The role of morphological juncture identification in complex word processing: An MEG investigation

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Introduction

The role of morphological representations in the processing of complex words remains a matter of debate (e.g., Hay & Baayen, 2005).

Moreover, while accumulating psycholinguistic and neurolinguistic evidence suggests morpheme *activation* during complex word processing (see, e.g., Rastle & Davis, 2008), positing a morpheme-based route to lexical access entails not only neurocognitive mechanisms for morpheme activation, but also:

- Mechanisms for the rapid *segmentation* of word forms to identify potential morpheme-level form representations
- Mechanisms for the *combination* of activated representations into complex word structures

We utilize magnetoencephalography (MEG) to pinpoint a mechanism for the initial segmentation of visual word forms into morpheme-level form representations, taking compounds as our test case.

We identify a response peaking around 150 ms post-onset which is sensitive to the properties of the juncture between morpheme forms. These findings suggest a segmentation mechanism using morphological juncture information, active within the first 200 ms of visual word recognition.

Previous Research

MEG evidence for morpheme activation in compounds: Fiorentino & Poeppel (2007) tested lexicalized compounds (e.g., *teacup*) and long monomorphemic words (e.g., *throttle*), closely matched in whole-word frequency, length, and number of syllables. Compound constituents higher in frequency/shorter/fewer syllables.

→ M350, a left-temporal component peaking around 350 ms post-onset and argued to reflect lexical access, yielded earlier peak latency for compounds than monomorphemic words, suggesting activation of morphological constituents from long-term memory within 300-400 ms post-onset.

Composition effects in compounds: Cross-linguistic evidence, largely from EEG, suggests effects of morpheme combination during compound processing (Bai et al., 2008; El Yagoubi et al., 2008; Vergara-Martínez et al., 2009; Koester et al., 2007, 2009; Fiorentino & Fund-Reznicek, 2009); see Bölte et al. (2011) for combinatoric effects in MEG using derived words.

Probing for segmentation effects: Segmentation-stage processing has yet to be elucidated using MEG/EEG. However, it has been proposed that segmentation may recruit information regarding letter or sound sequences indicating the presence of a morphological juncture (Hay, 2003; Seidenberg, 1987; Rastle et al., 2004; Lemhöfer et al., 2011).

→ MEG responses within the first 100-200 ms have been previously linked to visual word form processing (e.g., Tarkiainen et al., 1999), and recently argued to have access to morpheme-level form representations for suffixed words (e.g., Solomyak & Marantz, 2010), suggesting examination of this particular time window for morpheme-level visual word segmentation effects.

Current Study

We test novel compounds with a morphological juncture (boundary between the morphemes) that is composed of a bigram (two-letter sequence) that often divides morphemes, vs. one that often appears morpheme-internally, testing whether/when this juncture information is recruited during word recognition.

Materials and Methods

• 50 novel compounds with a junctural bigram which is has a high-likelihood of appearing morpheme-internally (like *gr*), and 50 novel compounds with a low morpheme-internal likelihood juncture (like *gp*)

• 50 non-morphemic nonwords containing a high morpheme-internal likelihood junctural bigram, and 50 non-morphemic nonwords with a low morpheme-internal likelihood junctural bigram

	Likelihood of Juncture Appearing Morpheme-internally	
Word Structure	*High-likelihood Juncture*	*Low-likelihood Juncture*
Novel Compound Words	pegrack	pegpack
Non-morphemic nonwords	segrask	segpask

• Junctural likelihood calculated using English Lexicon Project corpus (Balota et al., 2007)

• Using novel compounds ensures that there is no stored, whole-word representation that could be associated with constituent representations (cf., Bybee (1995)

•All conditions matched on length, syllabicity, position-specific bigram frequency, and number of orthographic neighbors (MCWord Database; Medler & Binder, 2005; http://www.neuro.mcw.edu/mcword/). Morphemes of high- and low-likelihood novel compounds also matched on length, syllabicity, position-specific bigram frequency, orthographic neighborhood, and log lemma frequency

• Stimuli and fixation points were presented in yellow, 24-pt Courier New font on a black background, using Presentation (Neurobehavioral systems, Inc.); stimuli presented in a different randomized order for each participant, in four blocks of 50 trials with a self-paced rest period between each block

• Passive reading design (e.g., Krott et al., 2006): no overt response from the participant was required.

Trial Structure: Fixation cross (500 ms) followed immediately by a target stimulus, presented at the center of the screen for 1600 ms, and an randomized ISI (range 1000-1400 ms)

Participants: 18 Monolingual native English speakers; all were right-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971)

MEG Recordings

MEG Recordings:

• MEG signals were recorded in a magnetically shielded room using a whole-head CTF 151-channel system with axial gradiometers sensors (5 cm baseline).

• Data were recorded in continuous mode using a sampling rate of 600 Hz and a pass-band of 0-150 Hz.

• Vertical and horizontal electro-oculograms were simultaneously recorded using bipolar EOG channels (vertical: above and below left eye; horizontal: left and right canthi). Electrode impedances were kept below 5 kΩ.

MEG Results

Data Analysis:

•Data segmented using an epoch from 500 ms before to 800 ms after the appearance of the stimulus.

• MEG signals band-pass filtered (0.5 to 30 Hz) using bi-directional 4th order Butterworth filters to reduce the high frequency noise and identify components of interest

• Trials containing ocular or muscular artifacts were excluded from averaging.

•Baseline correction was performed using a 100 ms prestimulus interval.

•Epochs from each condition were averaged from 100 ms before to 600 ms after the onset of the stimulus.

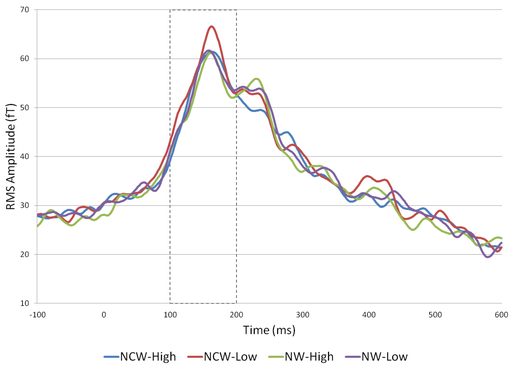
• Magnetic activity for each participant was quantified using the mean global field (MGF) computed as the RMS across sensors.

Findings:

→Peak amplitude of M150 response greater for novel compounds with low than with high morpheme-internal likelihood ($p < 0.05$)

→ This pattern observed in 78% of individual participants

→No similar effect of juncture for non-morphemic nonwords



Discussion

The current study revealed effects of morphological juncture likelihood within the first 200 ms of visual word recognition

The effect of morpheme-internal juncture likelihood was limited to the novel compound conditions (with no effect of juncture likelihood within the non-morphemic nonwords), suggesting the observed effect is not reflecting the detection of the bigram itself, but its consequences for morphological segmentation

These results suggest a morphological segmentation mechanism operating at the initial stages of visual word form processing, reflecting the initial parsing of word forms at the morpheme level.

More broadly, these findings support neurocognitive approaches to word recognition that make recourse to morpheme-level representation.

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