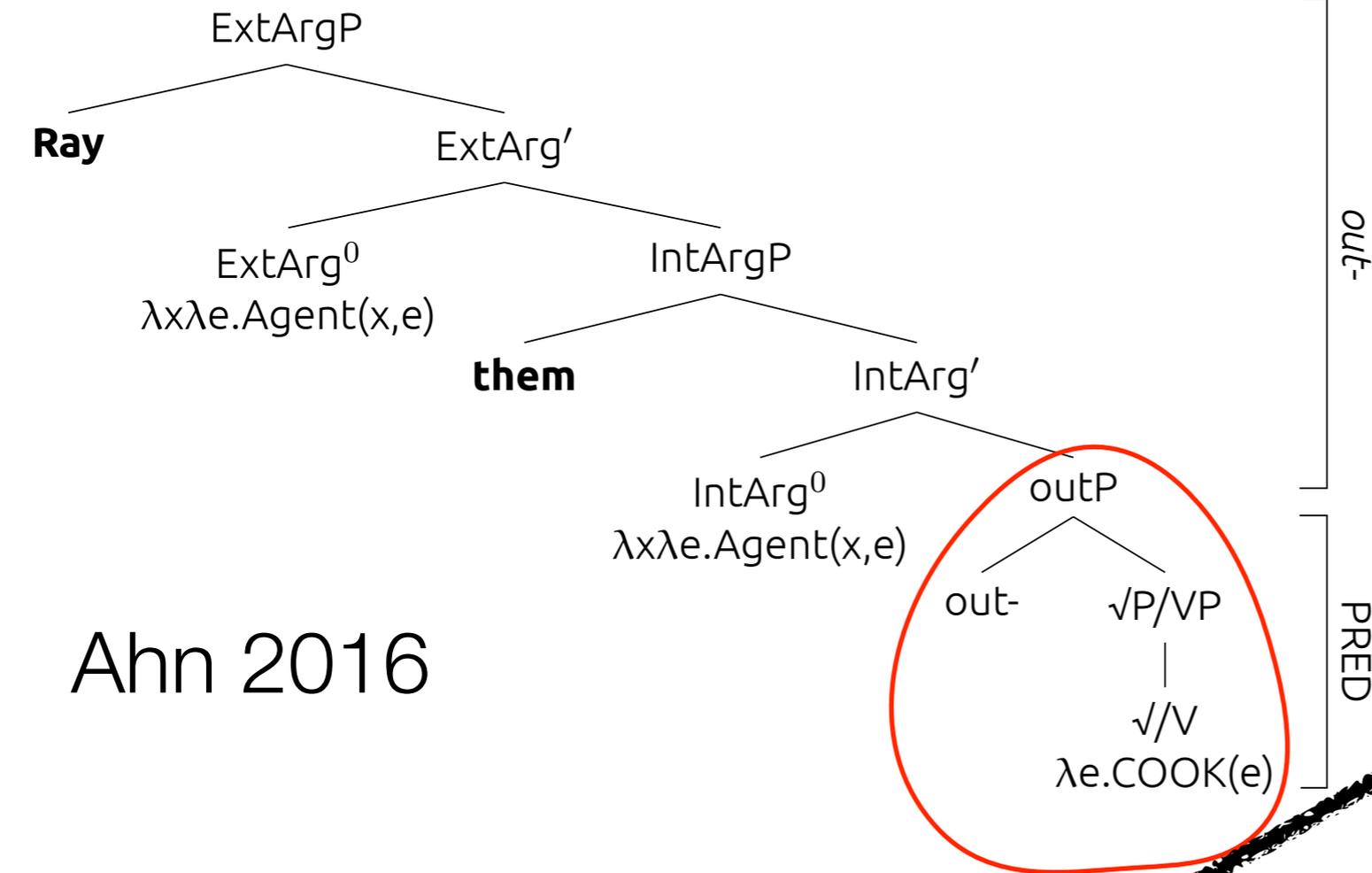
❖ **either argument of a ditransitive:**

(4) a. Jackie donated money to museums.

b. Jackie outdonated (\*money) (\*to museums) Lisa (\*money) (\*to museums).

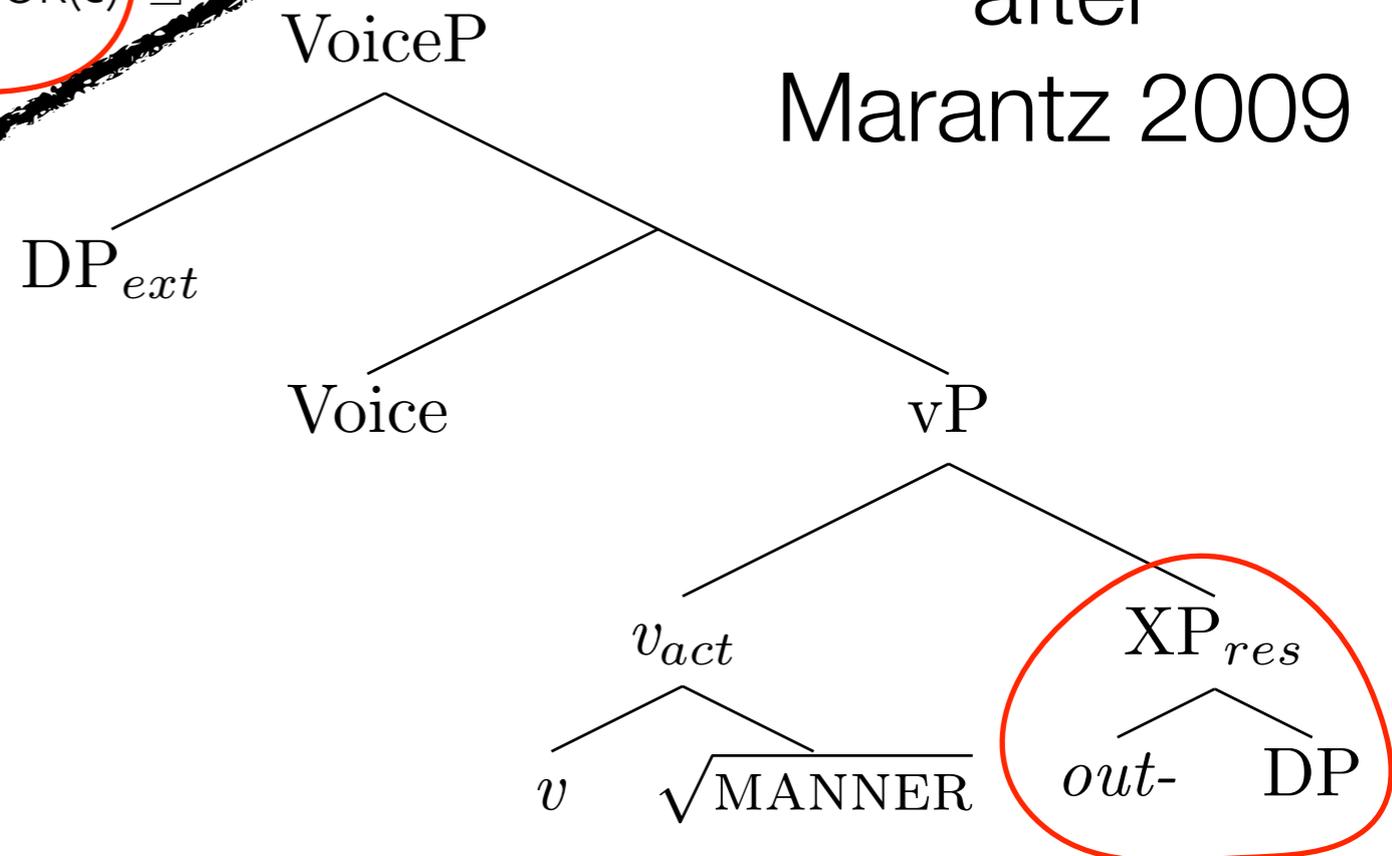
out-

Ray outcooked them



Ahn 2016

Adamson 2015  
after  
Marantz 2009



# Prefix Restrictions

	category restriction	argument/event structure restriction
<b>re-</b>	verbal <i>refill vs. *recold</i>	verb can take a result state internal argument <i>repaint (a table) vs. *relaugh</i>
<b>un-</b>	verbal <i>uncurl vs. *uncat</i>	verb must denote a reversible change of state event <i>unbend vs. *unthink</i>
	adjectives	n/a
<b>out-</b>	verbal <i>outlast vs. *outblue</i>	verb must not be obligatorily transitive: <i>*outmurder</i> event must denote an accomplishment or achievement: <i>*outknow</i>

# Prefix Restrictions

## argument/event structure restriction

**re-** syntactic: internal argument, result-state phrase

**un-** conceptual: reversible change of state event

**out-** syntactic: intransitive  $\rightarrow$  transitive  
conceptual: dimension of comparison

- ❖ Questions:
  - ❖ can we find a different profile for re- vs. un- selectional restrictions?
  - ❖ which one will out- pattern with?

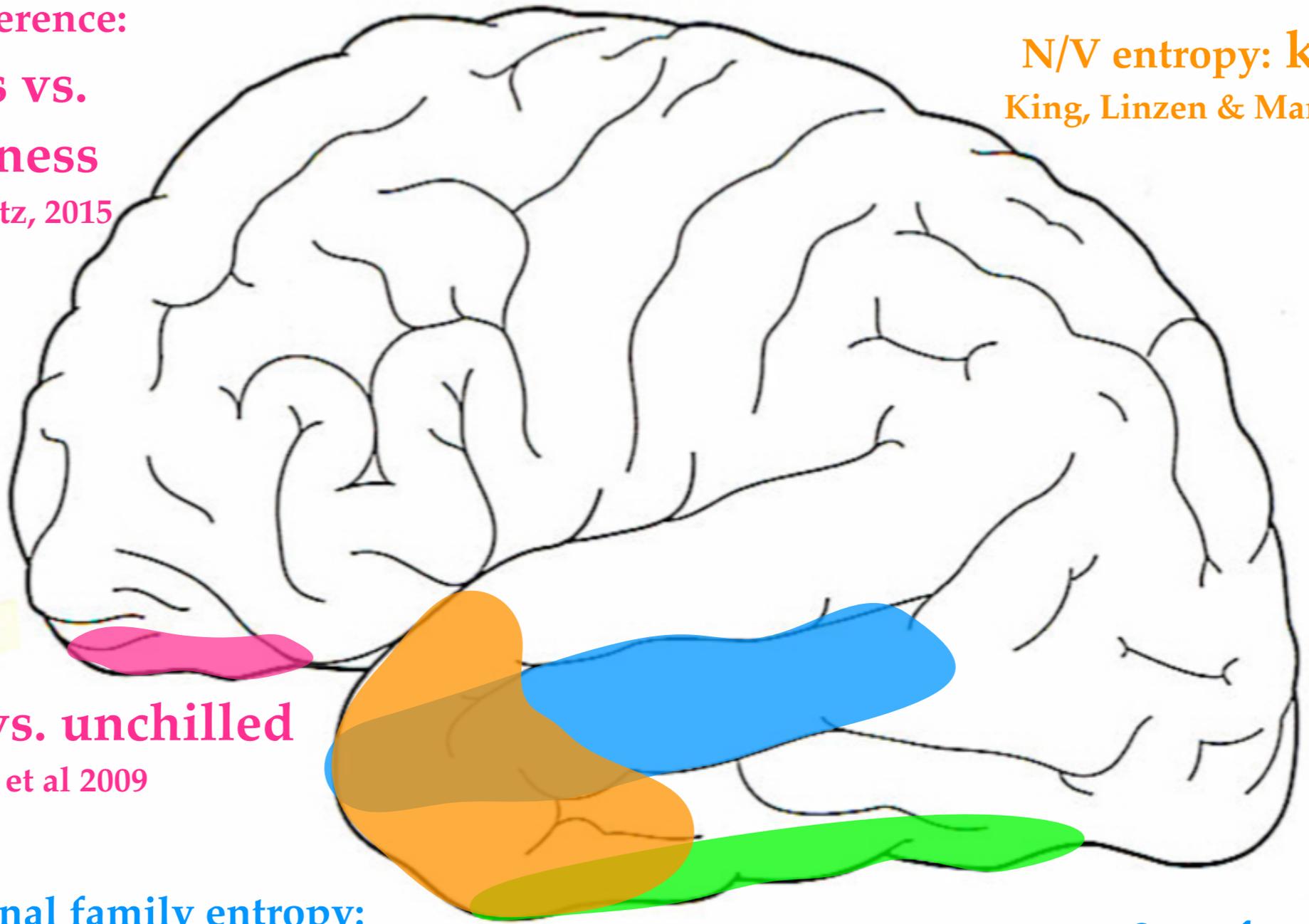
# Materials

prefix	Legal	Illegal	
		category violation	argstruc violation
re-	refill	recold	relaugh
un-	unbend	unfaith	unthink
out-	outpace	outlarge	outkill

- ❖ items matched within prefix for: stem frequency and length
- ❖ also included a set of pseudo prefix items (resume, uncouth)
- ❖ 260 legal and 260 illegal items (embedded in larger experiment)

2. semantic coherence:  
acute+ness vs.  
awkward+ness  
Fruchter & Marantz, 2015

N/V entropy: **kiss vs car**  
King, Linzen & Marantz, to appear

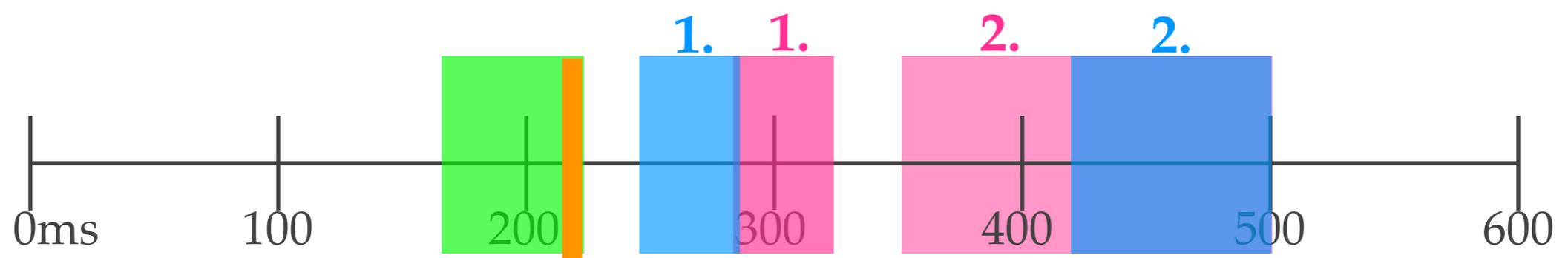


1. uncorked vs. unchilled  
Pylkkänen et al 2009

1. derivational family entropy:  
barbaric vs. famous  
Fruchter & Marantz, 2015

re | fill vs. re | sume  
Zweig & Pylkkänen 2009

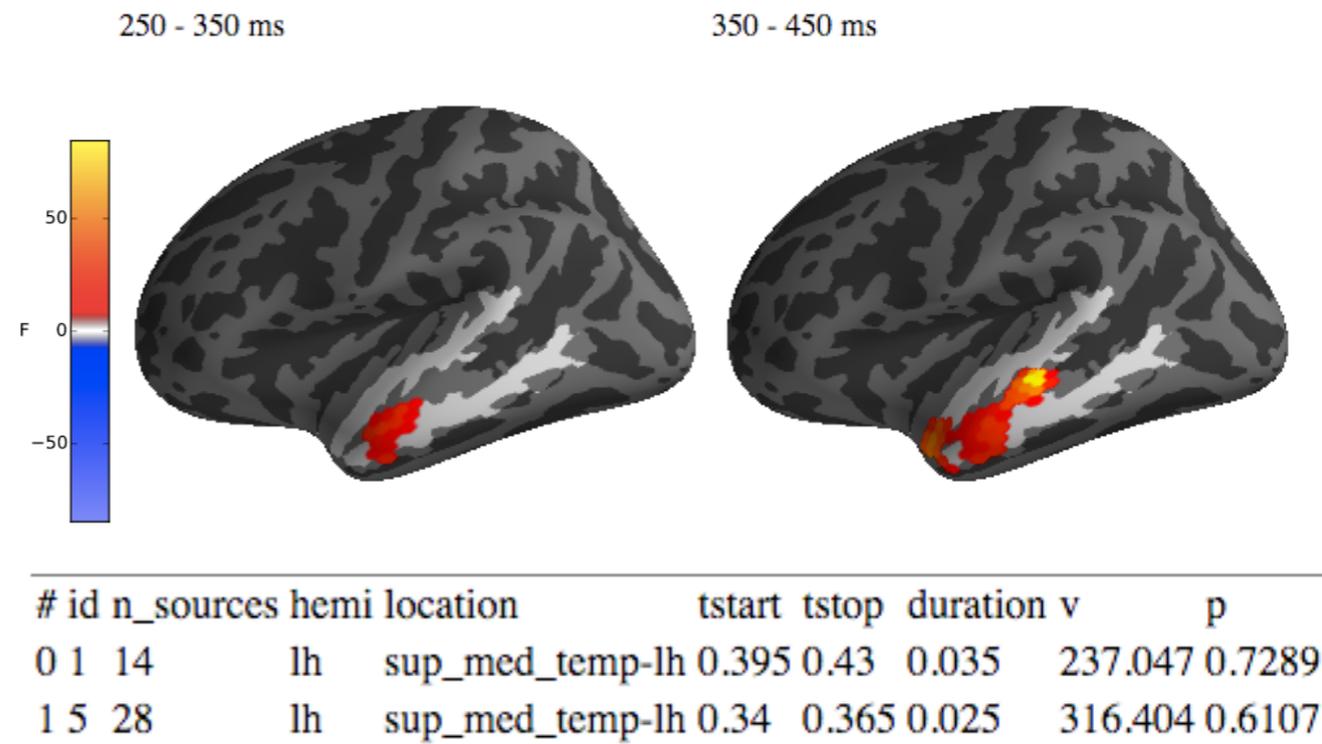
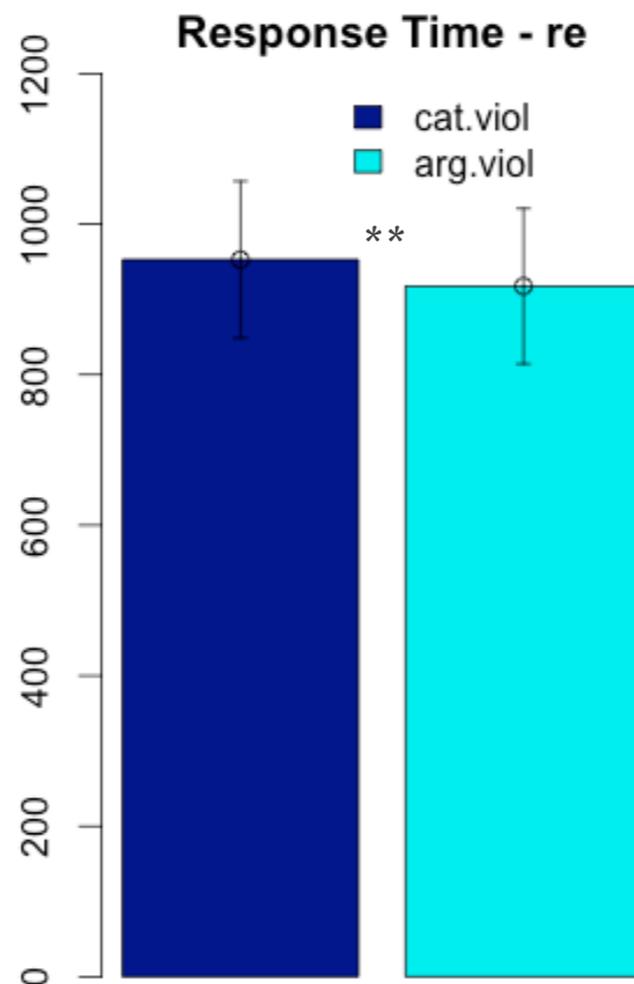
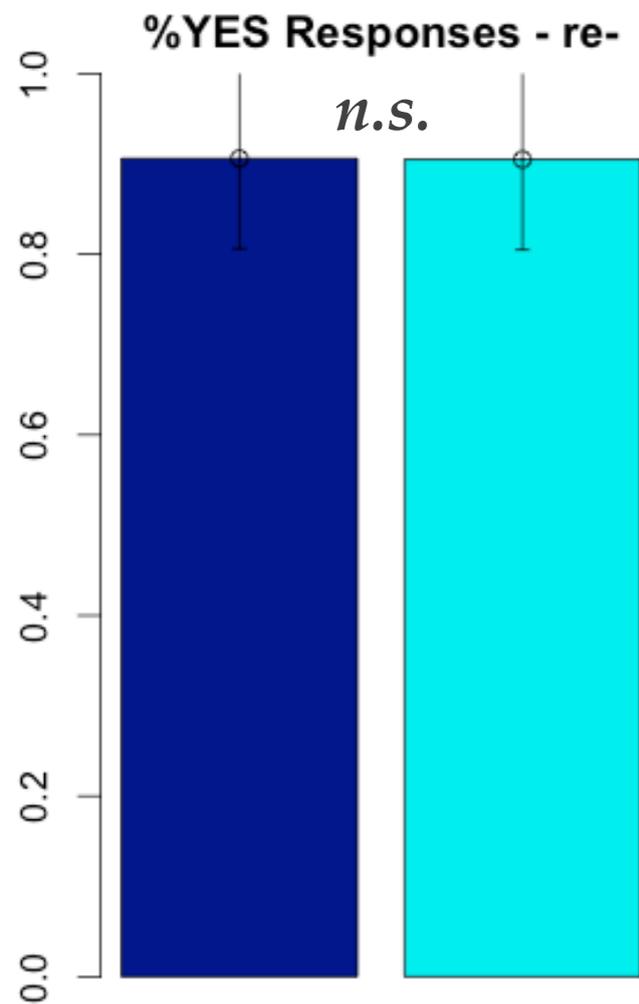
2. surface frequency:  
**barbaric** vs. **famous**  
Fruchter & Marantz, 2015



# RE-



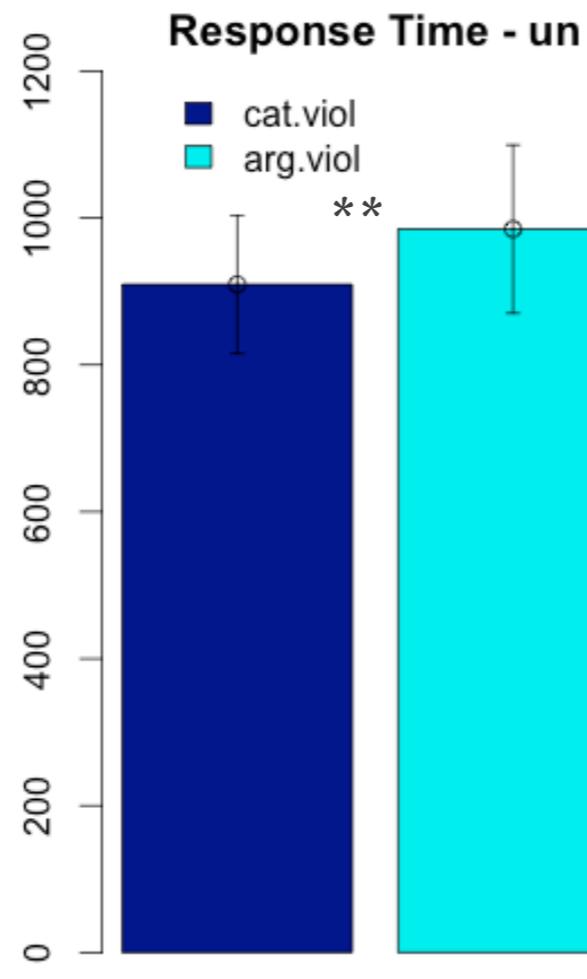
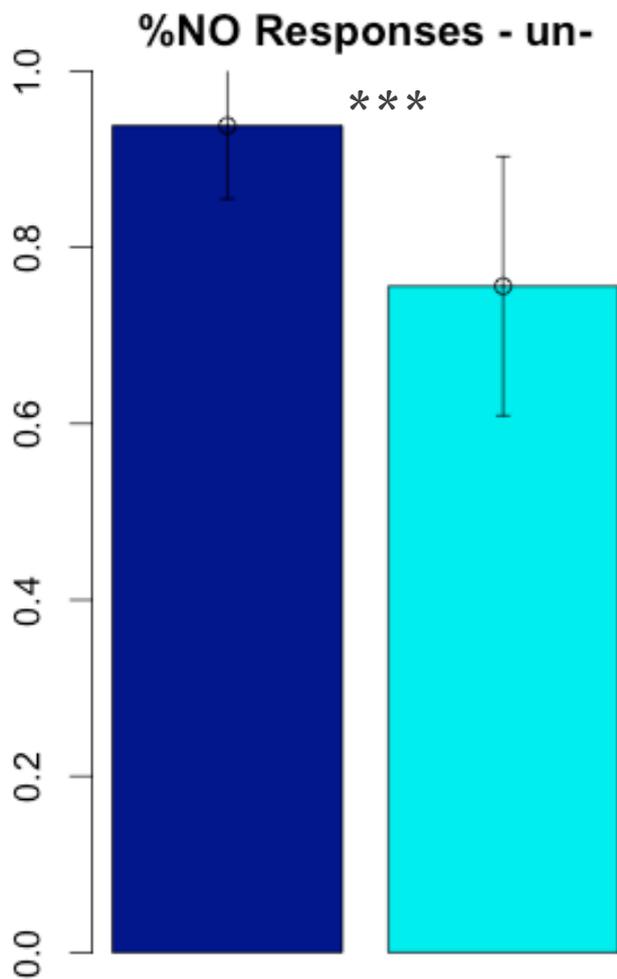
## Superior / Medial TL



- using the Eelbrain package in python (Christian Brodbeck)
- Extracted sources from anatomical ROIs ~ spatiotemporal permutation cluster tests run over these sources
- equivalent N sampling for each condition
- correction for multiple comparisons

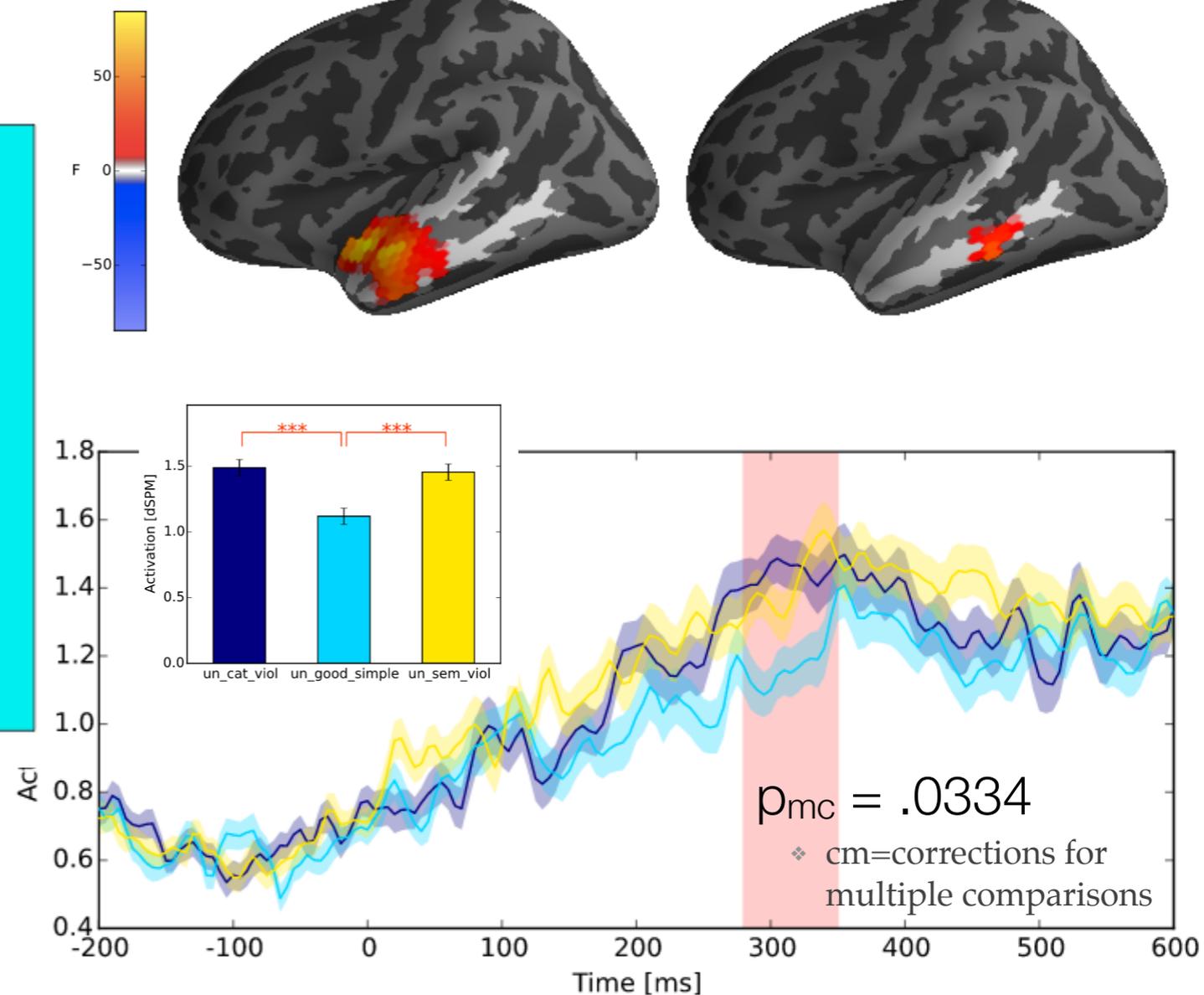
# UN-

## Superior/Medial TL



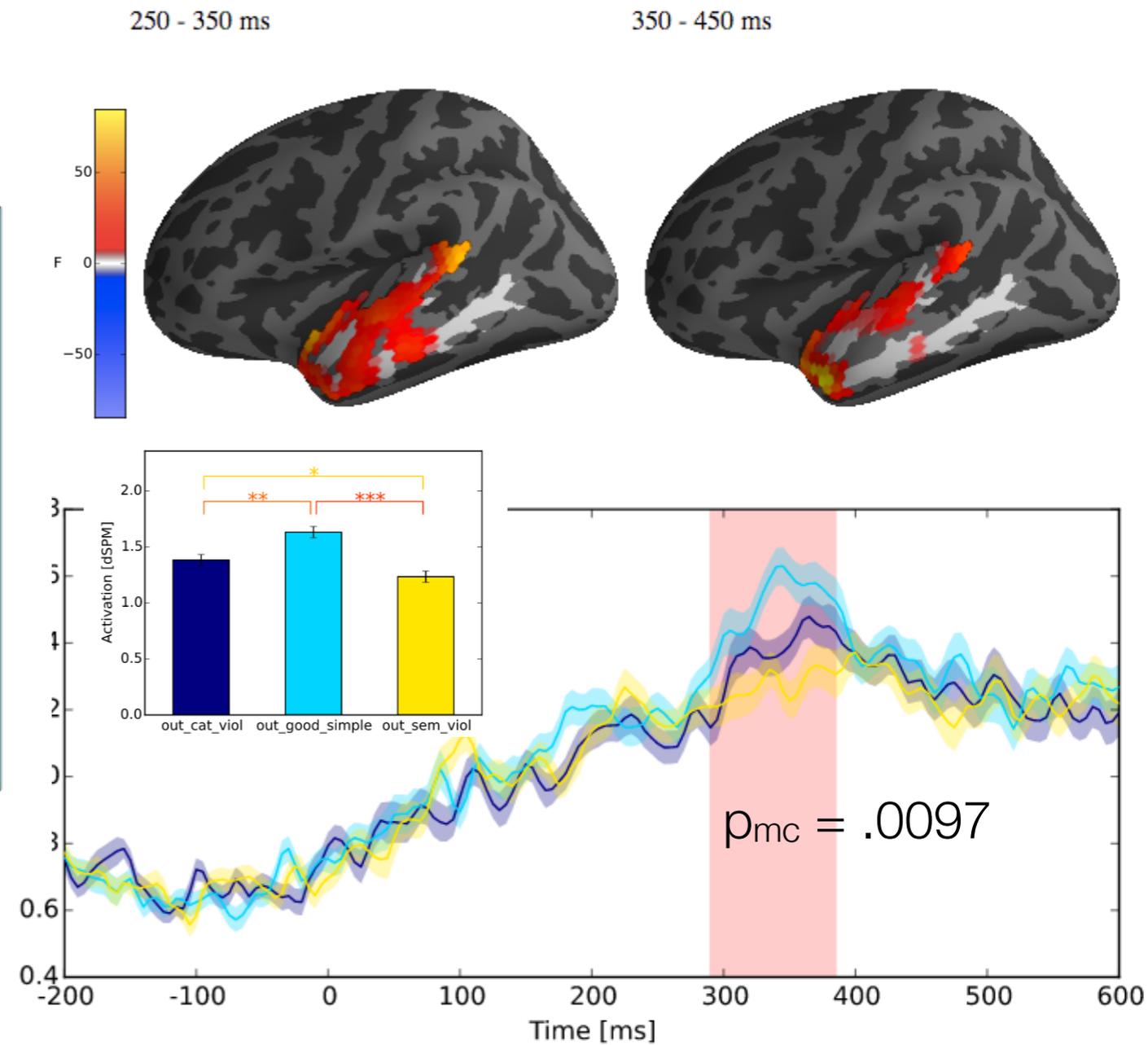
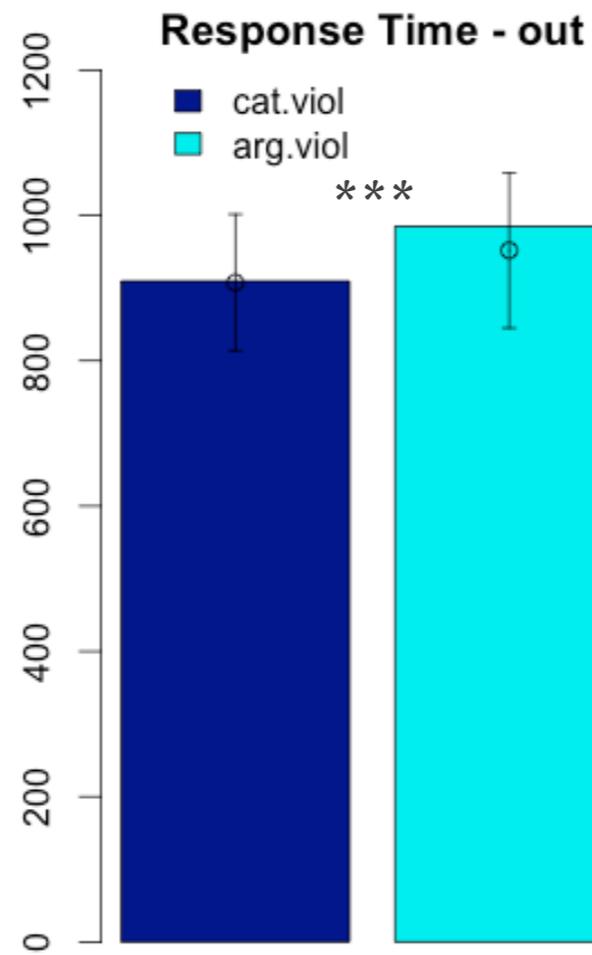
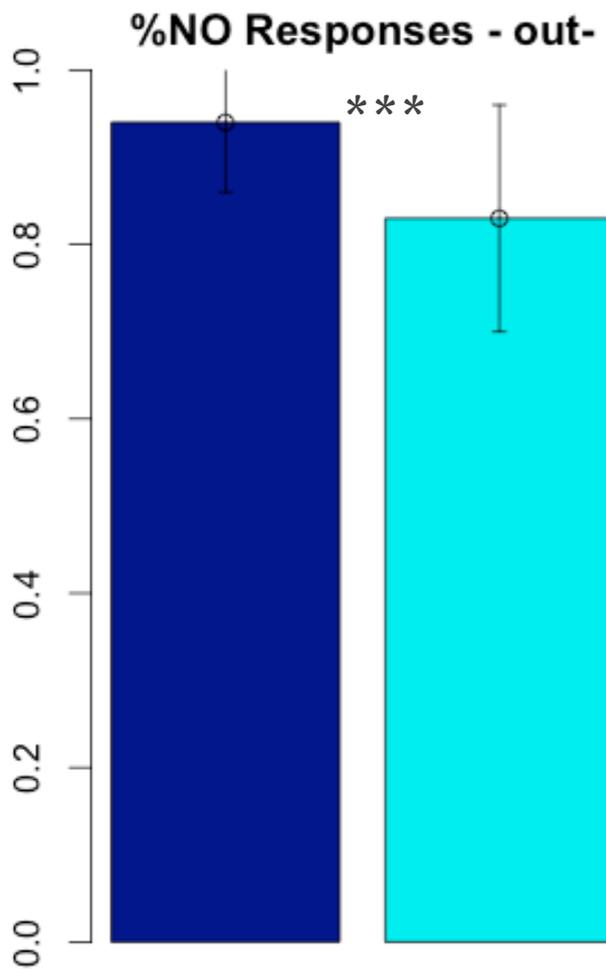
250 - 350 ms

350 - 450 ms

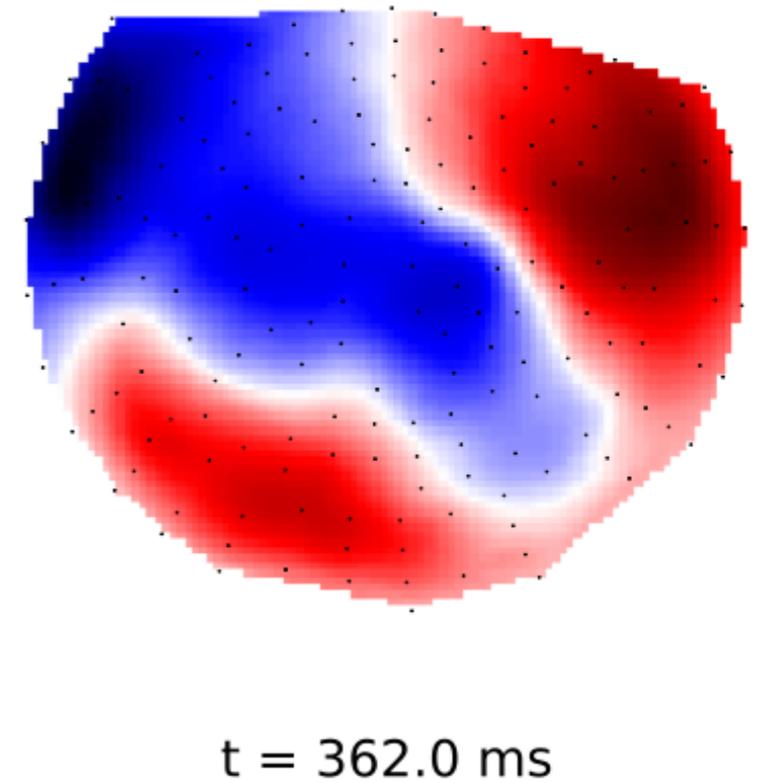
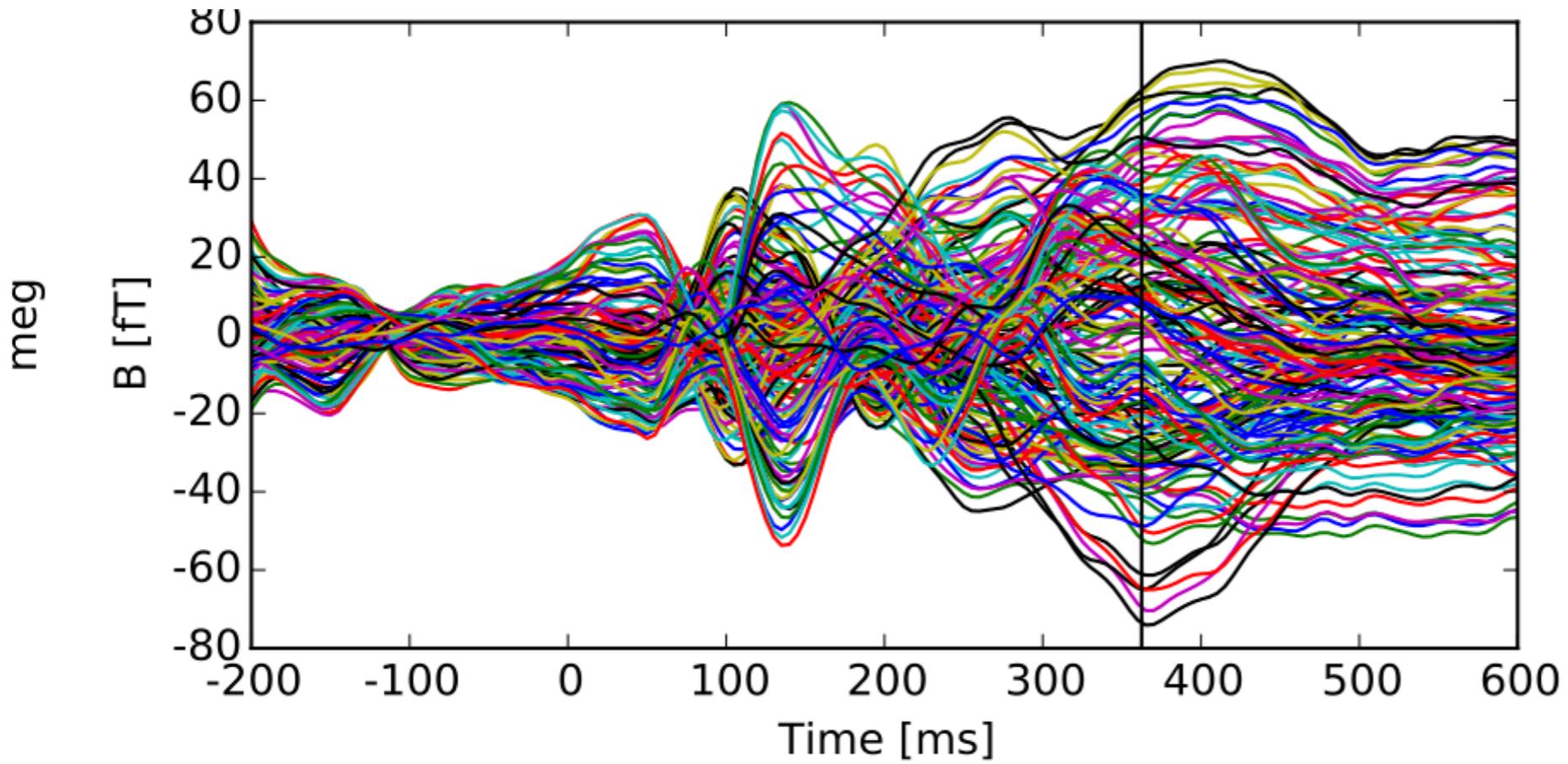


# OUT-

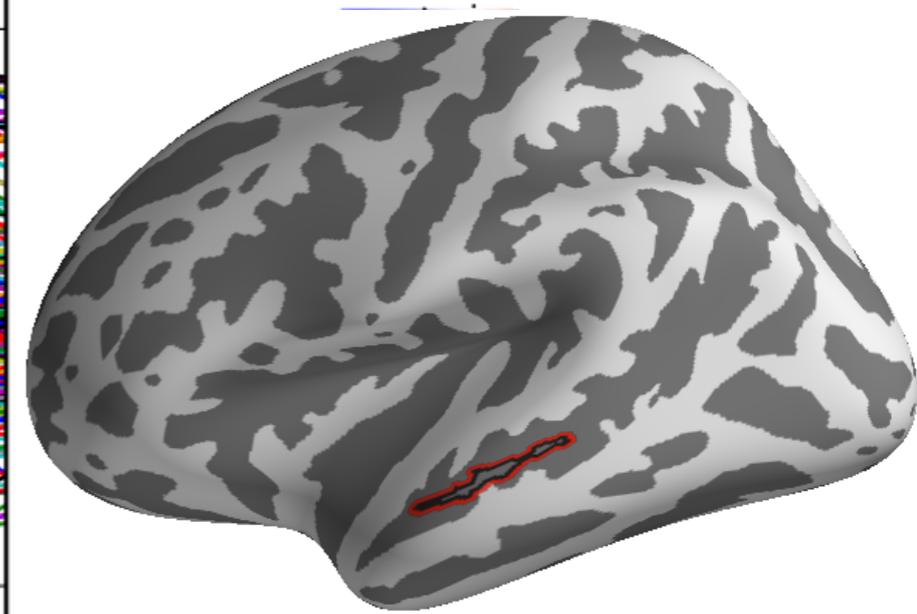
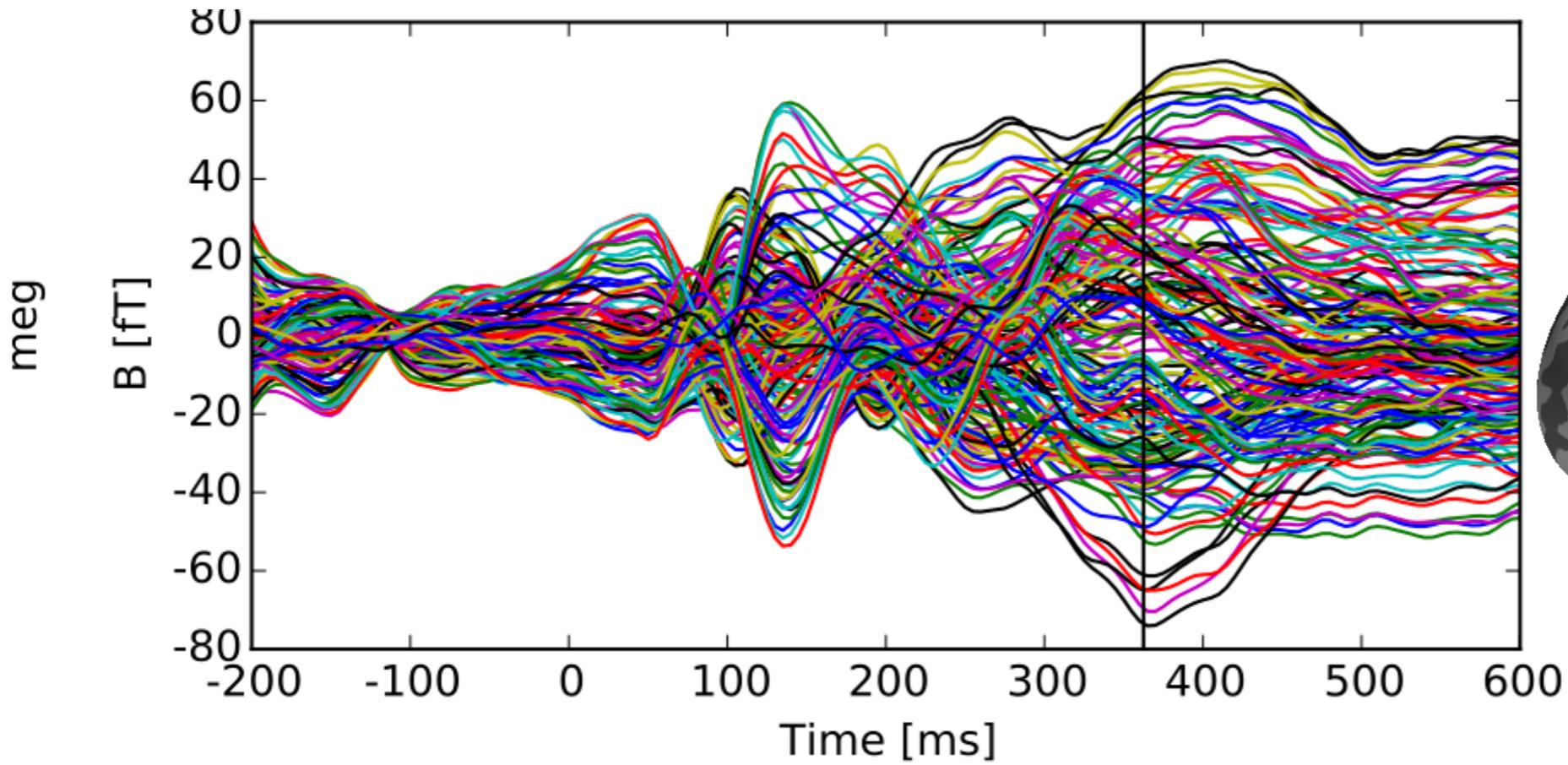
## Superior/Medial TL



# More restricted ROI:M350/N400m

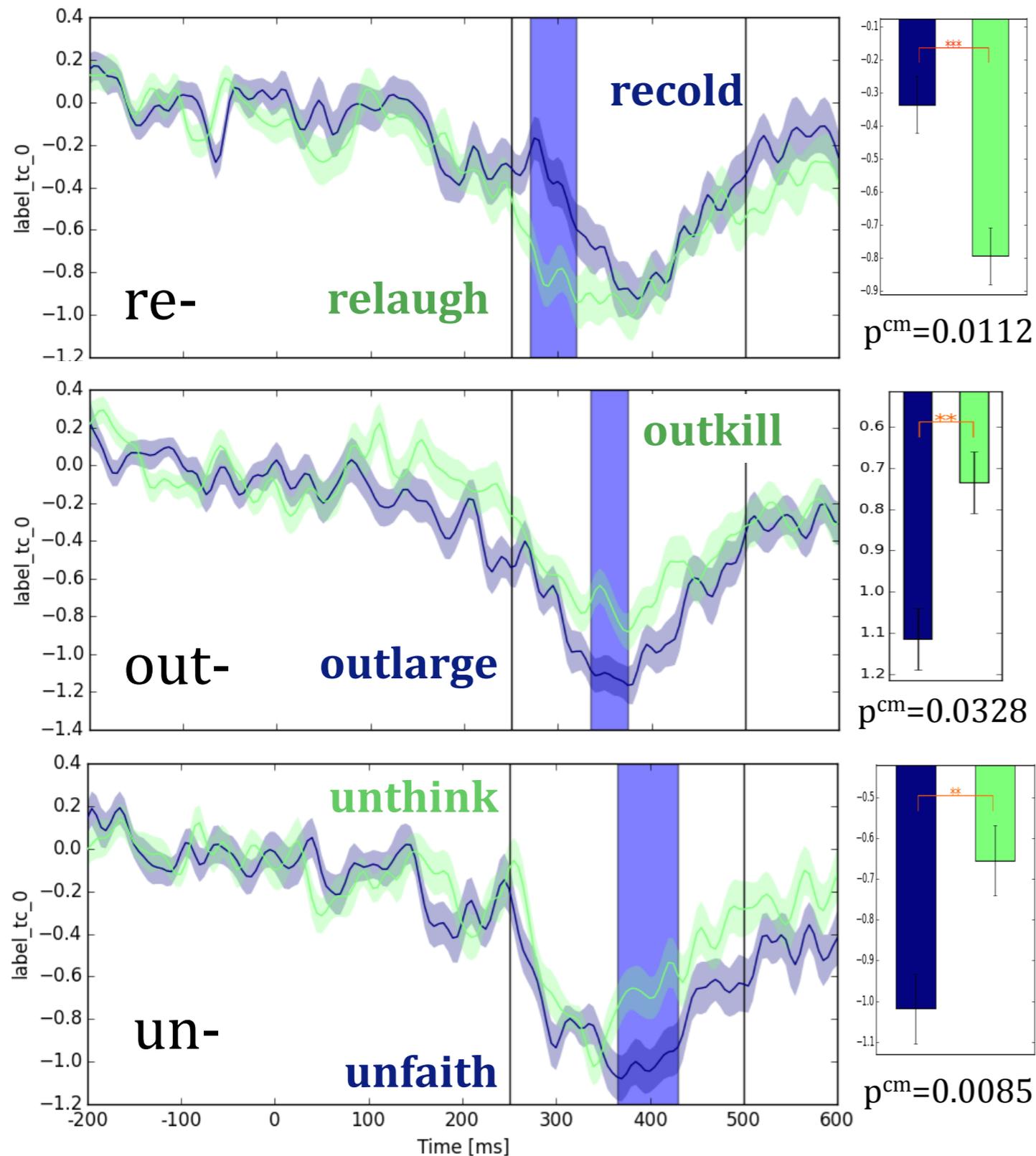


# More restricted ROI:M350/N400m



t = 362.0 ms

# More restricted ROI:M350/N400m



- Identified peak, negative, left TL response in grand averaged waveform and extracted ROI generator of this peak
  - Within prefix temporal cluster tests run on this ROI
  - correction for multiple comparisons

# Preliminary Conclusions

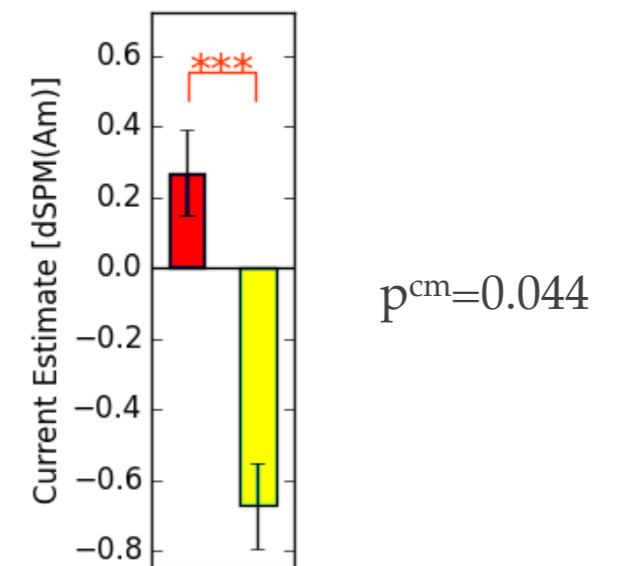
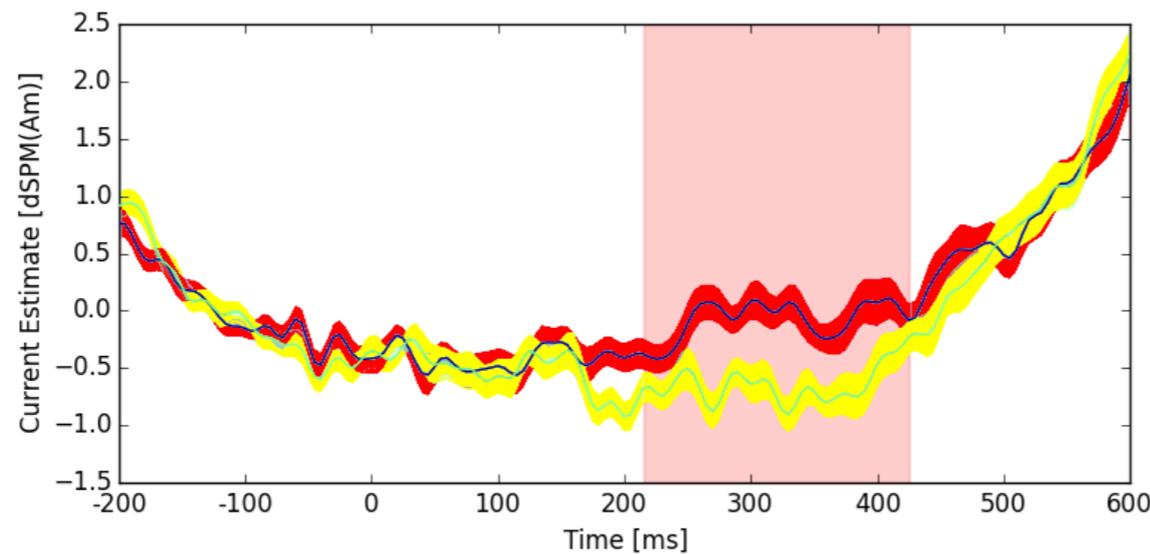
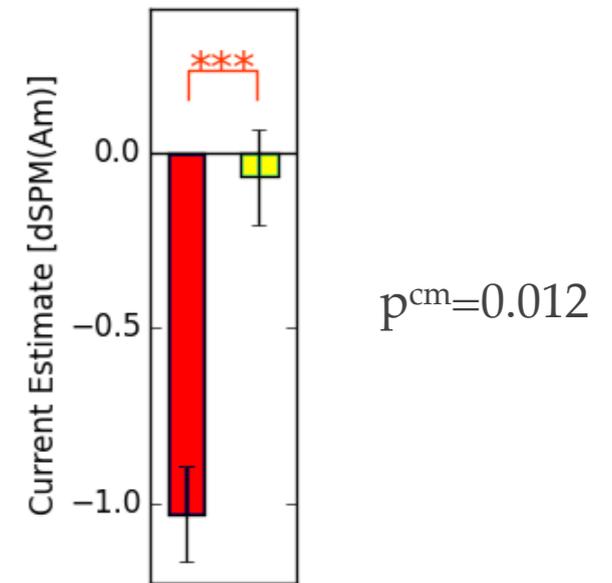
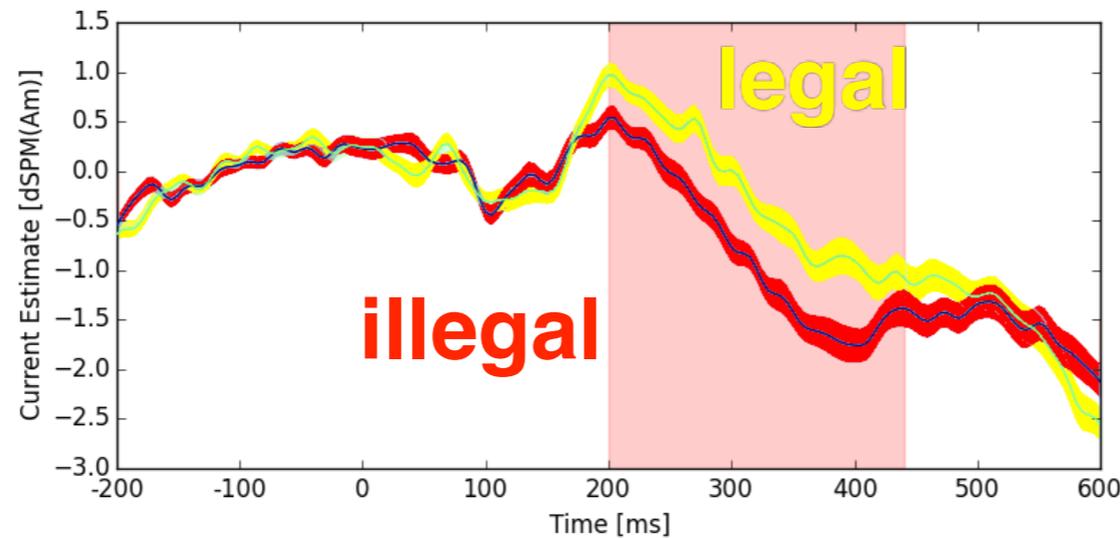
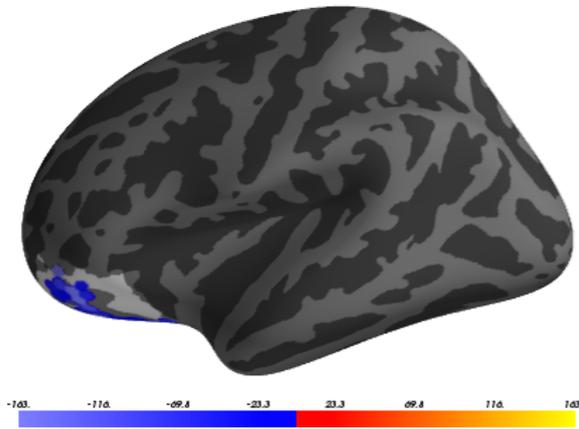
- ❖ significant differences between category and arg.struc violations for all 3 prefixes in Anterior Temporal Lobe
- ❖ earlier, opposite direction effect for **re-** vs. **out-** and **un-** (reflected in LD RTs)
- ❖ The **out-** and **un- cat.viol** costs occurred in the time window associated with **recombination and well-formedness verification** by Fruchter & Marantz 2015

# Preliminary Conclusions

- ❖ The **re- arg.struc.viol** costs are in the time window associated with **N/V category entropy** (King et al, in press) and subcategorisation entropy (Linzen et al, 2013)

argument/event structure restriction	
re-	syntactic: internal argument, result-state phrase
un-	conceptual: reversible change of state event
out-	syntactic: intransitive → transitive conceptual: dimension of comparison

# Results: latOF/BA11



- **illegal** vs. **legal** string contrast evokes sustained amplitude differences from 200-440ms
- earlier, and more sustained effect than F&M2015 or P.etal(2009)

❖ cm=corrections for multiple comparisons

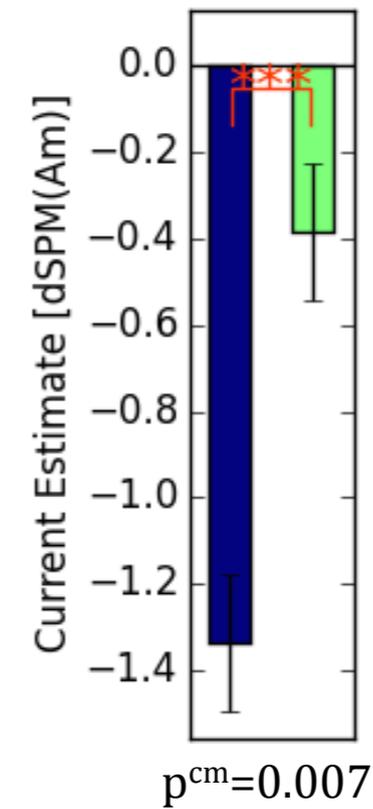
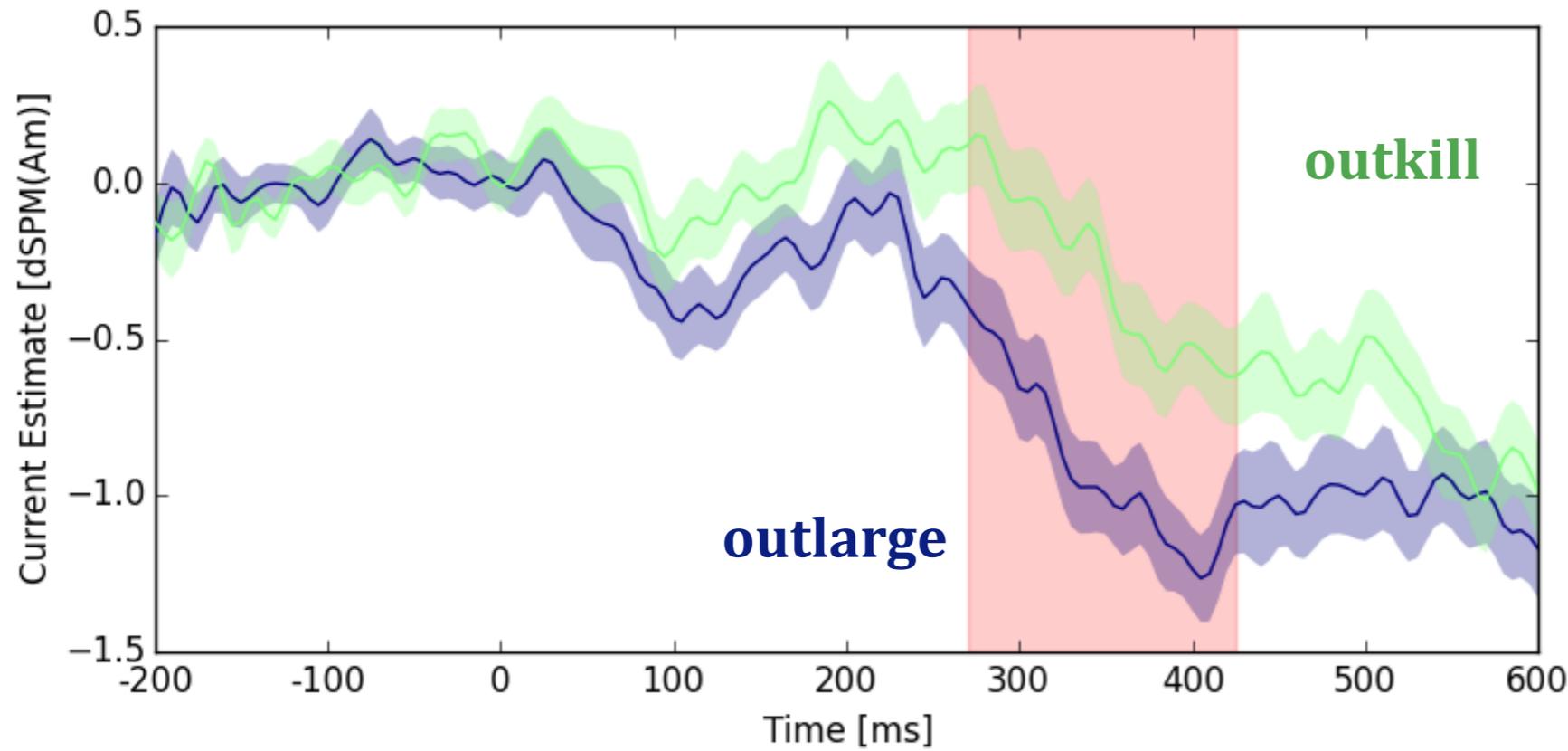
# Results: latOF/BA11



200 - 300 ms

300 - 400 ms

400 - 500 ms



❖ cm=corrections for multiple comparisons

# Preliminary Conclusions

- ❖ We replicate the finding that OF tracks wellformedness
- ❖ For out- (but not re- or un-) we find that **category violations** trigger a greater response than **arg/event structure** violations

# Next Steps

- ❖ ongoing data analysis

# Next Steps

- ❖ ongoing data analysis

prefix	Legal				Illegal			
	simple stem	complex stem			simple stem			
		verb	cat.viol	argstruc.viol	category violation		argstruc violation	
					-cont	+cont	-cont	+cont
re-	refill	recreated	reflatten		recold	rebright	relaugh	
un-	unbend	unblocked	unfaithful	unbathed	unlamp	unfaith		unthink
out-	outpace				outlarge		outkill	

# Wrapping Up

- ❖ the way you put complex words together MATTERS!
- ❖ even in the minimal domain of a short word, we can see evidence for rapid pre-activation of substantial, abstract syntactic structures
- ❖ with sufficiently articulated linguistic models and sufficiently explicit linking hypothesis
- ❖ blobs in the brain can become a useful tool for refining linguistic analysis

# Without Whom...



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Kyriaki Neophytou

- ❖ Coppe van Urk, Hagit Borer, Liina Pylkkanen and audiences at McMaster University, NYUAD and QMUL for helpful discussion
- ❖ Research supported by NYU Abu Dhabi Research Institute NeLLab grant

The  
UNTHANKS



# Un/Re-packing argument and event structure restrictions on prefixation: MEG evidence

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Linnaea Stockall, Christina Manouilidou, Laura Gwilliams and Alec Marantz

*Workshop on the syntax of argument structure: empirical  
advancements and theoretical relevance | 38.*

*Jahrestagung der Deutschen Gesellschaft für*

*Sprachwissenschaft*

*February 24-26, 2016*