Early decomposition effects during visual processing of past tense verbs: MEG masked priming evidence for form-based decomposition of irregular verbs

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Introduction

Past Tense Debate

1. Dual Mechanism Theory: regular verbs generated by rule, irregulars memorized and stored as whole forms in the lexicon.
   (Pinker & Prince, 1988)
2. Single Mechanism Theory: both regulars and irregulars generated by rule from stem and affix, with phonological readjustment of stem as necessary.
   (*Stockall & Marantz, 2006)*

Masked Morphological Priming

Behavioral evidence for form-based decomposition from masked priming with genuinely affixed words (teacher-TEACH) and pseudo-affixed words (corner-CORN), but not orthographic controls (brothel-BROTH; Rastle, Davis, & New, 2004).
Similar results for irregular items (fell-FALL),
but not pseudo-irregulars (bell-BALL; Crepaldi et al., 2010).

MEG/EEG Studies of Visual Word Recognition

MEG studies of single word reading show effects of *transition probability from stem to affix* on the M170 evoked response (Solomyak & Marantz, 2010). Here, following up on previous EEG and MEG studies showing masked priming effects (Morris & Stockall, in press; Lehtonen, Monahan, & Poeppel, 2011), we ask whether we can find early effects of masked morphological priming on the M170, for both regular and irregular past tense verbs.

Design

Stimuli

• 200 real word targets, preceded by related and unrelated primes; the two types of primes are matched for word length, frequency, and orthographic neighbors.
• 200 non-word targets, preceded by real word primes (related and unrelated); non-words matched for length and orthographic neighbors with real word targets.

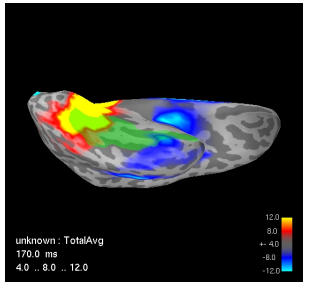
	Unrelated Prime	Related Prime	Target
Identity	busy	tree	TREE
Regular	ballet	rushed	RUSH
Irregular	rub	dug	DIG
Pseudo-irregular	cab	rug	RIG

Experimental Procedure

MEG Analysis

MEG Experiment:
•Right-handed native English speakers (n=16) completed a visual masked priming lexical decision task (word vs. non-word) consisting of 400 trials.
•MEG data was acquired continuously during the task.
•Structural MRIs were analyzed via FreeSurfer.
•Cortically-constrained inverse solutions were computed via MNE.

Priming Analysis via Anatomical Fusiform ROI:
•Anatomical regions of interest (ROIs) were selected from the automatic FreeSurfer parcellations of the cortex.
•Linear mixed effects models were employed millisecond-by-millisecond with the average activity within the fusiform ROI (for each trial) as the dependent variable, PrimeType (related vs. unrelated) as the fixed effect, and subject and item as random effects.

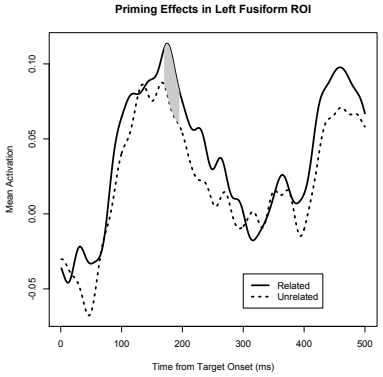


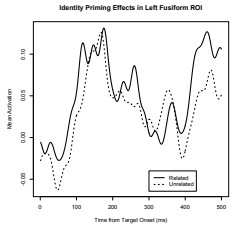
Left hemisphere of a representative subject's inflated cortical surface, from a ventral view. Average activity across all subjects and all trials is shown at 170 ms post-target onset. Red/yellow indicates activity directed upward (with respect to the head) and blue indicates activity directed downward. The anatomical fusiform ROI is highlighted in green.

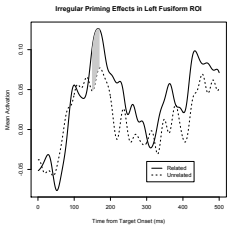
Behavioral Results

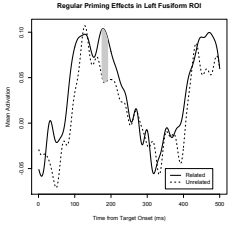
	RT Priming
Identity	**33.3 ms (p = 0.0001)**
Regular	**22.5 ms (p = 0.002)**
Irregular	**14.2 ms (p = 0.042)**
Pseudo-irregular	**14.6 ms (p = 0.083)**

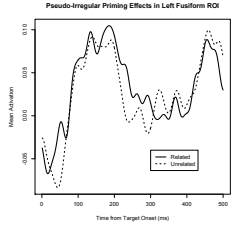
MEG Results











Priming Analysis	ROI / Hypothesized time window	Significance of effect*
M170 - **All**	Left fusiform / 146 – 196 ms	p = 0.011 for the cluster at 170-195 ms
M170 - **Irregular**	Left fusiform / 146 – 196 ms	p = 0.028 for the cluster at 149-170 ms
M170 - **Regular**	Left fusiform / 146 – 196 ms	p = 0.041 for the cluster at 174-192 ms

*Significance calculated via 10,000 iterations of permutation tests, based on multiple comparisons correction algorithm in Maris & Oostenveld (2007), as adapted by Solomyak & Marantz (2010).

Conclusions

1. Early M170 effects of masked priming manipulation in left fusiform ROI.
2. M170 priming effects for regular and irregular verbs, supporting notion that all past tense verbs are decomposed into stems and affixes, prior to lexical access.
3. Confirms predictions of Single Mechanism Theory (Stockall & Marantz, 2006), as opposed to Dual Mechanism Theory (Pinker & Prince, 1988) which predicts rule-based decomposition only for regular verbs.

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