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ARTICLE

Resolving homography: The role of post-homograph context in reading aloud ambiguous sentences in Hebrew

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Abstract

This study examined whether the context immediately succeeding a heterophonic-homographic word (ht-homographic) plays a role in ambiguity resolution during voiced reading of Hebrew. A pretest was designed to find the preferred alternatives of 12 ht-homographic words: 20 adult subjects completed truncated sentences, each ending with a homographic word, preceded by a context allowing for both of its alternatives to be read. Following the pretest, each word was embedded in four research conditions determined by post-homographic context (keeping preceding context constant): two adjacent revealing contexts, one supporting the preferred alternative and the other the un-preferred alternative; and two distant revealing contexts, one supporting the preferred alternative and the other the un-preferred alternative. Four lists of 12 sentences, each including the four conditions, were then read aloud by four groups of 20 adults. Results from a generalized linear mixed-model analysis showed that the immediately succeeding context affected the deciphering of un-preferred alternatives in voiced reading. An item analysis further showed that highly preferred alternatives were less prone to the immediately succeeding context effect than slightly preferred alternatives. We conclude that the context immediately succeeding a ht-homographic word plays a role in ambiguity resolution during voiced reading, through interactions with the word's lexical and syntactic characteristics.

Keywords: ambiguity resolution; context effect; Hebrew; homography

Ambiguous words can make it difficult to understand spoken and written texts, but hearers and readers resolve most ambiguity rapidly and accurately (Tabossi & Sbisà, 2001). In many cases, ambiguous words are hardly noticed. The apparent effortlessness of ambiguity resolution is explained, among other things, by the role of context in reading (Duffy, Kambe, & Rayner, 2001; Faust & Chiarello, 1998; Lee & Federmeier, 2009; Peleg & Eviatar, 2012; Sereno, Brewer, & O'Donnell, 2003; Simpson, 1981; Tabossi, 1988; Tabossi, Colombo, & Job, 1987). As such, ambiguity resolution is commonly examined to reveal covert relations in the interplay between a word and its context in sentence processing (Tabossi & Sbisà, 2001). The role of

context in ambiguity resolution is particularly important when considering Semitic writing systems (such as Hebrew and Arabic), in which heterophonic-homographic words (ht-homographs) are abundant (Abu-Rabia, 2001; Shimron & Sivan, 1994). Ht-homographs are words that represent two or more phonological forms. The high frequency of such words in Hebrew texts requires readers to lean on context for accurate interpretation (Share & Bar-On, 2018). Research in this area has most often addressed the words preceding an ambiguous word, which are known to affect ambiguity resolution (Bar-On, Ravid, & Dattner, 2017). However, the words succeeding an ambiguous word are likely to play a role in its resolution as well. This is undoubtedly the case in written language, which enables the reader to gather information from the immediately succeeding context. The current study attempted to answer the succeeding context question in voiced reading, based on an examination of Hebrew ht-homographic words. By revealing potential effects of upcoming words, we aimed to expand our understanding of how Hebrew readers successfully handle the ambiguity-related opacity of Hebrew texts.

Lexical ambiguity resolution

Lexical ambiguity resolution is traditionally linked to two factors in the process of sentence comprehension (Folk & Morris, 1995; Onifer & Swinney, 1981; Simpson, 1984; Stites, Federmeier, & Stine-Morrow, 2013): the context of the lexical item and the frequencies of its alternative readings. Most current approaches to sentence processing support the presence of an interaction between context and frequency, which takes place in the early stages of processing. These views vary, however, with respect to the level and type of contribution made by the context, either as an arbiter, as proposed by the modular, generative approaches, or as an integral part of the process, as proposed by the interactive, probabilistic models.

Generative approaches to sentence processing assume a modular process in which comprehension is the result of many different modules working in a linear order (Frazier, 1987; Frazier & Rayner, 1982; Rayner, Carlson, & Frazier, 1983). The first stage includes automatic, rapid access to the most frequent interpretation of each word, and outputs information about its basic semantic-syntactic features. A temporary syntactic tree is built based on this information. In the second stage, context, pragmatics, and world knowledge reveal the relevant interpretation of the sentence, incrementally adjusting the proposed syntactic tree.

Nonmodular approaches, in contrast, assume that comprehension results from a simultaneous interaction between different levels of linguistic information (Altmann & Steedman, 1988). Elman (2009), for example, advocated a connectionist model of sentence processing, arguing for the early, critical role of lexically specific information in the interpretation of structure. Such models assume a probabilistic, single-stage process with an emphasis on expectations and context sensitivity. In this view, each word activates a complete scheme consisting of its idiosyncratic syntactic information, semantic features, pragmatic usage-conditions, and discursive usage-patterns, invoking probabilistic expectations for the next word (Elman, 2009; Lee & Federmeier, 2009; Perfetti, 2007). Such models are in accordance with cognitive linguistic tradition and with psycholinguistic research, which propose a rich lexicon composed of words and their syntactic, semantic, pragmatic,

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and discursive information (Baayen, 2007; Dattner, 2019). The enriched lexicon (i.e., the knowledge a reader/hearer has about any word) contributes not only to efficient comprehension of the word but also to the processing of other words in the sentence.

While the relationship between frequency and context may be either linear or simultaneous, the frequent alternative of an ambiguous word is always activated, even when the preceding context does not support it (Peleg, Giora, & Fein, 2004). That is, context can enhance activation of an appropriate (supported) alternative, but it cannot fully deactivate an inappropriate (unsupported) but frequent alternative (also see Leinenger & Rayner, 2013, for a case in which context overcomes frequency effects). However, many of the studies addressing sentence comprehension and lexical ambiguity resolution treat context as the part of the sentence preceding the word in question, which is traditionally the final word in the sentence (Ferreira & Henderson, 1990; Peleg & Eviatar, 2008, 2012; Sereno et al., 2003; Simpson, 1981). This line of research has not taken into account the words following the target. Nevertheless, it has been suggested that orthographic information is integrated across multiple words (Snell, Meeter, & Grainger, 2017; Snell, Vitu, & Grainger, 2017), suggesting that upcoming context can affect ambiguity resolution as well.

Lexical ambiguity resolution in reading: The role of succeeding context

Both hearing and reading involve an accumulated preceding context, which creates expectations for the next word, and ties its deciphering to context, frequency, and rich lexicon characteristics. However, in addressing the effects of succeeding context, we must distinguish between the two modes of comprehension. While the hearer inevitably hears the succeeding word (or at least its initiation) *after* the ambiguous word, the reader has the advantage of *simultaneously* processing the ambiguous word and extracting partial information from its successor. This is due to the nature of eye movements during reading (Rayner, 1998; Reichle, Pollatsek, Fisher, & Rayner, 1998). Reading progresses in short segments of text, with visual information extracted during fixations that take place between saccades. While visual acuity is at maximum efficiency in the center of the retina (Reichle, Rayner, & Pollatsek, 2003), many eye movement studies show that some characters of the word following a fixated word are processed during fixation in silent reading (Rayner, 1998). This phenomenon is most often studied in reference to effects of the fixated word (the foveal word) on the nonfixated word (the parafoveal word), defined as the foveal on parafoveal effect. Studies have also shown the opposite effect, in which partial processing of the parafoveal, nonfixated word affects processing of the foveal, fixated word, influencing its reading time (Kliegl, Nuthmann, & Engbert, 2006; Snell, Meeter, et al., 2017; Snell, Vitu, et al., 2017).

Most eye-tracking studies examining the relationship between foveal and parafoveal words have focused on silent reading, with only a few addressing voiced reading. While silent and voiced reading are governed by similar principles, key differences between them involve the gap between visual processing and an aspect of phonological production known as the *eye-voice span* (Laubrock & Kliegl, 2015). The eye-voice span, or the distance that the eye is ahead of the voice in reading

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aloud, is a dynamic measure associated with updates to the working memory buffer during reading. By examining ambiguity resolution in voiced reading, we can assess the effects of eye-voice span on ambiguous word processing: during preparation for phonological production in voiced reading, the eye is already fixated on the following word (Laubrock & Kliegl, 2015). Thus, if an ambiguous word is read in accordance with its succeeding context, we can conclude that information retrieved from the adjacent word during motor preparation affects phonological production. One way to examine this effect is through *garden path sentences*.

A garden path (GP) sentence is a linguistic phenomenon in which the reader is led down a path, only to reach a dead end (Ferreira, Christianson, & Hollingworth, 2001). Consider, for example, the sentence "*The horse raced past the barn fell*." Readers tend to interpret *the horse* as the subject of the active-voice verb *raced*; when the reading process continues and they encounter another verb, *fell*, they realize that their preliminary interpretation was wrong, and reanalyze *raced* as a passive-voice verb (Slattery, Sturt, Christianson, Yoshida, & Ferreirae, 2013). The GP phenomenon sheds light on the various processes involved in evoking interpretation, such as the cumulative effect of context and monitoring and reanalysis processes. Using GP sentences, Bar-On et al. (2017) examined voiced reading of Hebrew ht-homographic words in novice readers (2nd to 4th graders), more proficient readers (7th graders), and fully skilled readers (11th graders and adults). Though all groups showed significantly lower accuracy in deciphering the homographic word in GP sentences than non-GP sentences, accurate deciphering in GP sentences increased in relation to reading proficiency, with novice readers reaching 20%, more proficient readers peaking at 30%, 11th graders reaching close to 40%, and adults reaching over 50% accuracy. Bar-On et al. (2017) hypothesized that the findings in older, more efficient readers reflected their ability to use the full perceptual span necessary for extracting information about ht-homographic words, taking advantage of both pre-homograph and immediate post-homograph contexts in the deciphering process.

The present study aimed to provide information regarding the effect of immediately following context on ambiguous word reading, adding to current literature on GP sentences and eye-movement tracking in this area. While GP studies focus on the processes of reanalysis occurring after an erroneous reading (Ferreira et al., 2001), the present study examined the effect of the upcoming word at the exact point where the target word is actually deciphered. While eye-movement tracking studies show a parafoveal on foveal effect in terms of reaction time, we are not aware of studies examining this effect in terms of ambiguity resolution. Ambiguity resolution sometimes involves the inhibition of one alternative in favor of the other (Rayner, Pacht, & Duffy, 1994). The hypothesis that the upcoming word can contribute to the accurate deciphering of the ambiguous word in such cases has not yet been examined. Moreover, while most studies discuss eye movements in silent reading, the current study addressed voiced reading of ht-homographic words. As noted above, voiced reading involves the additional factor of phonological production, the analysis of which allowed us to directly address the reader's choice between the two alternatives of an ambiguous word, at the exact time the phonological system was ready for production. Ht-homographs in the *unpointed* Hebrew writing system provided us with an efficient tool to examine the first phonological form produced by the reader.

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Heterophonic-homographs in Hebrew

From a phonological and orthographic point of view, ht-homographs are one of three types of lexical ambiguity, the other two being homophonic-homographs and homophonic-heterographs. In a homophonic-homographic word, a single orthographic form and a single phonological form refer to multiple meanings. For example, the word *lie* is spelled and uttered in a single way, but may be interpreted in two ways (untruth/lie down). This type of lexical ambiguity is very common in both written and spoken language (Leinenger & Rayner, 2013), and it is the focal point of most recent research on meaning-selection processes (Peleg & Eviatar, 2012). Homophonic-heterographic words involve one phonological form with two different spellings and two corresponding meanings, as in the words *new* and *knew*. This type of ambiguity should not pose a problem for readers with high-quality lexical representations (Perfetti & Hart, 2002). Finally, in heterophonic-homography, a single letter string is correlated with multiple phonological forms, each with a different meaning. For example, consider the written strings *read* (/rɪd/ or /red/), wind (/wɪnd/ or /waɪnd/), or live (/lɪv/ or /laɪv/). Each of these written strings can be pronounced in two different ways, and each pronunciation refers to a different meaning. Unlike the previous two forms of lexical ambiguity, ht-homographs are relevant only in written language. The reader has to decide on the appropriate meaning during the early stages of the reading process (i.e., word recognition). This decision, in turn, guides phonological retrieval. Due to the lack of phonological information available in the unpointed forms of Semitic orthographies such as Hebrew and Arabic (Abu-Rabia, 2001; Shimron & Sivan, 1994), ht-homographs are prevalent in these languages. They are rare, however, in English and other writing systems (Perfetti & Hart, 2011) and have therefore been studied less than the other types of lexical ambiguity presented above.

The Hebrew orthography has both a pointed and an unpointed version (Ravid, 2005). The former provides the reader with full phonological representation using two graphemic sets: diacritics, called *nikud*, denoting vowels and stop/spirant alternation, and a set of four letters AHWY[1] (אהו"י)[2] that denote both consonants and vowels. The pointed version is mainly used for early reading instruction, and in poetry and religious texts. The unpointed version is the default for proficient Hebrew readers. Vowels in this version are represented opaquely and partially by the AHWY letters alone, with no diacritics. Thus, almost every unpointed Hebrew word can potentially be read using many vowel patterns, some of which produce nonwords. The word MGDL (מגדל), for example, is composed of four consonantal letters, and can potentially be decoded as *magadal*, *megedal*, *migdel*, and so on. While lexical and morpho-orthographic information eliminates most of the nonlexical forms (Bar-On & Ravid, 2011), many unpointed Hebrew words still represent two or more phonological forms, making them ht-homographs. The above example, MGDL (מגדל), represents both *migdal* (tower) and *megadel* (grower).

Shimron and Sivan (1994) have shown that every third or fourth word in a Hebrew text is homographic. Reading unpointed Hebrew thus necessitates a constant state of ambiguity resolution (Bar-On et al., 2017; Share & Bar-On, 2018). This makes the use of context in deciphering ambiguous words inherent to Hebrew reading. In most cases, context leads to appropriate resolution of an

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ambiguous word, largely because most ht-homographs have two alternatives that differ in terms of their lexical or morphosyntactic features (Bar-On, 2015). As the two alternatives are relevant to two different contexts, the correct one can usually be ascertained correctly and automatically. Nevertheless, there are cases in which ht-homographic words can cause GP sentences, leaving room for upcoming words to support accurate deciphering.

The present study examined the effect of succeeding context on the resolution of ht-homography, utilizing the GP phenomenon. Specifically, we examined the relationship between the pre-homograph context and a post-homograph context that supported a less expected alternative, to determine whether the effect of the latter could overcome that of the former. To this end, we focused on the reading of fully skilled, adult readers, using ambiguous sentences with a pre-homograph context that could support both alternatives of an ambiguous word. After determining the preferred alternatives of a set of ht-homographic words, four post-homograph contexts were devised based on the four combinations created by two variables: support for the ht-homographic word alternative (preferred vs. the un-preferred) and distance of the post-homograph context word that reveals the accurate meaning from the homographic word (adjacent vs. distant, separated by a context suitable to the two alternatives). We hypothesized that the context immediately following a word would affect its deciphering, while a context located further along in the sentence would not.

Method

Participants

140 adults participated in the study, 66 males and 74 females, ages 20–60 (20–30: 86 participants; 30–40: 18 participants; 50–60: 36 participants). All were native Hebrew speakers, of medium or medium-high socioeconomic status, academically trained and literate, with no learning difficulties. This population was chosen in order to assess the most standard reading process. Sixty participants, divided into three different groups of 20, performed three pretests: Two groups completed word familiarity questionnaires, and one group underwent the pretest described below. The remaining 80 participants (divided into four groups of 20 with a balanced design in terms of gender and age) performed the main research task.

Research design

The research words: Familiarity characteristics

Research words were chosen in a two-step process. First, we searched for Hebrew ht-homographic words that could be embedded in sentences such that both pre- and immediate post-homographic contexts worked for both alternatives. In the second step, we performed a familiarity analysis on a preliminary list of 14 words. This was done to minimize word-familiarity effects, thus focusing our study on the effects of pre- and post-homographic context. Note that while frequency lists for Hebrew words are available (Frost, 2012, for example), they are composed of unpointed Hebrew corpora, and thus the frequency of a homographic word would represent the frequency of occurrences for all its alternatives combined, rather than

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Please read the following sentences:

1. The girl in the store is selling clothes.

הבחורה בחנות מוכרת בגדים

2. The girl in the store is known to me.

הבחורה בחנות מוכרת לי

Please mark the degree of difference in familiarity between the two underlined words on a scale of 0 to 4. If you mark 1 to 4, please mark the word that is more familiar.

No difference	Very minor difference	Minor difference	Mild difference	Significant difference
0	1	2	3	4

Figure 1. Example item from the alternative familiarity difference test.

for each alternative alone. Instead, we used a familiarity test that is believed to reflect frequency (Tanaka-Ishii & Terada, 2011).

Because the alternatives of most of the research words differed in terms of their lexical or morphosyntactic features (verb vs. noun, for example), as described below, the familiarity comparison was complex. Thus, we created a test in which each alternative was embedded in a sentential context consistent with its lexical and morphosyntactic characteristics. In the first test, a group of 20 adults was asked to rate the familiarity level of each of the 28 alternatives of the 14 words on a scale of 1 to 5. However, this test yielded no familiarity differences, as most of the words were rated as highly familiar. We then created a second test, in which another set of 20 adults was asked to compare the familiarity of each alternative to the familiarity of its competitor. Namely, participants were presented with both alternatives of a ht-homographic word and asked to rate the degree of difference between the alternatives on a scale of 0 (*no difference*) to 4 (*significant difference*). Participants who indicated a nonzero difference were further asked to indicate the more familiar of the two alternatives. Figure 1 shows an item in the familiarity differences test, comparing the two alternatives of the homographic word מוכרת MWKRT: (a) the verb *moxéret* "selling.FM," and (b) the adjective *mukéret* "known.FM." Following this test, two words that were judged as representing highly different alternatives (in terms of familiarity) were excluded from the study. The remaining 12 words had small familiarity differences between the two alternatives ($M = 0.83$, $SD = 0.67$), ranging from 0 to 2.15.

The research words: Lexical characteristics

Most of the 12 ht-homographic words were from two lexical categories. Eight words had a noun versus verb structure, and one had an adjective versus verb structure. In addition, one of the alternatives of five words was preceded by a prefixal clitic: a

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preposition, a relativizer, or a definite article. These clitics are known as *moše ve-kalev*, representing the letters משה וכלב (Ravid, 2012). Such combinations are very frequent in Hebrew, often leading to ht-homography (Bar-On, 2015). For example, consider the Hebrew letter string שיקום ŠYKWM, which was one of the 12 research words, and can be read in two ways: (a) the noun *šikum* "rehabilitation," and (b) the syntactic phrase *še-yakum* "that (he) will rise," which is composed of a relativizer element (*še-*, "that") and a verb.

Pretest: Finding preferred alternatives

The pretest aimed to determine the preferred alternative of each research word (i.e., the alternative that was more readily available than the other), in a particular preceding sentential context that fitted both alternatives. To this end, a group of 20 adult participants were instructed to complete a set of truncated sentences, each ending with one of the research words. The ht-homographic word was preceded by a context supporting both of its alternatives, and followed by a blank line on which the participant's completion indicated the deciphered alternative. For example, consider the following truncated sentence:

(1) I think this nice girl is מוכרת (MWKRT, "selling/known") _____

Completion of the sentence with the words *to me from high school* would indicate that the alternative "known.FM" had been chosen, while completion with the words *expensive clothes* would indicate that the "selling.FM" alternative had been chosen. Ten distraction sentences, similar to the research sentences in length, genre, and register level (but not posing a decoding problem), were added to the list to prevent participants from understanding the research purpose. The truncated sentences were presented in printed form on a sheet of paper, and participants were asked to complete them in writing.

The results of the pretest revealed a clear preference for one of the alternatives of each of the words (see Results section), allowing us to use these words to assess the contribution of pre- and post-word context on homographic word recognition.

Main task

The main task assessed the effect of post-homographic context on the deciphering of an ambiguous word as its preferred versus its un-preferred meaning. To this end, four conditions were constructed for each of the truncated sentences used in the pretest. Each condition incorporated a different post-word context. Two conditions resolved the ambiguity immediately after the homographic word, one providing a context supporting the preferred alternative (*adjacent*preferred*; [2]) and the other the un-preferred alternative (*adjacent*un-preferred*; [3]). Examples of the two immediate resolution alternatives are presented below:

(2) *adjacent*preferred*: It is hard to tell whether this nice girl is known (MWKRT) from TV or from the theater.

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(3) *adjacent*un-preferred*: It is hard to tell whether this nice girl is selling (MWKRT) clothes for less than other sellers.

Two other conditions, in which ambiguity resolution occurred later in the sentence, were used as control items. The context immediately following the ht-homographic word was identical in both distant conditions, supporting both alternatives. This context mostly included adverbial phrases, which were optional from a lexical, syntactic, and semantic perspective. That is, the immediate context did not restrict the reading of the ambiguous word, allowing for the two alternatives to be read accurately, and preserving the meaning that had already been deciphered. One distant context supported the preferred alternative (*distant*preferred*; [4]) and the other supported the unpreferred alternative (*distant*un-preferred*; [5]). The number of words separating the target word from the revealing context ranged from 3 to 5 (average 4.17). The number of characters (including spaces) ranged from 14 to 31 (average 21.5).

(4) *distant*preferred*: It is hard to tell whether this nice girl is known (MWKRT) to me and my friends from high school or college.

(5) *distant*un-preferred*: It is hard to tell whether this nice girl is selling (MWKRT) to me and my friends clothes for less than other sellers.[3]

Procedure

Forty-eight sentences featuring the four research conditions were divided into four 12-sentence lists using a Latin square, such that each list included all types of contexts and a single appearance of each of the research words. Ten identical distracting sentences were added to each 12-sentence list, and each list was presented to 20 participants. Participants were instructed to read the sentences aloud, and their reading was recorded and transcribed. The alternative that was first pronounced was coded as the participant's response, including corrections both within and after the reading of the target word (e.g., even if the reader switched from *mu* for *mukeret* to *mo* for *moxeret*, we coded it as *mukeret*), such that the preliminary meaning deciphered by the reader was indicated.

Results

Pretest

The results of the pretest (i.e., the completion task) are listed in Table 1, in parentheses. The pretest provided us with a clear division of the research words in two regards. First, each pair of homographic alternative readings clearly showed a clear tendency toward the preferred alternative. That is, the same alternative was read as a completion for the ambiguous truncated sentence in at least 70% of the cases, for

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Table 1. Percentage of reading the preferred alternative in four conditions

Orthographic form, preferred alternative (pretest score)	adjacent*preferred	adjacent*un-preferred	distant*preferred	distant*un-preferred
TWDH תודה, *toda* "thank" (100%)	100	65	95	90
HAM האם, *haʔim* "whether" (100%)	100	65	95	90
HTS9T הצעת, *haccat* "proposal.of" (100%)	100	55	100	95
MGDLYM מגדלים, *megadlim* "they.grow" (100%)	90	60	90	60
RTSẖ רצח, *racax* "he.murdered" (95%)	95	25	80	85
MQBLT מקבלת, *mi-kabalat* "from-receiving" (85%)	75	30	60	60
SYQWM שיקום, *šykum* "rehabilitation" (85%)	100	65	80	85
TB9 טבע, *teva* "nature" (80%)	50	45	50	80
MWKRT מוכרת, *mukeret* "she.is.familiar" (80%)	75	30	100	100
HMTNH המתנה, *ha-matana* "the-gift" (80%)	75	35	35	50
LPNWT לפנות, *lifnot* "to turn/to address" (75%)	90	31.5	80	80
HTQYP התקיף, *hitkif* "he.attacked" (70%)	80	35	55	70

each of the 12 words. Second, the results showed a graduated tendency, ranging from 70% to 100% preference of the alternative reading, with an average of 87.5% ($SD = 10.9\%$).

Main task

Comparing four conditions

Table 1 presents the percentage of reading the preferred alternative for each item in all four conditions. We examined the deciphering of the ambiguous words using a generalized linear mixed model fit by maximum likelihood (Laplace approximation). *Reading* was the dependent variable, with two categorical levels: deciphering the ambiguous word as its *preferred* versus *un-preferred* meanings. The independent variable (fixed effect) was the *revealing condition*, with four categorical levels: *adjacent*preferred* (reference level), *adjacent*un-preferred*, *distant*preferred*, and *distant*un-preferred*. Participant and item (i.e., specific words) were treated as random effects. Table 2 details the model's fixed effects.[4]

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Table 2. Generalized linear mixed-model results: Fixed effects

Revealing condition	β	Std. Error	*z* value (*p*)
Intercept adjacent*preferred	2.0212	0.2958	6.834 ($p < .001$)
adjacent*un-preferred	−2.2388	0.2487	−9.001 ($p < .001$)
distant*preferred	−0.6712	0.2505	−2.680 ($p = .00737$)
distant*un-preferred	−0.5433	0.2533	−2.145 ($p = .03197$)
Observations: 960			
Log Likelihood: −488.8			
AIC: 989.6			
BIC: 1,018.8			

The model first showed that the probability of reading the preferred meaning went up in the reference level condition (*adjacent*preferred*). The log odds of 2.0212 mean that the chance of reading the preferred alternative in the *adjacent*-preferred* condition was 7.47 times higher than the chance of reading the un-preferred alternative in this condition. Second, the model showed that the predicted probability of reading the preferred alternative went down significantly in the *adjacent*un-preferred* condition ($p < .001$), and less significantly in the two *distant* conditions (preferred, $p = .00737$ and un-preferred, $p = .03197$).

Pairwise comparisons using simultaneous tests for general linear hypotheses (Hothorn, Bretz, & Westfall, 2008) further showed that (a) the predicted probabilities of reading the preferred alternative in the two *distant* conditions were significantly higher than in the *adjacent*un-preferred* condition ($p < .001$), and (b) there was no significant difference between the two *distant* conditions ($p = .9453$). These results indicate the effect of the immediate post-homographic context on deciphering of the homographic word. The two *distant* conditions behaved similarly to one another in the model, and quite similarly to the *adjacent*preferred* condition as well; the condition in which the predicted probability of reading the preferred alternative was significantly lower than all the other conditions was the *adjacent*un-preferred* condition.

Item analysis

To further assess the main task's condition of interest (*adjacent*un-preferred*), in which the post-homographic context showed the most significant effect, we compared its preferred alternative percentage with the results of the pretest. Recall that the pretest indicated on the preferred alternative's preference level: the proportion of instances in which the preferred alternative of each item was read when nothing followed it (see Table 3). A Pearson's product-moment correlation showed a positive correlation between the two measures ($r = .619$, $p = .0316$). This correlation indicates that, within the *adjacent*un-preferred* condition, the chances of reading the preferred alternative

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Table 3. Item analysis: Preference level of the preferred alternative and ratio of preferred alternative deciphering in the adjacent*un-preferred condition

Item	Preference level	*adjacent*un-preferred* condition
HAM	1.00	0.65
HC9T	1.00	0.55
MGDLYM	1.00	0.60
TWDH	1.00	0.65
RCX	0.95	0.25
MQBLT	0.85	0.30
SYQWM	0.85	0.65
HMTNH	0.80	0.35
MWKRT	0.80	0.30
TV9	0.80	0.45
LFNWT	0.75	0.31
HTKYF	0.70	0.35

Note: Correlation: $r = .619$, $p = .0316$.

in words with a high preference level of the preferred alternative (i.e., high pretest scores) were higher than the chances of reading the preferred alternative in words with low pretest scores. This correlation emphasizes the effect of the preliminary preference level on the chance of reading the preferred alternative in a nonsupporting environment.

Discussion

The present study investigated the effect of adjacent (immediate) post-homographic context on ambiguity resolution. Comparing four conditions based on the location of the post-homographic context and its support of one of two alternatives, we found effects for both. The results showed no significant difference between the two distant conditions, such that the probability of reading the preferred alternative in these conditions was high. While contextual support for one alternative or the other had no effect in the distant conditions, it did affect the two adjacent conditions. First, the probability of reading the preferred alternative in the condition where it was supported by the adjacent context was significantly higher than both distant conditions. Second, the probability of reading the preferred alternative in the condition where the adjacent context supported the un-preferred alternative was significantly lower than the other three conditions. That is, our main finding is that the voiced reading of a ht-homograph is affected by the immediately following word.

These findings confirm our hypothesis, which was based on previous work examining the eye-voice span (Laubrock & Kliegl, 2015), in terms of reaction time. The present study utilized the ambiguity created by ht-homographs, focusing on their

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first deciphering. In the present context, the first deciphering was the first alternative that the reader produced when reading a word aloud. Even false starts were considered to be indications of the first deciphering, and were taken into account. The findings indicating similarity between the two distant revealing contexts, and their resemblance to the pretest results, suggest that the research sentences where suitable for both word alternatives. The fact that the distant revealing context had no effect on the deciphering of the ht-homograph further shows that the eye-voice span covers less than three words beyond the target word. Future studies can manipulate this parameter in order to better understand the range of the eye-voice span.

Regarding the adjacent context conditions, the high probability of deciphering the preferred alternative in a context that supports it is in line with the results of previous eye-tracking studies. Such studies address the contribution of an upcoming word to the reading time of the fixated word. The present study adds to this body of research, showing that upcoming information affects the accuracy of deciphering the preferred alternative of an ambiguous word.

Our most interesting finding involves sentences in which the adjacent context supported the un-preferred alternative. These sentences virtually exemplify the GP phenomenon. As every sentence had its preferred alternative (as revealed in the pretest), cases in which the upcoming word did not support this preferred alternative could have led the reader to a GP situation. However, while GP studies address monitoring processes that occur after the erroneous reading (Slattery et al., 2013), the present study shows that the deciphering of the less expected alternative of an ambiguous word is affected *online* by its immediately following context. In other words, our findings show that information retrieved from the upcoming word influences phonological production. During preparation for phonological production, the upcoming word enabled rejection of the preferred alternative, making it possible to read the un-preferred alternative. We may thus conclude that recognized words have some flexibility in a memory buffer, such that phonological encoding can be influenced by succeeding words prior to actual utterance.

Still, while we show that the immediate, adjacent context affects the reading of the un-preferred alternative, it does not overcome the dominance of the preferred meaning. It did not turn the picture upside down, but only pushed it toward a lower probability of deciphering the preferred alternative. This phenomenon resembles the Stroop effect (Stroop, 1935), in the sense that two forces are fighting over the reader's cognitive resources. In one corner of the ring, there is the preceding context, which evokes some prediction as to what the appropriate reading should be in accordance with what has been read so far. In the other corner, there is the upcoming word, according to which the second (less preferred) alternative is the appropriate one. Moreover, upon arriving at an ambiguous word, the reader has already gathered a large amount of cumulative information, evoking a highly probable prediction of its meaning. Conversely, the amount of information retrieved from the immediately succeeding context is relatively limited, allowing for a low probability prediction of its appropriate reading. Reading in such a conflicting context is difficult, and may lead to less-than-perfect results.

Finally, a relatively high correlation was found between pretest scores and the probability of reading the preferred alternative in the *adjacent*un-preferred* condition. When a preferred alternative had a high preference level according to the

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pretest, it was fairly immune to the effect of a nonsupporting upcoming word. However, when a preferred alternative had a relatively low pretest score, it was more prone to the effect of a nonsupporting upcoming word. Namely, the preference level of a preferred alternative played a role in its deciphering. Our main finding is thus strengthened by the correlation between the pretest and the main task. We show that in deciphering an ambiguous word, the role of the context preceding the word is not distinct from that of the succeeding context, nor from the role of the lexical characteristics of the word itself. These findings emphasize the significance of the *sentential* context, which is composed of the word's lexical characteristics, in accordance with the rich lexicon, together with the surrounding context.

It is important to note that while voiced reading provides information regarding reading process (Laubrock & Kliegl, 2015), silent reading is more natural. To the best of our knowledge, the contribution of parafoveal information to ambiguity resolution has not been studied thus far. Our findings put forward the proposition that parafoveal information in silent reading may have an effect similar to the upcoming word effect on which we report. Thus, it will be interesting to examine the parafoveal effect in resolving ambiguity of a fixated word during silent reading. The present findings also expand our knowledge on reading in the extremely homographic unpointed Hebrew text. The accumulated information gathered by reading the part of the sentence leading up to an ambiguous word in Hebrew is generally sufficient for efficient resolution. Nevertheless, ht-homographic words may pose a challenge when the context preceding them does not support a definite preferred alternative. In these cases, the immediately succeeding context plays a crucial role, albeit not a bulletproof solution. Our findings in Hebrew can be extrapolated to other writing systems as well: first, to Arabic, which is characterized by similar homographic phenomena, and then to other alphabetic orthographies, in which the issue is not homography but rather homonymic ambiguous words.

Notes

1. We use both Hebrew letters and capital Latin letters to represent unpointed written Hebrew words, to facilitate understanding in readers who are not familiar with Hebrew (Ravid, 2005).

2. Hebrew is read from right to left.

3. This is an English translation of the original Hebrew sentence in which we exemplify the experiment's condition. Thus, while the translation might sound odd or ungrammatical, the Hebrew source is a fully grammatical sentence in Hebrew.

4. The R syntax for the final model was as follows: `fit <- glmer(reading ~ condition + (1|Subj) = (1|Item), family="binomial", data = data).`

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