The role of visual familiarity on the relation between word frequency and laterality in a lexical decision task

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The word frequency effect, in which high frequency words are identified more efficiently than low frequency words, is a common finding in the word recognition literature (Monsell, 1991). A number of models have been proposed to account for this effect (see Monsell, 1991), but most of them would not predict laterality differences in the processing of low and high frequency words.

Nevertheless, at least one account of the word frequency effect has implications for models of laterality. Besner and Johnston (1989), among others, suggested that the frequency effect observed in lexical decision is due in part to a familiarity assessment process. Based on this notion, it is plausible to speculate that familiarity assessment is simplified with high frequency words (becoming a simple case of visual familiarity), and for this reason, lexical access is not necessary. For low frequency words, a visual familiarity assessment is not sufficient for lexical decision, and lexical access is required.

It is plausible to believe that the assessment of visual familiarity for high frequency words is based on a representation of the physical features of letter strings. From this perspective, visual familiarity assessment resembles a visual-spatial perception task, which requires an involvement of the right cerebral hemisphere (Iaccino, 1993). For low frequency words, lexical access (search through the lexicon to “see” if the letter string is present) is also required. Given the overwhelming evidence that verbal material produces a left hemisphere advantage, we must assume that the lexicon is located in that hemisphere.

These speculations suggest that when a high frequency word is presented to the left visual field (right hemisphere) processing should be quick and accurate. However, when a low frequency word is presented to the right hemisphere, visual familiarity assessment is not sufficient and the information must be transferred to the left hemisphere before a decision can be made. This makes decisions to low frequency words slower and less accurate than those for high-frequency words in the right hemisphere. Thus, left visual field presentation should result in a significant word frequency effect. In contrast, right visual field (left hemisphere) presentation of low and high frequency words should give direct access to the lexicon for both types of words. Therefore, no word frequency effect should be observed for left hemisphere presentation. These predictions were confirmed by Voyer & MacDonald (1997). Specifically, these authors showed that the expected high frequency word advantage was obtained for right hemisphere presentations but not for left hemisphere presentations.

The purpose of the present study was to manipulate visual familiarity in such a way that its role is minimized in the word / non-word decision. According to Besner and Johnston (1989), one easy way to reduce the influence of this factor is to use case alternation (as in “cAsE”, for example). The reasoning behind the use of this manipulation is that when reading in an everyday situation, we typically see words that are all written in the same case (uppercase or lowercase). This means that most readers have no experience reading case alternated words. Based on this fact, it is plausible to believe that such a manipulation reduces the familiarity of any word, regardless of its frequency. If this is the case and we assume once more that the right hemisphere is the locus of the word frequency effect because of the visual familiarity assessment process, the manipulation of case alternation leads to a number of predictions in a lexical decision task. The first prediction is that performance will be better for normal words compared to case-alternated words. The second prediction states that the typical word frequency effect will be observed. The next two predictions will only be confirmed if the model proposed is correct. Thus, according to the third hypothesis, high frequency words will produce a better performance only for the right hemisphere when letter strings are presented in normal case. The fourth prediction is that the word
frequency effect will be non-significant in both the right and left hemisphere for case-alternated words. This is because visual familiarity assessment will not be available for the discrimination of stimuli and both low and high frequency words will require lexical access.

**Method**

**Participants:**
- Forty-eight undergraduate students (24 males, 24 females)
- All right-handed according to the Waterloo Handedness Questionnaire (Steenhuis & Bryden, 1989)
- All with normal or corrected-to-normal vision and English as their native language

**Materials:**
- Thirteen low and 12 high frequency regular four letter words used in the lexical decision task of Exp. 4 by Seidenberg, Waters, Barnes, and Tanenhaus (1984) were utilized
- Nonwords were created by changing the first letter of the words
- Words were presented either in a normal uppercase form or in a case alternated form, starting with the first letter (i.e., wOrD)
- Stimuli were 3° of visual angle long by 0.8° high and were presented 3° away to the left or right of the central fixation cross
- Stimuli were presented by means of a Gateway 2000 microcomputer on a Gateway Crystal Scan 1024ni screen
- A program created with the MEL package (Schneider, 1993) was used to pace the presentation of stimuli and record responses

**Procedure:**
- Participants were seated 57 cm away from the computer screen.
- Half the participants were instructed to press the “1” key on the computer keyboard when the letter string formed an English word, and the “0” key when it did not. The other half used the opposite key arrangement.
- At the start of each trial, a warning signal (“GET READY”) was presented at the center of the screen for 500 ms, followed by a central fixation cross subtending 0.3° for 500 ms. A letter string was then presented randomly to the left or right visual field for 150 ms along with the fixation cross. The fixation cross remained until response.
- Participants were given 24 practice trials followed by 200 experimental trials (25 normal words, 25 case-alternated words, 25 normal nonwords, and 25 case-alternated nonwords seen once in each visual field).

**Results**
- A mixed design analysis of variance with visual field (left, right), case alternation, and word frequency (low, high) as within-subjects variables, and gender as a between-subjects variable, was computed.
- Sensitivity to the presence of a word (d’) was the dependent variable.
- Main effect of case alternation, $F(1,46) = 34.25, p < .01$.
  - Participants were more sensitive to the presence of a word for normal words ($M = 2.95$) than for case-alternated words ($M = 2.53$).
• Main effect of word frequency, $F(1,46) = 7.96, p < .01$.
  o Participants were more sensitive to the presence of high frequency words ($M = 2.84$) compared to low frequency words ($M = 2.62$).
• Case alternation by visual field by word frequency interaction, $F(1,46) = 4.51, p < .05$.
• In normal case, the word frequency effect achieved significance in the left visual field (right hemisphere), $F(1,46) = 4.23, p < .05$, but not in the right visual field (left hemisphere), $F(1,46) < 1$ (see Figure 1).
• In the case-alternated condition, the word frequency effect was significant for right visual field presentations, $F(1,46) = 13.63, p < .01$, but not for left visual field presentations, $F(1,46) = 1.86$ (see Figure 2).

**Discussion**

While replication of the word frequency effect is of interest, the working hypothesis for the present study was that the Voyer & MacDonald (1997) findings would be replicated in the normal case condition, whereas the word frequency effect would be eliminated in the case-alternation condition. This hypothesis was partially confirmed. Specifically, as was found by Voyer & MacDonald, the typical word frequency effect was obtained only for right hemisphere presentations in the normal case condition. In addition, the word frequency effect was not significant for right hemisphere presentations in the alternated case condition, as predicted. However, the word frequency effect achieved significance for left hemisphere presentation in the case alternated condition, contrary to expectations.

The present study thus provides some support for the notion that the cerebral hemispheres handle word frequency differently. The hypothesis proposed here suggests that the word frequency effect generally reported in the literature is due to right hemisphere mechanisms. However, it still leaves many questions unanswered. For instance, why does, contrary to expectations, the word frequency effect achieve significance for left hemisphere presentations in the case-alternated condition? This finding cannot be explained plausibly with the available data. Nevertheless, it is possible to speculate that the case-alternated low frequency words were so difficult to process that they produced the lowest sensitivity. Another possibility is that those words could not be processed by the left hemisphere and they were transferred to the right hemisphere for visual familiarity assessment. Unfortunately, if this explanation were correct, one would expect a reversed word frequency effect for the right hemisphere presentation of case-alternated low frequency words. This was not the case. It thus appears that the present study does not provide the data required to explain this finding. Further research is required to determine its origin. For example, one might consider using stimulus degradation in the normal case presentation condition. This manipulation would likely decrease sensitivity for low frequency words at the level observed for case-alternated words. A significant word frequency effect for left hemisphere presentations with degraded stimuli would support an interpretation in terms of task difficulty.

**References**


