# ERP Indices of Orthographic and Normative Word Frequency in Recognition Memory

Erika Nyhus[1,2], Simon Dennis[2,3], and Tim Curran[1]
[1]Department of Psychology and Center for Neuroscience, University of Colorado at Boulder,
[2]Department of Psychology, University of Adelaide, Australia, [3]Department of Psychology, Ohio State University

## Introduction

- Word frequency effect:
  - Rare words are better recognized than common words.
- Item noise and context noise models account for the word frequency effect in different ways (Bind, Cue, Decide Model of Episodic Memory, Dennis & Humphreys, 2001, Retrieving Effectively from Memory, Shiffrin & Steyvers, 1997).
- Context Noise with Feature Sampling: Word frequency effect due to both early feature and later context information.
- Previous ERP research has shown that word frequency modulates the N1 component (Sereno, Rayner, & Posner, 1998) and the parietal old/new effect (Rugg, Cox, Doyle, & Wells, 1995).
- These results are difficult to interpret as word frequency is often confounded with letter frequency.

- The present experiment used ERPs to test *when* letter frequency and word frequency information contributes to recognition memory.

## Methods

- 24 subjects analyzed, 19-29 years, 17 male, 7 female.
- Based on Malmberg, Steyvers, Stephens, & Shffrin (2002).
- Subjects studied lists of words crossed for letter frequency (Low/High) and word frequency (Low/High).

| Low Frequency Words<br>Low Frequency Letters | Low Frequency Words<br>High Frequency Letters | High Frequency Words<br>Low Frequency Letters | High Frequency Words<br>High Frequency Letters |
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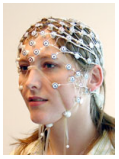
- Following the study phase subjects were asked to give confidence ratings during a recognition test.

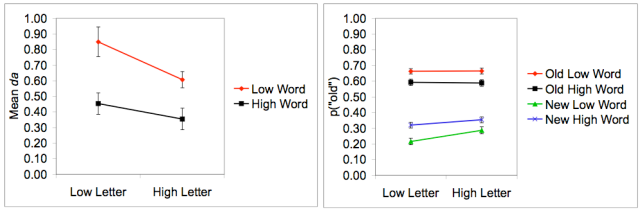
### EEG Methods

- Scalp voltages were collected with a 128-channel Geodesic Sensor Net™
- Artifacts discarded
- Baseline corrected from –100 to 0 ms
- Re-referenced to the average reference



## Behavioral Results

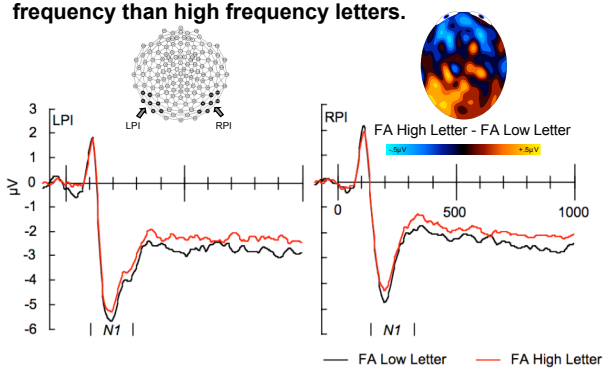
- Words with low frequency letters better discriminated than words with high frequency letters.
- Low frequency words better discriminated than high frequency words.



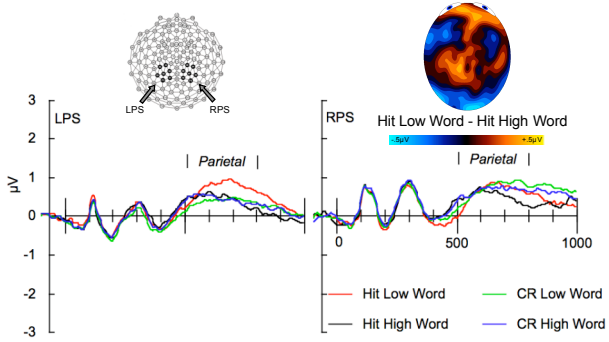

Error bars=Standard Error of the Mean

## ERP Results

- N1 amplitudes higher for false alarms to words with low frequency than high frequency letters.




- Parietal old/new effect amplitudes higher for low frequency than high frequency words, especially for hits.




## Summary of Results

- Behavioral results show letter frequency and word frequency effects:
  - Low frequency letters led to better recognition than high frequency letters.
  - Low frequency words led to better recognition than high frequency words.
- ERP results show letter frequency and word frequency effects:
  - Letter frequency modulates early posterior, inferior ERPs which reflect perceptual identification processes.
  - Word frequency modulates parietal old/new effect which may reflect either recollection processes (Rugg & Curran, 2007) or confidence (Finnigan, Humphreys, Dennis, & Geffen, 2002).

## Conclusions

- Multiple mechanisms can give rise to the word frequency effect.
- Letter frequency information (item features):
  - Accrues early
  - Affects perceptual identification
  - Indirectly affects memory: High frequency easier to identify leading to familiarity and more false alarms
- Word frequency information (context?):
  - Accrues later
  - Directly affecting memory

## References

Dennis, S., & Humphreys, M. S. (2001). A context noise model of episodic word recognition. *Psychological Review, 108*(2), 452-478.
Finnigan, S., Humphreys, M. S., Dennis, S., & Geffen, G. (2002). ERP 'old/new' effects: memory strength and decisional factor(s). *Neuropsychologia, 40*(13), 2288-2304.
Malmberg, K. J., Steyvers, M., Stephens, J. D., & Shiffrin, R. M. (2002). Feature frequency effects in recognition memory. *Memory & cognition, 30*(4), 607-613.
Rugg, M. D., Cox, C. J., Doyle, M. C., & Wells, T. (1995). Event-related potentials and the recollection of low and high frequency words. *Neuropsychologia, 33*(4), 471-484.
Rugg, M. D., & Curran, T. (2007). Event-related potentials and recognition memory. *Trends Cognitive Science, 11*(6), 251-257.
Sereno, S. C., Rayner, K., & Posner, M. I. (1998). Establishing a time-line of word recognition: evidence from eye movements and event-related potentials. *Neuroreport, 9*(10), 2195-2200.
Shiffrin, R. M., & Steyvers, M. (1997). A model for recognition memory: REM-retrieving effectively from memory. *Psychonomic Bulletin & Review, 4*(2), 145-166.

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For questions/comments please email:
nyhus@colorado.edu