Decomposing morphologically complex words: Across contexts and word types I

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Decomposing morphologically complex words: Across contexts and word types I

Today’s plan

Talk 2: Decomposing morphologically complex words: Across contexts and word types I

In Talk 1, I reviewed alternative conceptions of the role of morphemes in complex word recognition

❖ Impact of ‘idiosyncrasy’
❖ Segmentation-Activation-Composition
❖ Lexical decision/MEG study suggesting activation of compound constituents
Decomposing morphologically complex words: Across contexts and word types I

Today’s plan

Talk 2: Decomposing morphologically complex words: Across contexts and word types I

Today: cross-method investigation of decomposition

- Locus of impact from ‘idiosyncrasy of meaning’ (semantic transparency/opacity)

- The surprising and informative case of decomposition in complex nonwords
Decomposing morphologically complex words: Across contexts and word types

**Segmentation - Activation - Composition** of complex word representations

The lexical decision/MEG study provided evidence that constituents are activated during the processing of lexicalized compounds (across frequencies)

→ Evidence for morpheme activation
→ Speculation that initial segmentation not heavily dependent on “affix stripping”
Decomposing morphologically complex words: Across contexts and word types I

*Priming* has become a dominant way to probe for decomposition effects in the psycholinguistics literature.

Priming is simply the effect of a previously encountered word, say *cat*, on subsequent processing of that same word when encountered again.

\[
\text{cat} \rightarrow \text{cat} \\
\text{government} \rightarrow \text{govern}
\]
Decomposing morphologically complex words: Across contexts and word types I

*Priming* has become a dominant way to probe for decomposition effects in the psycholinguistics literature

→ Arguments/evidence that some types of priming may be more indicative of initial segmentation and activation

→ Others may also reflect influence of post-decompositional processes (as does simple lexical decision)

We will take advantage of this today
Masked Priming

- Masked priming (Forster & Davis, 1984) has played an increasingly large role in probing for morphological decomposition.

- The participant typically does not consciously “see” the prime, with prime durations around 60 ms or less.

Fixation/Mask: #######
Prime Word: cleaner
Target Word: CLEAN

Until Lexical Decision
Masked Priming

- Argued to reflect largely automatic processing
- Notice that you can do whole studies on complex word recognition without the participant consciously seeing any complex words!
Masked Priming Task: Demonstration

~40 ms Prime

Movie at www.u.arizona.edu/~kforster/priming
Masked Priming Task

Basic intuition: unconsciously presented, related prime may facilitate (or inhibit) processing of the target, as compared to an unrelated prime

Related condition: cleaner $\rightarrow$ CLEAN

Unrelated condition: portrait $\rightarrow$ CLEAN
Masked Priming Task

cleaner \rightarrow \text{CLEAN} \quad \text{faster than} \quad \text{portrait} \rightarrow \text{CLEAN}

If such an effect is observed in masked priming…

…AND this effect can be dissociated from effects of semantic or formal relatedness, then it provides evidence for automatic initial parse of prime into potential constituents
Masked Morphological Priming: Previous studies

- Orthographic relatedness typically does not yield facilitation in this design.

- Semantic relatedness likewise does not generally affect priming (though see Feldman, O’Connor, & Moscoso del Prado Martín, 2009; cf. Davis & Rastle, 2010).

- Indeed, evidence from affixed words for morphological activation whenever prime is segmentable into existing morphemes (see Rastle & Davis, 2008, for a review).
Masked Priming and Constituent Access

Rastle et al. (2004): English stimuli, 42ms prime duration

Priming effects (relative to unrelated primes)

<table>
<thead>
<tr>
<th>Transparent Pairs</th>
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<tbody>
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<td>Apparent Morphology</td>
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Corn + -er
Masked Priming and Constituent Access

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broth + -el
-el is not a suffix!
Masked Priming and Constituent Access

Rastle et al. (2004): English stimuli, 42ms prime duration

Priming effects (relative to unrelated primes)

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<th>Pairs</th>
<th>Effect</th>
</tr>
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<tbody>
<tr>
<td>Transparent Pairs</td>
<td>cleaner/CLEAN</td>
<td>27ms facilitation</td>
</tr>
<tr>
<td>Apparent Morphology</td>
<td>corner/CORN</td>
<td>24ms facilitation</td>
</tr>
<tr>
<td>Orthographic Overlap</td>
<td>brothel/BROTH</td>
<td>No significant effect(4ms)</td>
</tr>
</tbody>
</table>
Masked Morphological Priming: Previous studies

- Rastle et al. (2004): Priming (facilitation) whenever the surface string is segmentable into existing morphemes
- No similar effect for purely orthographic overlap
- Effect cannot be semantic (else corner would not prime CORN)
Masked Morphological Priming: Previous studies

- Masked priming may thus be reflecting initial across-the-board segmentation into minimal morphological units (putative constituents).

- With longer duration, conscious presentation of the prime, effect e.g., of transparency do emerge (Rastle et al., 2000).
Masked Priming and Constituent Access

Longtin et al. (2003): Masked priming (46ms prime duration)

<table>
<thead>
<tr>
<th>Pairs Type</th>
<th>Pairs</th>
<th>Facilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent Pairs</td>
<td>gaufrette/GAUFRE wafer/waffle</td>
<td>38ms facilitation</td>
</tr>
<tr>
<td>Opaque Pairs</td>
<td>fauvette/FAUVE warbler/wildcat</td>
<td>43ms facilitation</td>
</tr>
<tr>
<td>Pseudo-derived Pairs</td>
<td>baguette/BAGUE little stick/ring</td>
<td>26ms facilitation</td>
</tr>
<tr>
<td>Orthographic Overlap Pairs</td>
<td>abricot/ABRI apricot/shelter</td>
<td>26ms inhibition</td>
</tr>
</tbody>
</table>
Masked Morphological Priming: Previous studies

Exhaustivity: masked morphological priming whenever surface string is compatible with a segmentation into existing morphemes (see Rastle & Davis, 2008 for a review)

McCormick et al. (2008, 2009): robust to regular morpho-orthographic changes

Dropped “e”: adorable ➔ ADORE
Shared “e”: writer ➔ WRITE
Double-consonant: metallic ➔ METAL
Masked Priming and Compound Processing

Evidence for compound constituent activation?

➢ Since previous research using complex primes has tended to focus on affixation, questions regarding the nature and scope of masked morphological priming effects remain.

Will reported dissociations among morphology, form and meaning hold for masked compound primes in English?
Priming of compound constituents (Fiorentino & Fund- Reznicek, 2009)

- Evidence for masked morphological priming of compound constituents – i.e., rapid priming without affixation?

- Would semantic transparency strongly constrain priming effects?

- Would priming of CW constituents dissociate from that of orthographic form overlap prime-target pairs (penguin - PEN; platform - FORM)?
Stimuli: Transparency Rating Study

Rating study (N=40): assessed relation among compound and each of its constituents

- Pre-tested 188 compounds (no morphemes repeated)
- 38 transparent and 38 opaque compounds selected based on position-specific and whole-word transparency ratings, and carried forward for the masked priming experiments
Design and Participants

Participants, Study 1 (Non-heads): N=78 Native speakers of English

Participants, Study 2 (Heads): N=78 Native speakers of English

Stimuli visually presented using DMDX, as follows:
Non-head/Initial Position Priming

- **Expt. I: Transparent**
  - Fixation/Mask: #######
  - Prime Word: teacup
  - Target Word: TEA

- **Expt. I: Opaque**
  - Fixation/Mask: #######
  - Prime Word: bellhop
  - Target Word: BELL

- **Expt. I: Form**
  - Fixation/Mask: #######
  - Prime Word: penguin
  - Target Word: PEN
Head/Final Position Priming

**Expt. II:**
- **Transparent**
  - **Fixation/Mask:** #######
  - **Prime Word:** teacup
  - **Target Word:** CUP
  - **Until Lexical Decision**

- **Opaque**
  - **Fixation/Mask:** #######
  - **Prime Word:** bellhop
  - **Target Word:** HOP
  - **Until Lexical Decision**

- **Form**
  - **Fixation/Mask:** #######
  - **Prime Word:** platform
  - **Target Word:** FORM
  - **Until Lexical Decision**
Predictions

If all compounds treated as **atoms**, then *no priming*, just like the typical ‘brothel-broth’ results.

- facilitation for neither *T, O, nor Form*

If initial access always through whole-words (or is strongly constrained by semantics) then *only transparent compounds should prime* their constituents.

- facilitation for *T*, but not *O, nor Form*

If **morpheme-based**, not reliant on semantic or formal regularity, then *priming for both transparent and opaque compounds*.

- facilitation for *T and O, but not Form*
Results: Priming of Non-head/Initial Position

✓ Significant, statistically equivalent priming for Transparent and Opaque compound constituents

✓ No significant priming for Form condition

Table 3. Priming of Non-head/Word-Initial Position (by Participants)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Response Time in ms. (error %)</th>
<th>Mean Difference (Priming)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Control</td>
</tr>
<tr>
<td>Transparent Compound</td>
<td>622, SE 8.5 (2%)</td>
<td>646, SE 8.6 (3%)</td>
</tr>
<tr>
<td>Opaque Compound</td>
<td>645, SE 8.9 (4%)</td>
<td>667, SE 8.7 (5%)</td>
</tr>
<tr>
<td>Orthographic Form Overlap</td>
<td>676, SE 9.4 (6%)</td>
<td>683, SE 9.3 (6%)</td>
</tr>
</tbody>
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* p < .05. ** p < .01.
Results: Priming of Head/Final Position

Table 6. Priming of Head/Word-Final Position (by Participants)

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<tr>
<td>Transparent Compound</td>
<td>643, SE 9.2 (2%)</td>
<td>667, SE 9.2 (3%)</td>
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<td>Opaque Compound</td>
<td>646, SE 9.2 (2%)</td>
<td>662 SE 9.0 (3%)</td>
</tr>
<tr>
<td>Orthographic Form Overlap</td>
<td>702, SE 10.7 (7%)</td>
<td>699 SE 9.6 (8%)</td>
</tr>
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</table>

* p < .05. ** p < .01.

- **Significant, statistically equivalent priming** for Transparent and Opaque compound constituents
- **No significant priming** for Form condition
Accuracy Rates

- Tiny accuracy effects, but when present, they are present for Transparent and Opaque CW, but not for Form Overlap

- Effects did not differ in magnitude across transparent and opaque conditions.
Results: Masked Priming of Compounds

Across these two experiments, we find significant priming for the constituents of compounds both transparent, like teacup and opaque, like bellhop

…but not for form-related word pairs like penguin-pen or platform-form.
Potential Effect of Headedness/Position?

- Difficult to see in current dataset: the participants differed, as did the items to maximize position-specific item controls, making direct comparisons more difficult

- Position vs. morphological headedness? (see e.g. Jarema et al., 1999, Arcara et al., 2008 for studies engaging these issues, using other methods)
Summary

Masked priming results suggest initial, automatic morpheme activation extends to compound words

- Not limited to derivationally or inflectionally complex primes (e.g., McCormick et al., 2008, Rastle et al., 2004, Longtin et al., 2003, among others); see also Shoolman & Andrews, 2003, for a study in which compounds were the target rather than the prime)
When (if ever) does semantic transparency affect processing?

Masked priming results suggest initial across-the-board decomposition regardless of transparency

Where and how, then do transparency effects come into play?

Fiorentino & Fund-Reznicek (2009) speculation: Semantic transparency may largely constrain post-decompositional combinatorial processing
When (if ever) does semantic transparency affect processing?

If we test the compounds (and monomorphemic words) in an unprimed lexical decision task, will we find

(i) effects of morphological constituency

- Our lexical decision/MEG experiments suggest that morpheme activation influences RT

AND (ii) effects of transparency?

- Plenty of reason to argue that lexical decision is sensitive to post-decompositional processing as well
Fiorentino (2014): New evidence for the decomposition and composition of lexicalized English compounds

Tested sets of transparent and opaque compounds, as well as the long monomorphemic words with embedded pseudomorphemes from Fiorentino & Fund-Reznicek (2009)

- teacup
- bellhop
- penguin
- platform

Task: simple word/nonword lexical decision

Participants: N=24 native English speakers
Predictions

If all compounds treated as *atoms*, then *no RT differences between word types* (as they are controlled for whole-word level properties)

If morpheme-based, the compounds will be responded to more quickly than long monomorphemic words (e.g., Fiorentino & Poeppel, 2007, Fiorentino & Fund-Reznicek, 2008, Ji et al., 2011)

If compound processing is both morpheme-based and affected by transparency, the transparent compounds will be responded to more quickly than opaque compounds (e.g., Ji et al., 2011, Libben et al., 2014)
Results

**Effects of constituency:** Transparent compounds responded to significantly more quickly than both word-initial and word-final pseudoembedded monomorphemic words.

Likewise Opaque compounds were responded to faster than word-initial and word-final pseudoembedded monomorphemic words.

**Effects of transparency:** response times were significantly faster for transparent than for the opaque compounds.

→ Correlation analysis: as transparency decreased, response time increased ($r = -0.238, p < 0.039$).
Summary: Masked priming and lexical decision for transparent and opaque compounds

Together, these masked priming and lexical decision findings suggest:

Initial morpheme-based segmentation and activation both for transparent and opaque compounds (masked priming),

Effects of transparency in later, post-decompositional processing (lexical decision)
Summary: Masked priming and lexical decision for transparent and opaque compounds

Consistent with across-the-board, obligatory decomposition regardless of idiosyncratic properties like limited semantic transparency

→ Transparency affected post-decompositional, combinatorial processing
Across-the-board decomposition-first approaches would predict that novel words comprised of existing morpheme forms should undergo similar rapid morpho-orthographic segmentation, but relatively few studies have tested this (cf. Longtin & Meunier, 2005; Morris et al., 2011)

Sounds straightforward, but it turns out not to be….!
Fiorentino et al. (submitted): Novel complex word priming

Who might predict differences to emerge?

Theories which either account for so-called morphological relations between words and their constituents as connections between whole words (e.g., teacup and tea are separate whole words related in a network fashion; e.g., Bybee, 1995)

Processing models in which constituent access proceeds subsequent to whole-word access (e.g., supralexical models; Giraudo & Grainger, 2001)
However, plenty of evidence from simple lexical decision that novel complex words are harder to reject than unstructured nonwords, suggesting some role for morpheme-based processing in novel words.

For novel compounds: Fiorentino et al., 2014; Taft, 1985, among others; novel affixed words: Crepaldi, 2010, Caramazza et al., 1988 among others

Few studies have actually tested whether morphologically-structured nonwords show similar patterns of masked priming to those reported with lexicalized words.

Fiorentino et al. (submitted): Novel complex word priming
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Longtin & Meunier (2005): Masked priming evidence from French suggesting that novel suffixed words primed their root, while a pseudoembedded constituent in a novel word without the appearance of exhaustive morphological constituency did not show similar priming effects

→ Novel complex word constituent vs. pseudoembedded morpheme priming so far looks the same as for lexicalized primes
Fiorentino et al. (submitted): Novel complex word priming

Longtin and Meunier (2005)

<table>
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<th>rapidifier $\rightarrow$ RAPIDE gloss: ‘quickify $\rightarrow$ QUICK’</th>
<th>Priming</th>
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<td>Ex. 2 Pseudo-embedded</td>
<td>rapiduit $\rightarrow$ RAPIDE although $\textit{rapid}$- is a root in French, $\textit{-uit}$ is not an affix)</td>
<td>No priming</td>
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Morris et al. (2011): Masked priming/ERP study testing three prime-target types:

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flex+ -ity?
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*flex + -int is not a suffix!*
Dependent variables in ERP priming studies: reduction in negative-going components for related compared to unrelated conditions: N400 (and sometimes N250)

Kutas & Federmeier, 2011
Morris et al. (2011): Experiment 1 results

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Same behavioral priming

Same N250 and N400 priming
Fiorentino et al. (submitted): Novel complex word priming

Morris et al. (2011): Experiment 2 results

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- Greater priming for real and novel derived prime-target pairs than pseudoembedded pairs in posterior lateral column of electrodes

Same behavioral priming
Same N250 priming
Fiorentino et al. (submitted): Novel complex word priming

Morris et al. (2011):
Fiorentino et al. (submitted): Novel complex word priming

Summary of previous literature:

Two previous attempts, mixed results

Longtin & Meunier (2005): same pattern as for lexicalized words

Morris et al. (2011): only in one experiment, and only in N400, did a dissociation between exhaustively segmentable and pseudoembedded conditions emerge
Current study: Target morpheme preceded by novel compound, pseudocompound, or unrelated nonword

Novel compound prime: drugrack ➔ rack
Pseudocompound prime: slegrack ➔ rack
Unrelated prime: sepblosh ➔ rack

- 96 triplets (32 per condition); all conditions matched on length, syllabicility, bigram frequency
- 32 additional unrelated prime-real word target conditions to reduce overall prime-target relatedness
- 128 prime-target pairs with nonword targets
Fiorentino et al. (submitted): Novel complex word priming

<table>
<thead>
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<th>Experiment 1:</th>
<th>Masked priming (50 ms prime duration)</th>
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<tr>
<td>Experiment 2:</td>
<td>Unmasked priming (250 ms prime duration)</td>
</tr>
<tr>
<td>Experiment 3:</td>
<td>EEG with unmasked priming (250 ms prime duration)</td>
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<th>Experiment 1:</th>
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<td>Experiment 2:</td>
<td>N=30 participants</td>
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<td>N=31 participants</td>
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Fiorentino et al. (submitted): Novel complex word priming

Priming effects:

Significant and equivalent RT facilitation observed for the novel compound head constituent and the pseudoembedded morpheme in masked priming

A dissociation between novel compounds and pseudoembedded emerges in unmasked priming
Fiorentino et al. (submitted): Novel complex word priming

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<th>Condition/Paradigm</th>
<th>Novel Compound</th>
<th>Novel Pseudocompound</th>
<th>Unrelated</th>
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<tr>
<td>Masked</td>
<td>640 (2.5%)</td>
<td>642 (3.0%)</td>
<td>653 (3.3%)</td>
</tr>
<tr>
<td>Overt</td>
<td>627 (2.2%)</td>
<td>645 (2.1%)</td>
<td>669 (3.9%)</td>
</tr>
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<td>Novel Pseudocompound</td>
<td>Unrelated</td>
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Fiorentino et al. (submitted): Novel complex word priming
Fiorentino et al. (submitted): Novel complex word priming

N400 Priming effects (300-500 ms time window):

Three-way dissociation in right posterior, similar to the dissociation found in lateral posterior electrode column in Morris et al. (2011)

Both novel compounds and pseudocompounds differed from the unrelated condition, and novel compounds showed greater priming than pseudocompounds.
Fiorentino et al. (submitted): Novel complex word priming
Evidence for activation of the putative head constituent of novel compounds

- Consistent with findings from lexicalized compounds
- Consistent with lexical decision and other findings suggesting morpheme-based processing of novel CW
- Broadly consistent with across-the-board morpheme activation, even for novel putatively complex words
- Does not seem to be supralexical (the novel compounds lack their own representation)
- Cannot be accounted for as links between atomic representations in network (for the same reason)
Dissociating morphological and orthographic priming:

- What was common to the current study and previous studies was facilitation of putative constituents.
- What was different is the ease of distinguishing morphological and orthographic facilitation.

Why was it harder to dissociate morphological and orthographic priming in Morris et al. and our study?

Critical difference seems to be the role of the lexicality of the prime in the orthographic condition.

Fiorentino et al. (submitted): Novel complex word priming
Masked orthographic priming: does not tend to yield robust facilitation (effects, if any, tend to be inhibitory)

platform $\rightarrow$ FORM  No robust priming

…Except with nonword primes

slegrack $\rightarrow$ RACK  Robust priming
Fiorentino et al. (submitted): Novel complex word priming

platform ➔ FORM

No exhaustive morphological parse smaller than [platform], and [platform] is an attested monomorpheme

➔ Priming pattern (lack of facilitation/presence of inhibition) suggests that the prime and target compete/prime inhibits the target
Fiorentino et al. (submitted): Novel complex word priming

slegrack $\rightarrow$ RACK

Robust priming

No exhaustive morphological parse, and [slegrack] is also not an attested monomorpheme

$\rightarrow$ Result is perseverant activation of RACK
Thank you!

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