Making Reading Easier: The Influence of Vowelization in a Deep Language Orthography on Online Text Comprehension

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Abstract. The purpose of this study is to examine whether online text vowelization of words in context facilitates reading in Hebrew, which is a deep orthography language. The study compares the effect of vowelization on reading among native and non-native Hebrew speakers. Participants will perform a self-paced reading - cumulative presentation (Marinis, 2003) task, that includes a 2 (voweled/nonvoweled) X 2 (homographs/unambiguous words) X 2 (location of words: beginning or middle/end of sentence) design. Results indicated that vowelization does not facilitate reaction times of homographs for both Hebrew and non-Hebrew speakers. The results are discussed in relation to precious studies and the participants' characteristics.

1 Introduction

The rapid growth in present-day communication technologies has led to an accelerating shift in reading habits, from print to digital-online. Due to design and usability constraints that involve online reading, such as hyperlinks, scrolling and line-length, it is of great importance to improve readability and accessibility of online information, particularly (1) in deep orthography languages, which often lack correspondence between letters and sounds (Frost, Katz & Bentin, 1987); (2) in countries where multiple languages are spoken; and (3) for people with reading disabilities. The Hebrew language is an ancient deep-orthography language that uses a punctuation system (diacritical marks) which provides vowel information to improve readability and comprehension, especially for low-frequency words (Koriat, 1994; Frost, Bentin & Katz, 1987), borrowed words (Birnboim & Share, 1995), and words that are ambiguous without vowels: the same sequence of letters produces two different pronunciations and meanings (Frost, 1995). Vowelization is most important for children at the early stages of learning Hebrew (Shimron, 1993), for non-native Hebrew speakers, for individuals with reading difficulties (Gvion & Friedmann, 2001, Birnboim & Share, 1995), and when reading under time constraints. To date, most studies have tested the readability of single words. The effect of vowelization on the readability of words in context has not been tested or standardized.

The present study examines the effect of online text vowelization of Hebrew words in context on reading among native Hebrew speakers and speakers of Hebrew as a second language. Results will facilitate the determination of criteria for vowelization to improve online reading. In a country that unites individuals with various language backgrounds (i.e. Arab-Israelis, immigrants from Russia and other countries) and that stands at the forefront of technology, it is most important to create a readable, accessible and thus usable computerized environment. The characteristics of the Hebrew language enable us to examine the conditions under which vowelization may contribute to the minimization of on-line reading errors, which will allow creating such a computerized environment.

2 Literature Review

2.1 Hebrew Orthography

Most Hebrew texts today, both online and in print, are unvoweled. Voweled texts are used to facilitate reading, mainly in children's books, poetry, prayer books, and sacred scriptures. In special cases, it is common to vowel selected letters or words even in unvoweled texts. The major means of delivering vowel information in voweled words is by using diacritical marks – dots and minor strokes – placed below, inside or above the letters. In its unvoweled form, Hebrew is considered a "deep orthography" language. In deep orthography, the relation between spelling and sound is more opaque and letters may represent different phonemes in different contexts; moreover, different letters may represent the same phoneme (Frost, Katz, & Bentin, 1987).

2.2 Vowelization and reading comprehension

Navon and Shimron (1981, 1985), and Shimron and Navon (1982) studied the effect of vowelization in the recognition of words. They compared naming latencies of vowelized words, unvowelized words, and words printed in irregular vowelization in which the correct vowel signs were replaced by incorrect signs. They found that both children and adults read vowelized words significantly faster than the unvowelized ones. This effect, however, decreased and became insignificant when context was added (Navon & Shimron, 1985).

Koriat (1984) examined whether vowelization aids word recognition using a lexical decision task. The assumption was that if phonological recoding is a necessary precursor to lexical access, vowelization should improve readability since it reduces phonological ambiguity. He found that vowelization, used as a between-subject factor, has little effect on response latency. Later, Koriat (1985) examined the influence of vowelization on reading low-frequency words. He found that reading time decreased when context was provided; however, it affected both voweled and unvoweled words. His conclusion was that the effect of context was additive to the effect of vowelization. Similar findings were obtained by Bentin and Frost (1987); however, the findings of the naming task were controversial. Thus, they concluded that for fluent Hebrew speakers, the contribution of vowel signs in providing phonological information is limited. This claim was supported by Shimron (1993) in his review of studies of the role of vowels in reading.

In a series of experiments, Frost (1995) measured naming latencies for high and low frequency unvoweled words and for words having a large or a small number of vowels not represented by letters. He found a positive correlation between the number of unrepresented vowels in a word and the length of the naming latencies, suggesting that vowelization facilitates reading of phonologically ambiguous words. More recently, Shimron (1999) found that vowel signs speed up recognition memory of words, and improve recall of words printed in the context of mixed lists. Abu-Rabia (2001) found a significant positive effect of vowelization on the Hebrew readability of non-native Hebrew speakers.

The literature review indicates that most studies tested the influence of vowelization on readability of single words only. However, the effect of vowelization on the readability of words in context has not been tested or standardized. The research literature suggests that the effect of vowelization on readability is still ambiguous and that the question of whether and under which circumstances vowelization facilitates reading latencies is still open. The purpose of this study is to examine the effect of online text vowelization of words in context on different kinds of readers of a language with deep orthography, using Hebrew as an example. The study focuses on homographic words – words that have more than one meaning in their unvoweled version. To date, no systematic study has examined the above questions by means of on-line reading techniques.

2.3 Hypothesis

Our hypothesis is that vowels will shorten reading latencies, especially in the case of low frequency words at the beginning of sentences (no context information). We expect this effect to be greater for non-native Hebrew speakers compared to native speakers. Although reading voweled words may involve more information processing, we do not expect it to be more time consuming. This hypothesis relies on Shimron's (1993) notion that "the activation of different sets of orthographic detectors may be performed in parallel, and [that] because of the interactive nature of the word-recognition process, there will often be an advantage to a multisource input" (p. 64).

2.4 Importance of the study

The study will contribute to our understanding of the impact of vowelization on readability, and provide guidelines for vowelization of online and offline texts. Results will also be helpful in facilitating reading of other deep languages, such as Vietnamese and Chinese that incorporate tones in their phonology to distinguish words.

3 Method

3.1 Participants*:* 44 students at the Open University of Israel participated in the study as part of their requirements for a B.A. in Psychology. Participants included native Hebrew speakers (N=32) and speakers of Hebrew as a second language (N=12).

3.2 Tasks:

3.2.1 Computerized task: Participants performed a self-paced reading - noncumulative presentation task (Marinis, 2003), using a computer to present the stimuli.

Stimuli: Words will be printed in a san serif digital 12-point Arial font, and will be presented in their proper location in the sentence on the computer screen. Font-type and size selection were made according to most suitable characteristics for online reading (Shneiderman, 1998). The design includes 2 (voweled/nonvoweled) X 2 (homographs/unambiguous words) X 2 (location of words: beginning, middle/end of sentence) creating 8 possible conditions.

Procedure: A series of sentence segments, composed of one word or more, will be projected on the screen, controlled by the participants. After the entire sentence is projected, participants will receive a comprehension question that tests their understanding of the sentence and the words. Participants will be instructed to read each word at a natural pace and to respond to the comprehension question as accurately as possible. The sentences will be presented in random order. The task will consist of one block of 160 trials (80 sentences with ambiguous words and 80 sentences used as fillers), half of which will be voweled. Prior to the beginning of the experiment, subjects will be given instructions and eight practice trials in which feedback on their performance will be given. Response times (RT) for reading each segment and the complete sentence will be recorded as well as accuracy of the responses to the comprehension questions.

3.2.2 Demographic questionnaire: In order to collect data on participants' language and reading skills, a demographic questionnaire will be distributed.
The tasks will be administered during one session at the Open University of Israel Psychology Lab.

4 Preliminary Results:

4.1 Accuracy:
No subjects were excluded from the analysis since accuracy rates were high.
Table 1 shows mean accuracy for all subjects in the verification sentence.

Table 1 - Mean accuracy for the verification sentence (N=44)

	Mean ACC (%)	**Stdv**
CHBN	85.2	.076
CHBY	83.9	.097
CHEN	93	.086
CHEY	95	.079
CLBN	86.8	.107
CLBY	88.2	.092
CLEN	92	.089
CLEY	93	.085
EHBN	93	.098
EHBY	91	.107
EHEN	84.8	.102
EHEY	85.2	.093
ELBN	86.6	.109
ELBY	86.6	.104
ELEN	86.4	.116
ELEY	86.4	.1036

C/E - Control vs. Experiment condition
H/L - High vs. Low frequency word
B/E - target word at the beginning vs. End of sentence
Y/N - Vowelization - yes or no

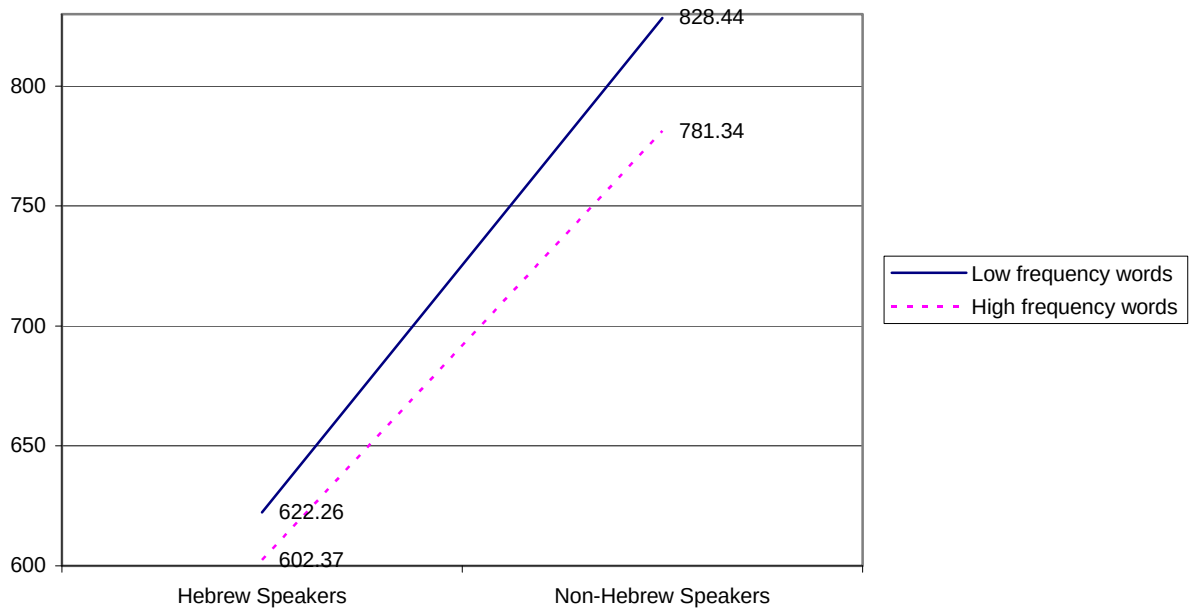
A 2 (control/experiment) X 2 (voweled/nonvoweled) X 2 (homographs/unambiguous words) X 2 (location of words: beginning or middle/end of sentence) ANOVA (repeated measures) was calculated to examine between subjects and within subjects differences in the task's performance.
Results from this analysis revealed main effect for condition: Control sentences were read more accurately than experiment sentences (89.7% vs. 87.5, respectively; $F(1,43)=9.175$, $p=.004$). Main effect for location of target word was also found: sentences with target word at the end were read more accurately than sentences with target words at the beginning (89.5% vs. 87.7, respectively; $F(1,43)=5.322$, $p=.025$). Main effect for group was also found: Non-Hebrew speakers were less accurate compared to Hebrew speakers (90.1% vs. 84.5, respectively; $F(1,42)=12.8$, $p=.001$).
Although main effects in accuracy rates were found, as seen from table 1 differences are minimal and both group's accuracy rates were high, namely, all participant read and understood the target sentences and responded correctly on the verification sentences.

4.2 Reaction Times

Data analysis: Only trials in which accuracy was 100% were included in the RT analysis. Trials in which response times were faster than 200 msec and slower than 2000 msec (2 sec) were removed from the analysis. Analysis included control and experiment sentences.

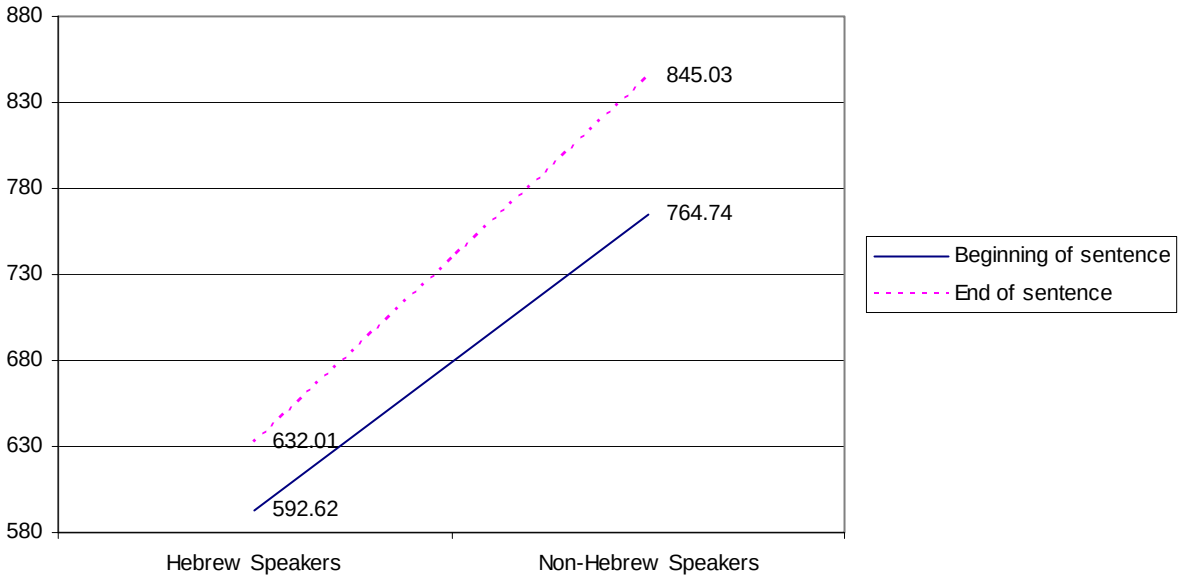
A 2 (control/experiment) X 2 (voweled/nonvoweled) X 2 (homographs/unambiguous words) X 2 (location of words: beginning or middle/end of sentence) ANOVA (repeated measures) was calculated to examine between subjects and within subjects differences in the task's performance.
Results from this analysis revealed a marginal effect for condition: control sentences were read somewhat faster than experiment sentences (703.66msec vs. 713.54, respectively; F(1,42)=4.204, p=.047). Main effect for frequency was also found: sentences which contained high frequency words were read faster than low frequency words (691.86msec vs. 725.35, respectively; F(1,42)=29.14, p=.000). An interaction between frequency and group (mother tongue) was also found (fig 1): The difference in RT between high and low frequency words was larger for non-Hebrew speakers F(1,42)=4.81, p=.034).

Fig 1: Interaction between Group and Frequency of words



Main effect for location was also found; when target words were located at the beginning of the sentence, the sentence was read faster than when they were located at the middle or end of the sentence (678.69 msec vs. 738.52, respectively; F(1,42)=83.181, p=.000). An interaction between location and group (mother tongue) was also found (fig 2): The difference in RT between sentences in which target words were presented at the end and at the beginning was larger for non-Hebrew speakers (F(1,42)=9.718, p=.003).

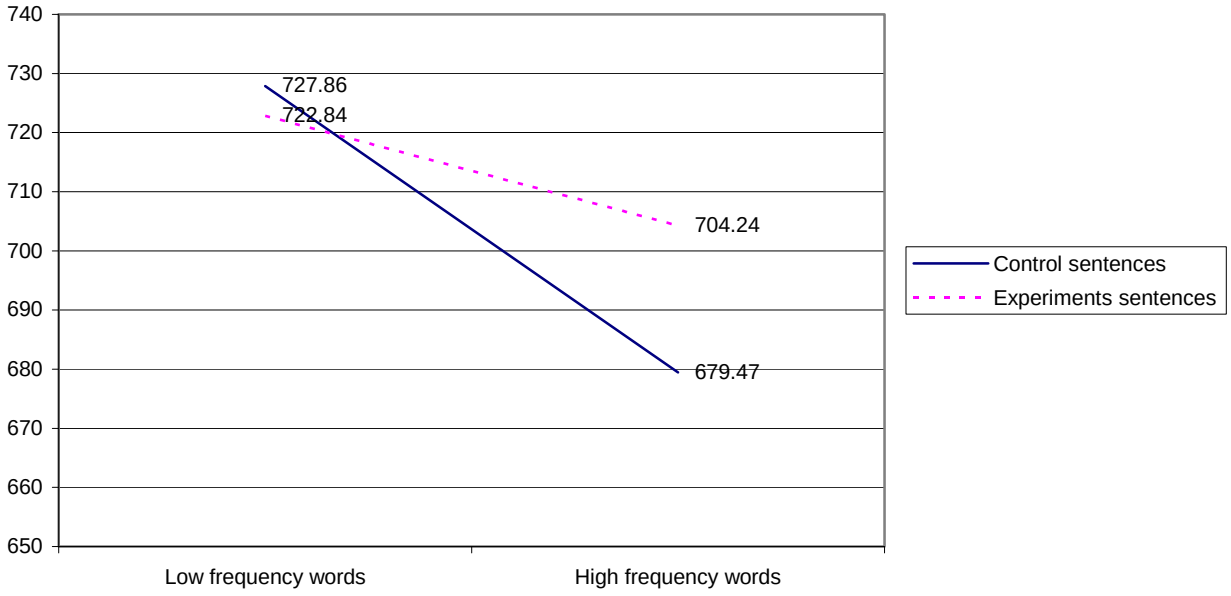
Fig 2: Interaction between Group and Location



Marginal effect for vowelization was also found; non-vowelized target words were read faster than vowelized target words (701.98 msec vs. 715.22, respectively; F(1,42)=4.393, p=.042). No interaction between group and vowelization was found.

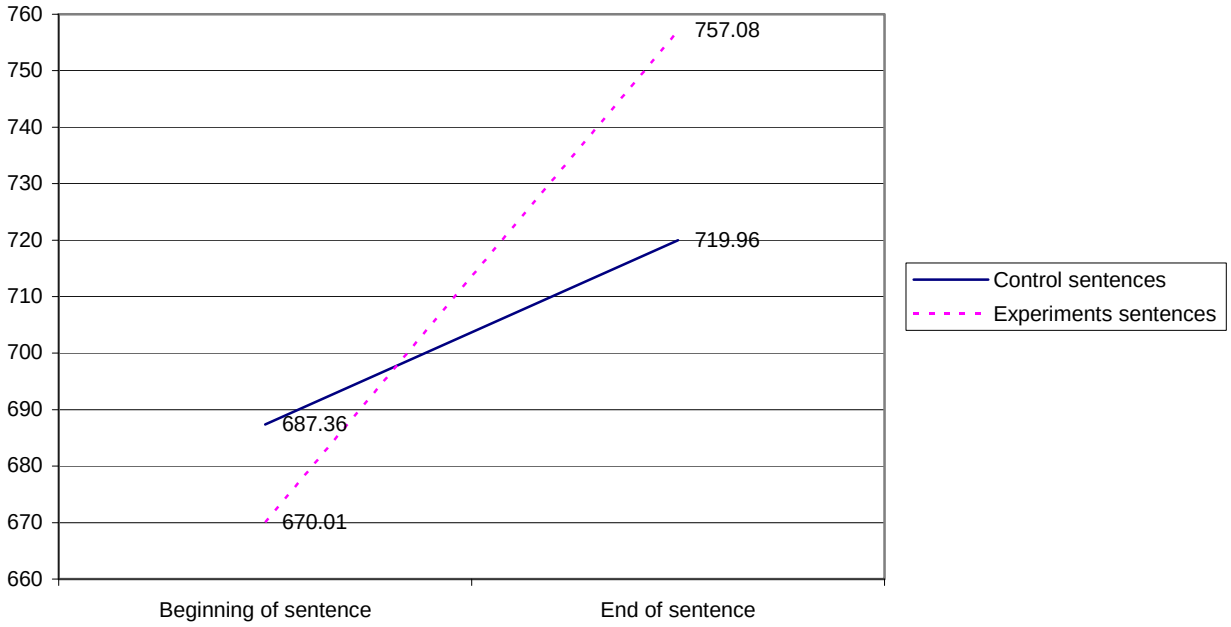
An interaction between condition and frequency was found: (fig 3): The difference in RT between high and low frequency words in the control sentences was lager than in the experiment sentences (F(1,42)=8.002, p=.007).

Fig 3: Interaction between Condition and Frequency



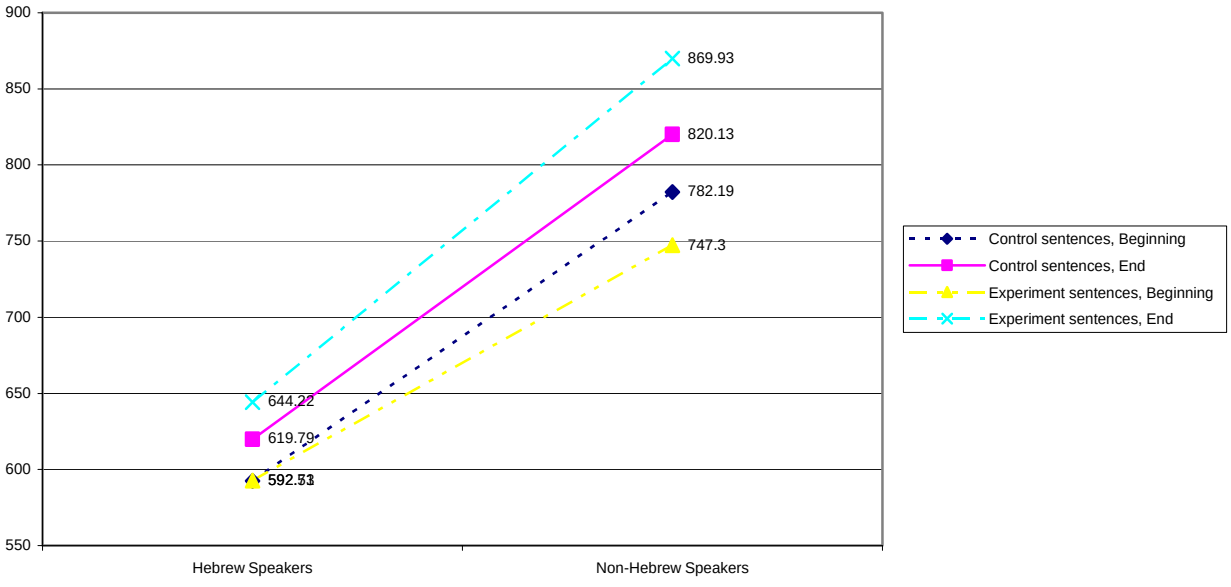
An interaction between condition and location was also found: (fig 4): the location of target word in a sentence had a differential effect on RTs of control and experiment sentences and when target word was presented at the beginning of the sentence it affected less RTs for both Hebrew speakers and non-Hebrew speakers (F(1,42)=20.208, p=.000).

Fig 4: Interaction between Condition and Location



In addition, a triple interaction between condition, location and group (mother tongue) was also found, as presented in Fig 5 (F(1,42)=6.219, p=.017). As can be seen, non-Hebrew speakers were less affected by the various conditions.

Interaction between Group, Condition and Location



5 Discussion

The purpose of this study was to explore the effect of online text vowelization of Hebrew words in context on reading among native Hebrew speakers and speakers of Hebrew as a second language. The main finding of the current study is that overall, vowelized words were read slower that unvowelized words, both for the Hebrew speakers and non-Hebrew speakers.

Other findings can be summarized as follows:
1. Both Hebrew and non-Hebrew speakers had high accuracy rates in the verification sentences, namely, they read and understood the sentences in the experiment.
2. Overall, non-Hebrew speakers are slower in reading Hebrew compared to Hebrew speakers.
3. High frequency words were read faster overall, however for the non-Hebrew speakers frequency of words affected reading latencies compared to Hebrew speakers.
4. Control sentences were read faster overall, however when target word was presented at the beginning of the sentence it affected less reading latencies for both Hebrew speakers and non-Hebrew speakers.
5. Target words at the end of the sentences were read faster than in the beginnings and this effect was larger for the non-Hebrew speakers.

Our main hypothesis was that vowels will shorten reading latencies, especially in the case of low frequency words at the beginning of sentences (no context information) and for non-native Hebrew speakers compared to native speakers. We did not find such an effect in the current study. We found that non-vowelized target words were read faster than vowelized target words both for Hebrew as well as non-Hebrew speakers. This finding supports Navon and Shimron's (1985) finding, in which the effect of vowelization on reading latencies decreased and became insignificant when context was added. In spite of the ambiguity in the research literature regarding the effect of vowelization on readability, the current finding supports Bentin and Frost's (1987) and Shimron (1993) notions regarding the aim of vowel signs in the Hebrew language. For fluent Hebrew speakers, Bentin and Frost's (1987) pinpointed that the contribution of vowel signs in providing phonological information is limited. Shimron (1993) pinpointed that the reading of the Hebrew alphabet is not impaired when vowel sounds are lacking. Nevertheless, this finding contradicts Abu-Rabia's (2001) findings of significant positive effect of vowelization on Hebrew readability of non-native Hebrew speakers.

Aiming at explaining the main result of the current study, we suggest several alternative explanations. First, he number of participants in each group was not equal (32 vs. 12 in the Hebrew and non-Hebrew speakers, respectively) which might affect effects' sizes. Secondly, among the 12 non-Hebrew speakers were 4 Arabic speakers who were born in Israel. The rest were from Russia and vicinity and all were more than 12 years in Israel. All were at least second-year students at the Open University of Israel and thus were familiar with unvowelized text in Hebrew. Thus, it might be that all participants were more familiar and had more encounters with unvowelized Hebrew text compared to vowelized text. Thirdly, target words were vowelized in all syllabi. It might be that too many vowels in a word create redundancy effect that causes interference in the reading process of the word. Thus, it might be that one vowelized syllable (or the minimal number of syllabi for distinguishing between the various reading alternative) would be not only sufficient for reading and understanding the word correctly, but also would facilitate reading and thus reading latencies would shorten. Finally, in order to conceal the purpose of the experiment from the participants, in each vowelized sentence we vowelized two additional words. Although these words were chosen based on their minimal syllabi and thus the minimal vowels needed, it might be that this supplement influenced subjects' responses and thus reading latencies were larger.

All other results of the current study are consistent with previous findings. As expected, non-Hebrew speakers have less years of experience with reading Hebrew and thus are slower in reading. In addition, low frequency words were read slower than high frequency words, compatible with previous findings (Frost, 1995). When target words were presented at the beginning of the sentence, reading latencies were slower as opposed to when they were located at the middle or end of sentence. This might be due to the fact that when approaching target words at the middle or end of sentence context is already available and influence the participant's expectations regarding the upcoming word. The effect of context on reading latencies was discussed by Navon and Shimron (1985).

5.1 Future Reserach

In relation to the groups' characteristics we believe that our future studies should include (1) larger group sizes, especially in the non-Hebrew speakers, (2) non-Hebrew speakers' immigrants (minimal exposure to unvowelized text in Hebrew), (3) young children in their first stages of learning how to read in Hebrew, (4) and individuals with dyslexia (Gvion and Friedmann, 2001). In relation to the structure of the experiment, target words should include only one vowelized syllable (or the minimal number of syllabi for distinguishing between the various reading alternative), and more consideration should be taken regarding the number of additional vowelized words in each vowelized sentence.

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