Early and late neurological responses to preconscious form and semantic information in lexical category decision

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Abstract

Prior research has shown evidence for early semantic processing of lexical items. Neurological evidence shows that there are both early and late semantic effects that differ qualitatively.

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 form *deer* during competition, but also the meaning of *deer*.

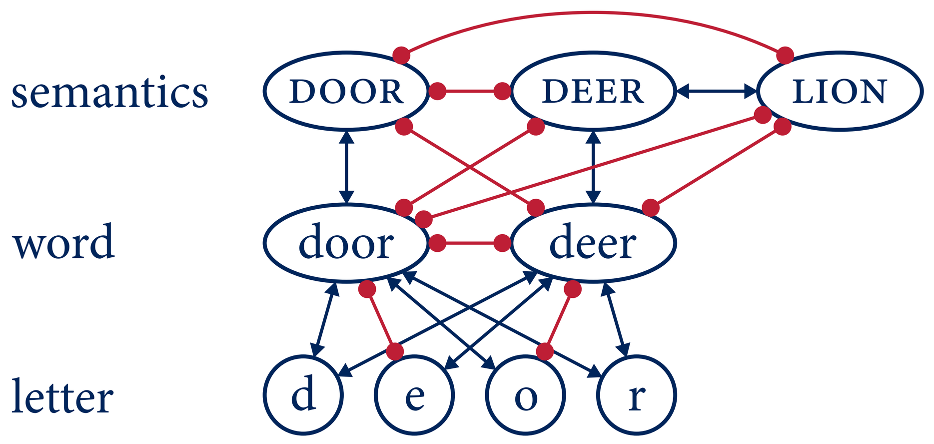

Fig. 1: A simplified diagram of an activation network. Because the excitatory connections between *deer* and *door* overlap, either stimulus can briefly activate the semantics of the other.

Bell, Forster, and Drake (2015) 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 account in semantic decisions, prior to conscious word recognition.

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

- What semantic factors are the latency and amplitude of the P200 and N400 components sensitive to?
- 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 (Kleiner et al., 2007). There were a total of 10 given categories and 280 items plus 8 practice items. Subjects were randomly assigned to one of two counterbalanced groups so that each target 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).

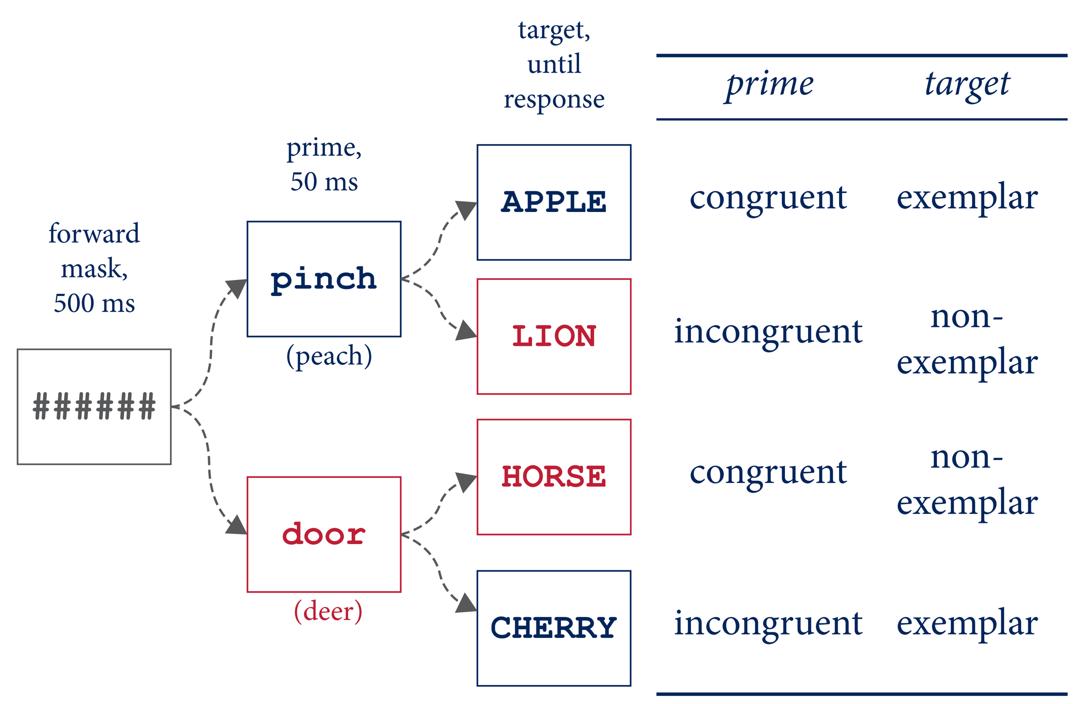

Fig. 2: The timing and conditions of the primes and targets are given with sample stimuli, assuming the exemplar ("yes") category is FRUIT and the non-exemplar ("no") category is ANIMAL.

5 Results

1. Behavioral results closely matched previous work (Bell, Forster, & Drake, 2015), with incongruent primes producing longer latencies ($p < 0.0001$).
2. There was a greater ERP N400 for nonexemplar targets ($p < 0.001$).
3. The N400 amplitude was sensitive to agreement between the prime and the target ($p < 0.001$), with congruent primes producing *more negative* N400 amplitudes.
4. While P200 onset latency proved sensitive to prime category, N400 onset latency was sensitive to prime-target agreement.

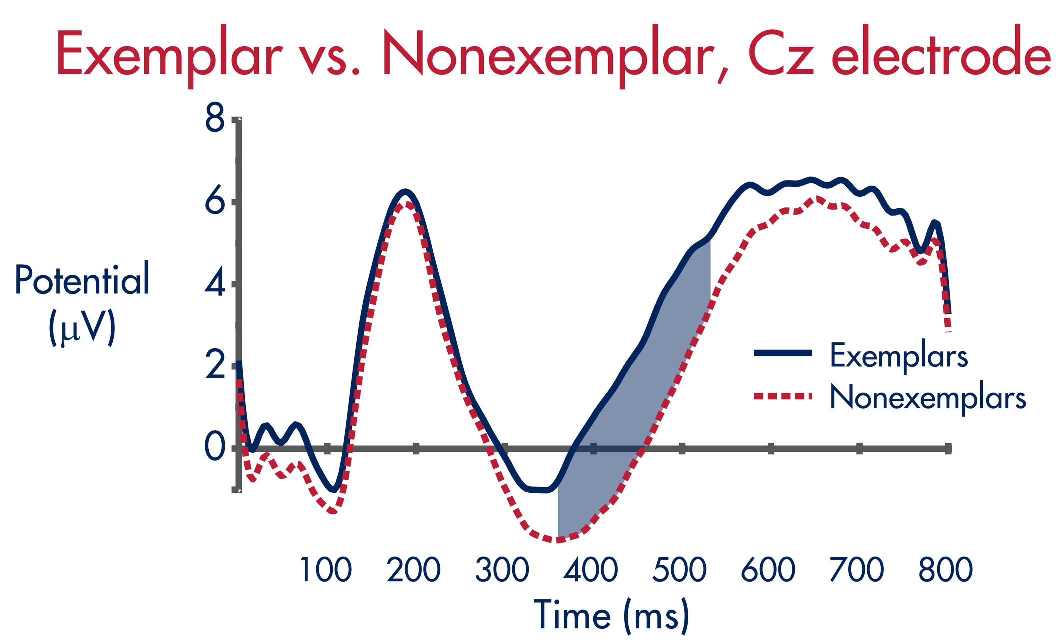

Fig. 3: A strong, widespread N400 effect was found for nonexemplar targets relative to exemplars, indicating semantic incongruence.

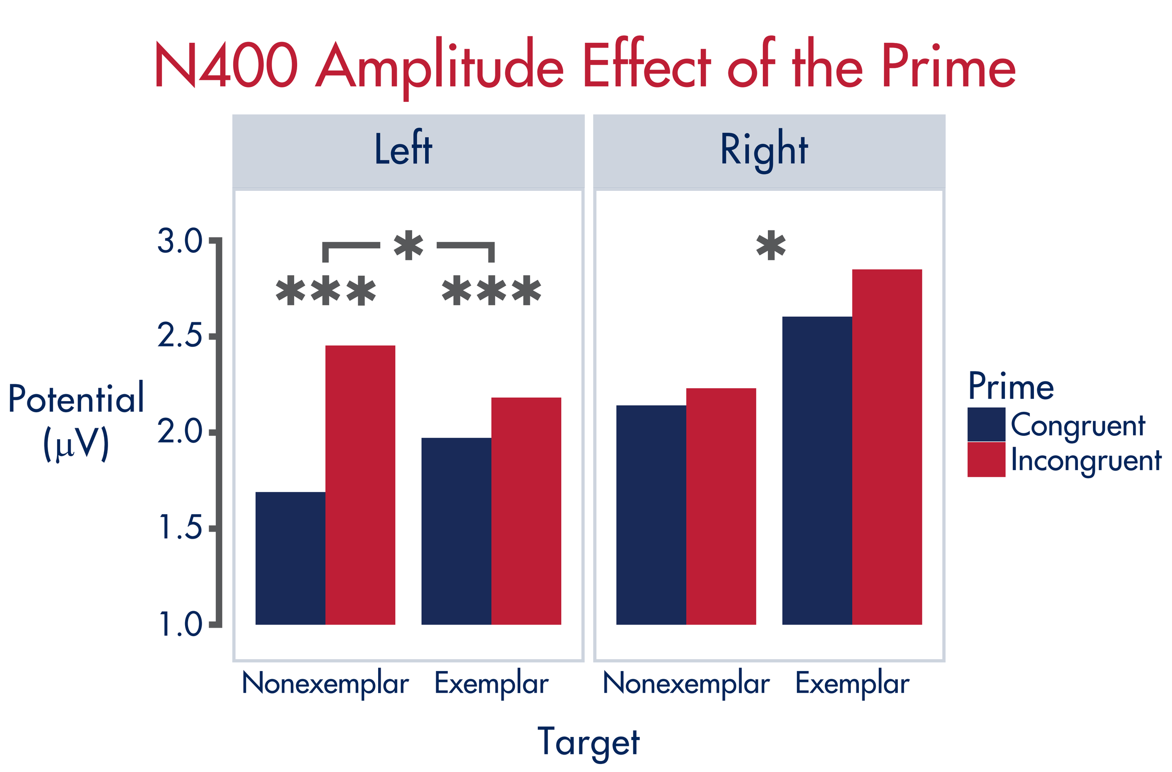

Fig. 4: Contrary to an ease-of-integration interpretation of the N400, it was the *congruent* primes which produced a more negative N400 in left hemisphere. Amplitude is the mean over 350–550 ms.

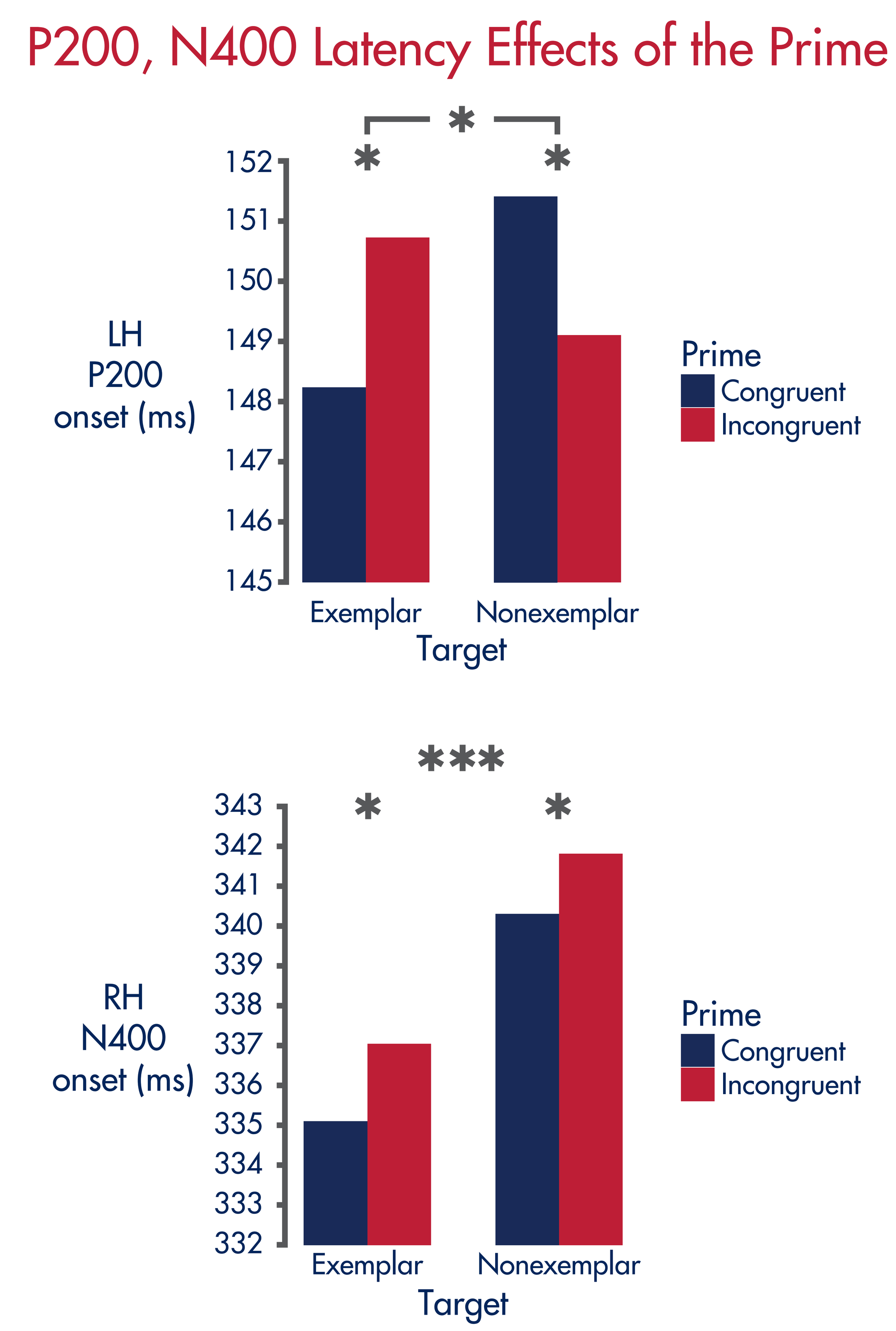

Fig. 5: P200 latency in the right hemisphere reflected prime category (interaction $p < 0.05$), while the N400 reflected prime-target agreement ($p < 0.05$).

6 Familial sinistrality effects

The additive genetic load significantly predicted the size of the right-hemisphere latency effect of target category on the N400 component, adjusted $R^2 = 0.22$.

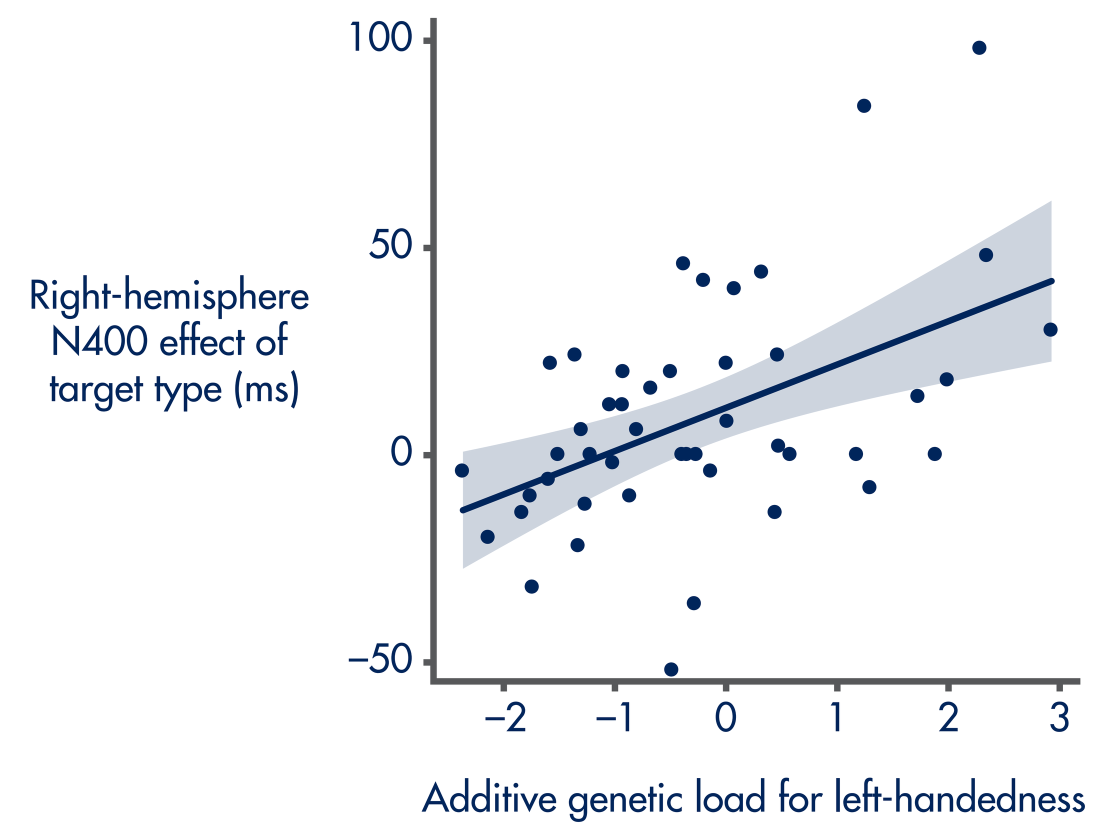

Fig. 6: The size of the N400 latency effect of target type increases as a function of additive genetic load for left-handedness.

7 Discussion

The P200 latency effect of the target is consonant with a cascaded activation account in that a categorical effect of the indirect prime is detectable, despite the inability of the average subject to categorize the prime itself. For this effect to occur, the form neighbor of the prime must contribute quite early to the semantic judgment being made.

A possible counterargument to a semantic interpretation of the P200 latency effect is that the task, while itself semantic in nature, is highly constrained by the relatively small size of the categories under consideration. Interestingly, the size of the P200 latency effect of the prime increased over successive trials ($p < 0.001$), suggesting a learning effect that could include an improvement in preactivation. Indeed, when the task is alternative forced choice on which of two words is related to a masked prime, no effect of indirect primes is found (Bell, Forster, & Drake, 2015), countering a cascaded activation interpretation.

The N400 onset latency roughly corresponds to the difference in response times as a function of both prime and target type. However, this difference is not simply carried forward from early latency differences, but rather emerges only after the P200, suggesting a complex interaction of prime and target semantics.

References

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Acknowledgments

Thanks to Elizabeth Fowler, Arpan Patel, Daniel Carrera, and Joshua Massee for their assistance, and to Electrical Geodesics Incorporated, who provided the EEG equipment necessary for the study. An allocation of computer time from the UA Research Computing High Performance Computing (HPC) and High Throughput Computing (HTC) at the University of Arizona is gratefully acknowledged.