# A dissociation of reaction time and N400 in lexical activation of form neighbors

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## Abstract

Prior research has shown evidence for early semantic processing of lexical items. New research shows that this processing is neurologically late, and varies in distribution according to familial sinistrality.

## 1 Cascaded Activation

Some theories of lexical access assume *cascaded activation* that spreads continuously between units at different representational levels, e.g. activation of an individual letter or whole word. Alternatively, *staged* models assume an activation threshold at a given level before it is transmitted to another level. Cascaded activation predicts that the word *door* should temporarily activate not only the word *deer* during competition, but also the meaning of *deer*.
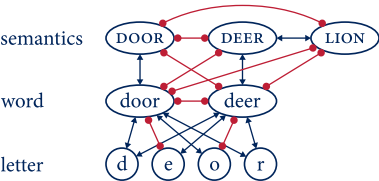


Fig. 1: A simplified diagram of an activation network. Because the excitatory connections between *deer* and *door* overlap, either stimulus can briefly activate the semantics of the other.

Forster and Bell (2013) tested this prediction using masked primes. Participants responded "in or out" to words in a target category, e.g. FRUIT. A 50 ms prime similar in form either to a member of the category or to a member of an opposing category preceded each target word. For example, if the target category is FRUIT, a "congruent" trial pinch-APPLE would be responded to faster than an incongruent trial hazard-APPLE (*pinch* is orthographically close to *peach*, and *hazard* is close to *lizard*.)

Responses were faster to congruent than incongruent trials. The results indicate that in a semantic task, very early information can be taken into

## 2 Familial Handedness

45% of right-handed individuals report at least one left-handed blood relative among their siblings, parents, uncles/aunts, and grandparents. Past research (Hancock & Bever, 2013; Sammler et al., 2012) has shown processing and neurological differences between right-handers with (FS+) and without (FS−) left-handed relatives. (All subjects discussed in this poster are right-handed.)

FS+ individuals have shown more sensitivity to tasks involving isolation and access of single words, e.g.

➤ Faster RTs in recognizing probe words from sentence fragments
➤ More facilitation in an auditory masked prime paradigm

There are related neurolinguistic differences:

➤ FS+ individuals show early right frontal activation to probe words from sentences; FS− individuals show early *left* frontal activation.
➤ FS+ individuals show no ELAN (early left anterior negativity) in the "odd-word" paradigm; FS− individuals show a strong ELAN.

## 3 Research Questions

➤ At what timepoint will the neurological correlate of early semantic congruence effects appear?
➤ Will FS+ participants show a rightward lateralization for categorical semantic judgments relative to FS− participants?

## 4 Method

45 right-handed native English speakers (F: 12 FS+, 12 FS−; M: 11 FS+, 10 FS−) were shown a category such as FRUIT and a series of English words. Participants judged whether the words belonged to the category using a button box. For each given category, the words not belonging in the category all belonged in an opposing category such as ANIMAL.

Each word was preceded by a masked prime that was similar in form to a word either in the target word's category or into the opposing category. Form similarity was established using the Spatial Coding Model (Davis, 2010), with similar meaning 0.6−0.75 similarity, and dissimilar meaning less than 0.4 similarity. Words were presented and responses collected using PsychToolbox for MATLAB (Kleiner et al., 2007). There were a total of 10 given categories and a total of 280 items plus 8 practice items. Subjects were randomly assigned to one of two counterbalanced groups so that each target word could appear in both prime conditions.

Electroencephalographs (EEGs), reaction time, and error rates were recorded. 63 EEG channels were referenced against the averaged mastoid reference and high-pass filtered at 0.1 Hz using MATLAB. Evoked potentials were time-locked to the onset of the target word, with a baseline of 150 ms immediately before the prime was displayed. Additive genetic effects for non-righthandedness were calculated by an Monte Carlo Markov Chain model based on Hancock (2013).



Fig. 2: The timing and conditions of the primes and targets are given with sample stimuli, assuming the exemplar ("yes") category is FRUIT and the non-exemplar ("no") category is ANIMAL.

## 5 Event-Related Potential (ERP) Results

1. There was a greater ERP N400 for nonexemplar targets (p < 0.001).
2. The target-related N400 effect was greater in the left hemisphere for FS− than in the right hemisphere, and greater in the right hemisphere for FS+ than in the left hemisphere (p < 0.02).
3. There was a greater N400 for primes resembling nonexemplars in electrodes over left-hemisphere language areas (p < 0.0005).
4. This prime-related N400 effect was also right lateralized for FS+ relative to FS− (p < 0.01).
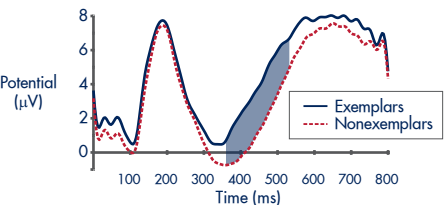
### Exemplar vs. Nonexemplar, Cz electrode



Fig. 3: A strong, widespread N400 effect was found for nonexemplar targets relative to exemplars, indicating semantic incongruence.
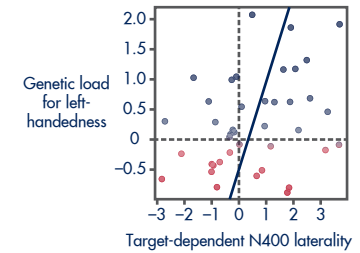
### Target-dependent N400 Laterality x FS



Fig. 4: The target-dependent N400 effect in the averaged right hemisphere electrodes minus the left hemisphere electrodes correlates with additive genetic effect for non-righthandedness (p < 0.02).
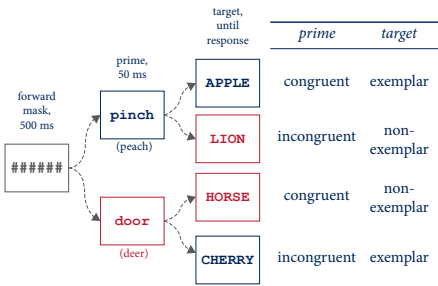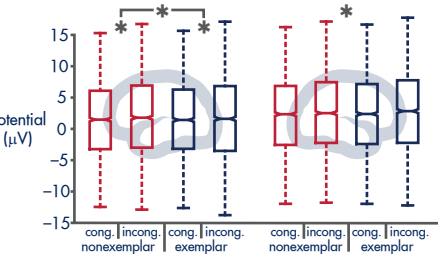
### N400 Effect of the Prime, 350−550 ms



Fig. 5: Contrary to the findings for targets, it was the congruent primes which produced a more negative N400 in left hemisphere. Boxes show interquartile range around the median.

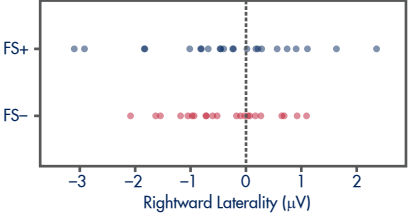### Laterality of Prime N400 Effect



Fig. 6: The size of the prime N400 effect in the averaged right hemisphere electrodes minus the left hemisphere electrodes (p < 0.01).

## 6 Behavioral results

Replicating previous behavioral results, congruent primes produced faster response times, but no effect of familial sinistrality was found.
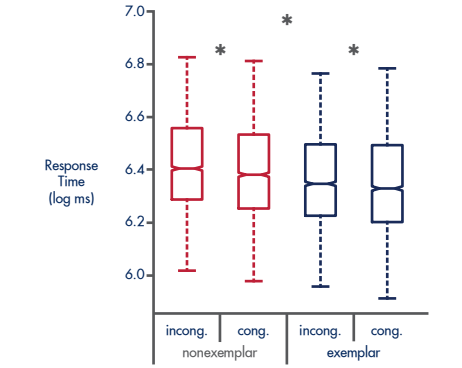


Fig. 7: Log reaction times show significant effects of prime congruence (p < 0.005) and target type (p < 0.0001). There was no significant interaction. Boxes show interquartile range around the

## 7 Discussion

The neurological data supported a cascaded model of lexical access, in which an anticipated semantic category can be activated by the form neighbor of an exemplar of that category, even when that neighbor is unconsciously perceived. Although the prime preceded the target, its influence affected the semantic judgment hundreds of milliseconds later.

Unlike the target-dependent N400, which was widely distributed and centered on the central sulcus, the prime-dependent N400 effect was left-lateralized, suggesting that the inital form and semantic activation occur in the left hemisphere.

The behavioral reaction time effects replicated the earlier findings that target-congruent primes led to faster responses for both exemplar and nonexemplar responses. Interestingly, no effect of FS was found in the behavioral data, unlike in the ERP data.

However, the consistency with prior results showing that FS affects the neurological distribution of language function is further indication of the need to track FS in subjects and patients in psychological and linguistic investigations that have a neurological component.

### References

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