A High-Density ERP Study on Word Frequency and Neighborhood: Lexical Status Effects in the P100

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Introduction

While effects of word frequency and neighborhood on word reading have been widely documented experimentally, underlying neural mechanisms are less clear. Although there have been ERP studies on the topic, the research focus was often on late time window (e.g., N400) and the semantic stage of word processing. Inspired by results of our previous studies and other literature (e.g., on face processing and on sensory memory), we conducted the current ERP study to further investigate the issue. We hypothesized that word frequency and neighborhood effect might occur at a sensory/perceptual level.

Our Goal: We aimed to explore the relation between early sensory/perceptual processing of visual word stimuli and these word-inherent but also experience-dependent features.

Method

Participants: 14 adults (11 females, Mean age = 24)

Stimuli and task: 180 4-letter words and 180 4-letter pseudowords (e.g., blup) were presented singly in a lexical decision task.

Stimuli were manipulated along 3 dimensions: frequency (Freq), size of neighborhood (Neigh) and total frequency (Total Freq), which was equal to the sum of Freq of a word/pseudoword and Freq of its neighbors (Freq of a pseudoword = 0). (Figure 1).

Freq range (Log): (3.40 – 12.41)

- Low Freq : 3.40 – 7.34, e.g., yawl
- Medium Freq : (7.40 – 9.74), e.g., swan
- High Freq : (9.78 – 12.41), e.g., card

Neigh range: (1 – 15)

- Low Neigh (1 – 5)
- Medium Neigh (6 – 10)
- High Neigh (11 – 15)

Total Freq range (Log): (5.84 – 14.55)

As a result, there were 36 categories of stimuli in total used for testing

Lexical Decision Task (LDT) → 5 blocks of 72 stimuli (36 words & 36 pseudowords) were presented. Participants made a word/non-word judgement as quickly and as accurately as possible. ISI was randomly chosen to be 300, 400 or 500 ms. Response-hand mapping was counter-balanced across subjects (Figure 2.)

Electrophysiological Recordings:

-128-Channel EGI System, converted to 81 standard sites in BESA

- 500 Hz sampling rate, offline filtered 1 to 30 Hz. Impedances < 50 kΩ, artifacts rejected/corrected using BESA.

- Epoch = 200 ms prestimulus, 800 poststimulus

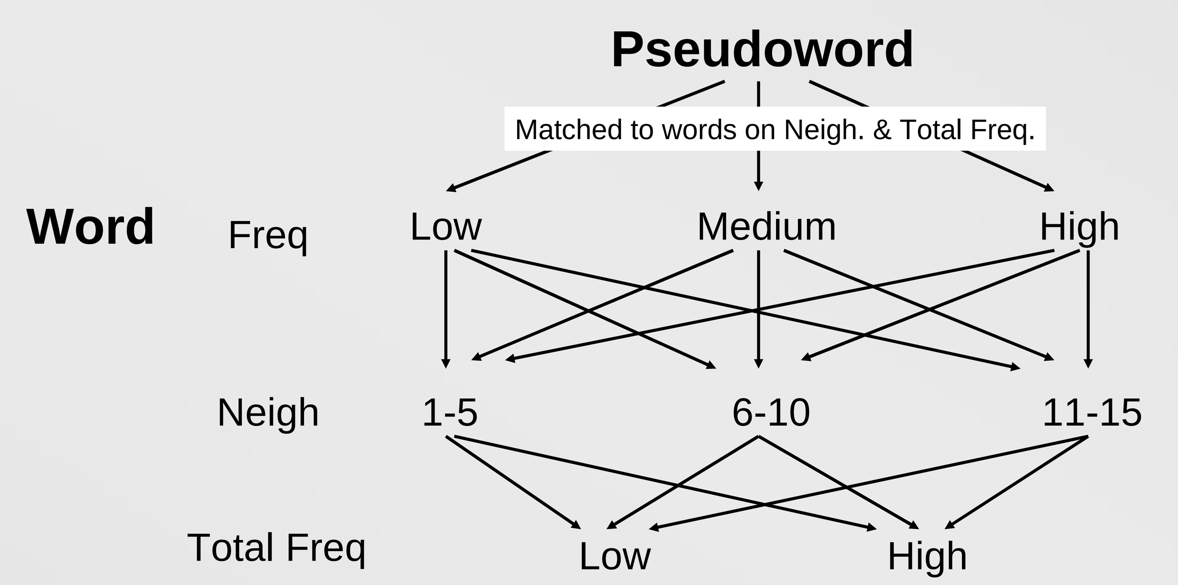


Figure 1. 36 categories of stimuli that vary in lexicality, freq., neigh., and total freq.

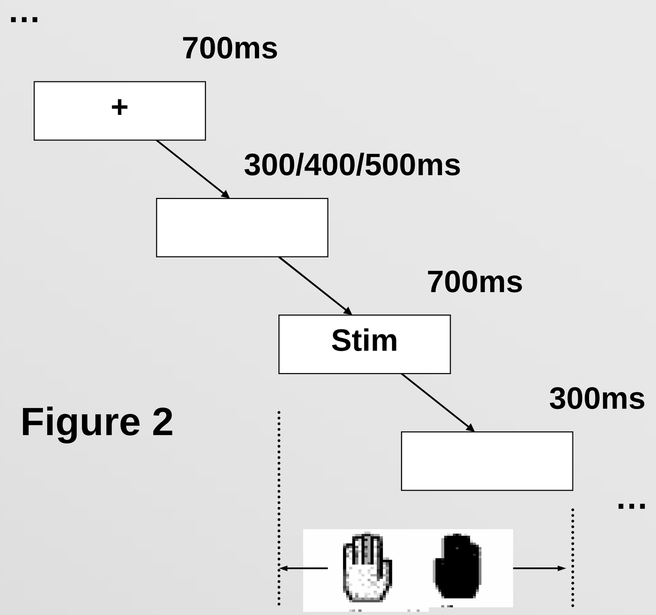


Figure 2

Results

Behavioral Data: Hierarchical regression analyses were performed on reaction time (RT) in separate for words and pseudowords

For words:

Step 1. Freq √
Step 2. Neigh x
Step 3. Freq*Neigh x
Step 4. Total Freq x

➡ Only word frequency was a significant predictor for RT, (F (1,16) = 105.4, p<.001), accounting for 86.8% variance. (Figure 3)

For Pseudowords:

Step 1. Neigh √
Step 2. Total Freq x

➡ RT was predicted by the size of neighborhood (F (1, 16) =10.032, p = .006, accounting for 38.5% variance. (Figure 3).

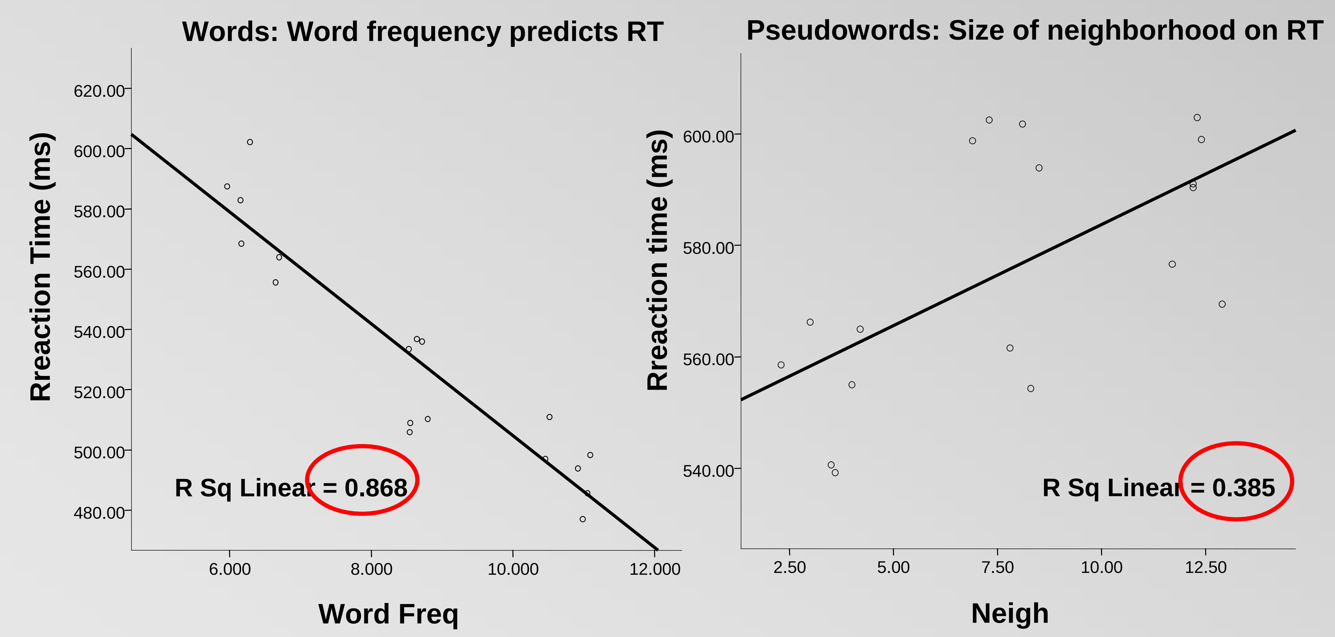
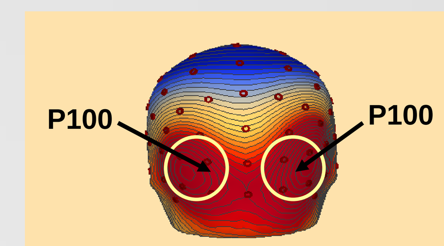


Figure 3. Reaction time: frequency effect for words and neighborhood effect for pseudowords

EEG Data: Hierarchical regression analyses were performed on P100 component in separate for words and pseudowords, and also in separate for left and right hemisphere.

Left P100:
Average of PO7, PO9, O9, O1
Right P100:
Average of PO8, PO10, O10, O2



Left hemisphere

For words:

Step 1. Freq √
Step 2. Neigh x
Step 3. Freq*Neigh x
Step 4. Total Freq x

➡ Word frequency was a significant predictor for P100 (F (1,16) = 5.2, p = .037), accounting for 24.4% variance. (Figure 4)

For pseudowords:

Step 1. Neigh x
Step 2. Total Freq x

➡ None (Figure 5)

Right hemisphere

For words:

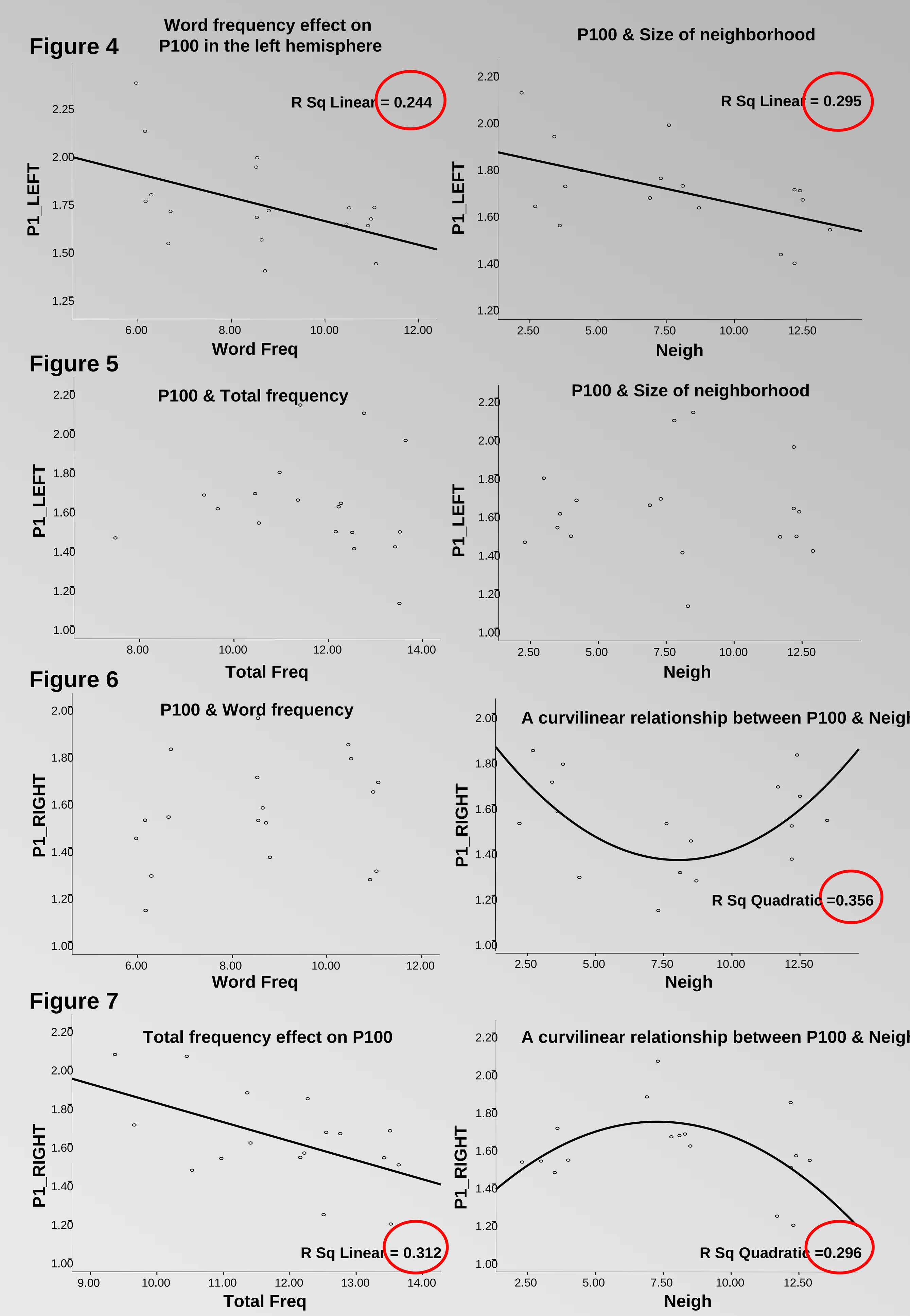
Step 1. Freq x
Step 2. Neigh x
Step 3. Freq*Neigh x
Step 4. Neigh*Neigh √
Step 5. Total Freq x

➡ A curvilinear relationship between neighborhood and P100 (F (1, 12) = 9.6 p = .009), accounting for 35% variance. (Figure 6)

For pseudowords:

Step 1. Neigh
Step 2. Total Freq √
Step 3. Neigh*Neigh √

➡ A curvilinear relationship between neighborhood and P100 (F (1, 13) = 5.6, p = .034), accounting for 20% variance.
Total frequency effect (F (1, 14) = 4.2, p = .059), accounting for 20% variance (Figure 7)



Conclusions

(1) Neural activities of early sensory/perceptual processing of visual word stimuli can be influenced by higher-order features (e.g., orthographic relationships) and are correlated with visual experience of those features.

(2) They are highly specific, taking into account of both a word itself and its neighbours. One consequence of such highly specific visual analyses is that in spite of being extraordinarily similar, words and pseudowords can be differentiated by 100ms, purely based on their orthographic features. Subsequently, words and pseudowords might be processed differently in the brain.

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Poster downloadable after the conference at http://www.psyc.brocku.ca/people/segalowitz.htm