Visual and phonology in reading: An examination of the role of homophonic words in response and decision times

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Reading words and understanding sentences presented in printed words have caused conflicting debate. The study investigated the role of homophones and frequency on understanding the written word. Results have shown that high frequency homophones took longer to process for meaning than correctly spelled words. Spellings and frequency interacted to cause a delay in meaning processing if frequency was high. Phonology and orthography played a part in meaning processing facilitating or interfering.

Keywords: homophone, phonology, frequency, orthography, lexicon

INTRODUCTION

Debate has emerged recently over the nature of information a reader can extract from a printed word for its meaning. Reading researchers have debated as to whether phonology contributed to the activation of meaning during printed word recognition. Research results have shown that readers have an internal storage of words called the lexicon which records every word as a lexical entry separately for the following information: meaning, spelling and pronunciation. Every reader needs to access the information in the internal dictionary first before he/she can decipher. The process of reading and accessing meaning involves (a) translation of the visual information of the printed word into its corresponding phonological representation which will be used to gain access to the word’s lexical entry (Gough,1972; Rubenstein, Lewis and Rubenstein, 1971).

Some research also demonstrated that a reader could gain access to the internal dictionary directly without any need for phonological recoding of the printed word by means visual representation. This view was supported by Baron (1973); Bower (1970) and Kolers (1970).

According to Schvaneveldt and Rudy (1974a) visual and phonological representations could be used simultaneously in what has come to be known as the dual model, part of the ‘race’ model or the ‘co-operation’ model by Coltheart, Davelaar, Jonasson and Besner (1977).

Experimental studies that yielded the results were sometimes inappropriate hence the need for caution. For example, tasks such as same-different judgments, rhyming judgments and naming latency experiments did not need use of lexical knowledge. Data from such studies could not be used to support any argument about response times.

However, lexical decision tasks that could discriminate English words from non-English were not a valid approach. It requires one to access the store of English words required in the natural internal lexicon to check their availability. For this to happen, English orthography was necessary. The decision making process takes time.

Controversial results suggested that more research was needed to clarify issues about reading.

Further research on response and decision times generated conflicting results. For example, Rubenstein et al (1971) tested participants on response and decision time on homophones and non-homophones. Results showed that participants took longer to decide and respond that homophones were words and to reject pseudo homophones. Rubenstein and colleagues (1971) concluded that lexicon access code was a phonological one and that the dual route would resolve the problem of access. Re-coding of letters into phonological representation and subsequent use to search in the
internal lexicon delayed the response. Rubenstein and others used the search process from high to low frequency items. Failure to find an entry led to a prolonged search hence more time was taken for non-words or pseudo homophones. Low frequency homophones took much longer to access than high frequency. Davelaar (1978) and Coltheart (1977) on the other hand reported that high frequency homophones did not differ from their controls and that low frequency members were slower to access than real words. According to Meyer et al (1974) and Fleming (1993) on phonological mediation hypothesis argued that re-coding and prior lexical access were necessary for accessing word meanings while Frederiksen and Kroll (1976) concluded that such re-coding was unnecessary. On the other hand, orthography fulfilled the requirement for direct access hypothesis.

However, Schvaneveldt and Gomez who used similar stimuli in a replicated experiment concluded otherwise. The above discussion has demonstrated that spellings and frequency were likely to impact on the overall rate of reading and understanding of sentences. Either re-coding the visual to phonology or interference might have contributed to a slower response. Consequently, the study also investigated the interaction between spelling and frequency by considering the hypothesis: Replacement of original words by higher frequency homophones made accessing meanings slower than the original.

Fleming (1993) in a study of homophones concluded that homophone primes such as dough and doe were made ambiguous and more difficult to understand meaning through auditory presentation (/do/) compared with homophone primes made unambiguous through visual presentation. In view of the above background the current study investigated the hypotheses:
(a). Homophonic sentences will take longer to understand than correctly spelt sentences.
(b). Sentences with low frequency words will take longer to understand than sentences with high frequency words.
(c). There was an interaction between spellings and word frequency such that high frequency homophonic words slowed understanding of sentence meanings more than original words.

**METHOD**
**Design**
This was a within-participant experimental research design in which participants were presented with 40 original sentences, of which 20 (10 in high frequency in the original version) and another 10 higher frequency homophones in the incorrect version were correctly spelt and twenty with substituted homophones of high and low frequency. The sentences were matched for number of words and homophones. Sentences were displayed on the computer in random order but in every 10 half the sentences were made true or reasonable while the respond true or false to each. Time between display and respond true or false to each. Time between display and response was timed to determine how long the participant took to respond to each. On the whole every participant was exposed to correct and homophonic versions of A and B.

**Participants**
DD303 psychology students from Regions 4 and 8 born between January and June (Homophones Jan_Jun) participated as part of their TMA02 assignment. They were all aware of what they were doing and the role of each was explained fully in the Project Booklet 2.

**Materials**
The experiment made use of 40 sentences rich in homophones. Half of the sentences comprised key and correct homophones of high frequency and the other half lower frequency and incorrectly spelled. The other half, were lower frequency in the original and high for the wrong spellings. Half of the sentences were true and the rest false.

**Apparatus**
Participants were equipped with Project Booklet for DD303 which provided the guidelines for the experiment. A Personal Computer (PC) for the display of sentence stimuli and data processing were made available.

**Procedure**
OUDD303 Psychology students were sampled by month of birth. This experiment is for the homophone Jan_Jun. The experiment was down loaded from the purposely designed DD303 Experimental Participation Website (EPW) following the guidelines. Participants ran the experiment and uploaded the results file. Datasets for all participants in each group were combined to form a single dataset for the Region 4 downloaded and merged with dataset from Region 8 (my choice). This was analysed using SPSS for analysis of variance (ANOVA). Statistical test results were interpreted to test the hypotheses (a), (b) and (c). Results are presented in the following section.

**RESULTS**
The study assessed the differences in (a) reading and understanding times between correctly spelt words and their homophonic versions, and (b) the impact of word frequency on reading times and understanding. The results are shown in table 1 and figure 1. Results showed that homophones of high frequency needed more time than original words. Frequency had a low impact on understanding. A flat graph line is an indicator of the result. The practice session was followed by the main experiment involving 117 participants in a within-participant experiment.

The main study sought to find answers to the following hypotheses:
- Homophonic sentences would take longer to understand than correctly spelt words.
Analysis name: Homophones and Frequency
Column conditions: Freq
Row conditions: type
Statistics: TrialText.RT:Mean
Filters: TrialText.ACC: = 1;
Data file: homophones jan
File does not have data alterations.

Table1: Mean by type and Freq

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<th>Type</th>
<th>Mean trial text. RT</th>
<th>Mean trial text. RT</th>
</tr>
</thead>
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<td></td>
</tr>
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</tr>
<tr>
<td>O</td>
<td>3902.90</td>
<td>5285.85</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Mean by type and Freq

- Sentences with low frequent words would take longer to understand than sentences with high frequency words. Here would be an interaction between spelling and frequency.

Participants were rated for their response times to forty statements comprising homophones and correctly spelled words of either high or low frequency. The same participants responded to the two conditions in the experiment hence it was a within experiment. Each of the two conditions had two levels of analysis namely, Type/spelling: homophone or correct; frequency: high or low. Response or decision times were analysed using a repeated measures (within-participants) ANOVA with spelling and frequency as the main independent variables (IVs). The analyses revealed significant main effects of spelling \( F=138.181, \text{df}=116, p<0.0001 \) and frequency \( F=166.056, \text{df}=116, p<0.0001 \). As predicted, statistical means revealed that low frequency homophones required more time (7,811 secs) to understand than high frequency homophones (5,423 secs) and original and high frequency words (3,939 secs). High frequency homophones had a lower response time of (5,338 secs). There was also a significant interaction between the two IVs \( F=9.789, \text{df}=116, p<0.0001 \). Interaction was measured using pair-wise tests which compared response times for every participant separately. It was revealed that homophones had a greater impact on reading speed and decision time to understand sentences than word frequency. Their combined effect increased the amount of time required to process word meanings Figure 1.
DISCUSSION
Results have shown that processing high frequency homophones was more difficult than low frequency. Accessing meaning required translation into the phonological format before a decision was made about the meaning. In other cases trying to understand the context of the sentence in which the homophones were used delayed decision making when the visual could not allow direct access to the meaning, for example, 'Stalks are bread for their meet in parts of grease.' Results supported Fleming's (1993) 'phonological mediation hypothesis' which states that phonology contributed to the activation of meaning during printed word recognition but contradict the direct access hypothesis. Understanding of meanings can be made easier without the visual as in the example cited. Thus, the visual acts as a hindrance to understanding meanings because lexical storage has various meanings hence the need to search for the more appropriate one. Multiple meanings of words like 'stalks,' required the reader to search more for the more appropriate meaning according to context (Meyer, Schvaneveldt and Ruddy, 1974b). The same applies to wrongly spelled words in a given sentence, 'meet' for 'meat,' 'bread' for 'bred' and grease for 'Greece.' Such misspellings delayed meaning processing considerably due to the need to check and re-check spellings. They prevent direct access to sentence meanings. Results confirm findings by Coltheart (1977, 2001). In addition error rates and participants' orthographic and English language knowledge of spelling to meaning might have contributed to slow response times for homophones supporting Starr and Fleming (2001). Thus, homophone confusion error may be the cause rather than phonology.

Original high frequency words had the shortest response times mainly because there was direct access to meanings of words and sentences. On the other hand, low frequency original words took slightly more time owing to the need to search for appropriate meaning but almost same as low frequency homophones because orthography allowed more direct access to sentence meanings. Repetition of some sentences primed meanings leading to shorter response times in agreement with Scarborough et al (1971) on repletion effects.

An analysis of interactions showed that homophones and frequency have an impact on understanding meanings. High frequency homophones caused more confusion and disruptions to sentences hence greater impact on meaning.

REFERENCES

Department of Psychology, University of Reading, England.