Kajian Malaysia, Vol. 32, No. 2, 2014, 23–40

MORPHOLOGICAL PARAFOVEAL PREVIEW BENEFIT EFFECTS WHEN READING DERIVED WORDS IN MALAY

Heather Winskel[1*] and Khazriyati Salehuddin[2]

[1]School of Health and Human Sciences, Southern Cross University, Coffs Harbour Campus, Hogbin Drive, Coffs Harbour, NSW 2750, Australia
[2]School of Language Studies and Linguistics, Faculty of Social Sciences and Humanities, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
[*]Corresponding author: heather.winskel@scu.edu.au

Eye-movement tracking is a method that is used to study reading across different languages and is increasingly being employed. Eye movements provide a window into the underlying cognitive processes and mechanisms while a person is reading (Rayner, 1998). The majority of research investigating eye movements during reading has been conducted on European languages such as English and German; relatively little work has been conducted on other writing systems such as Malay. Malay offers an interesting opportunity to investigate early morphological processing because Malay has a rich derivational morphology that is more structurally and semantically transparent than English. The current study investigates whether the morphological constituents of affixed words (prefixed and suffixed) in Malay influence early word processing during reading using the boundary paradigm (Rayner, 1975). The boundary paradigm involves the positioning of a preview word stimulus in place of the target word so that when the eyes move towards the preview word, they cross an invisible boundary that triggers a change from the preview word to the target word. Two commonly used affixes were used: a prefix pe- *and a suffix* -an, *which both convert a verb into a nominal (e.g.* lakon, *"to act", with the prefix* pe- *becomes* pelakon, *"actor"; and* makan, *"to eat", with the suffix* -an *becomes* makanan, *"food"). Thirty participants read 72 single sentences that were identical in length (having the same number of letters) and contained affixed and pseudo-affixed words. Parafoveal previews consisted of identical affixed and control conditions. The dependent measures were first fixation duration and gaze duration. The results revealed a significant preview benefit for the identical condition compared with the affixed and control conditions and for the affixed condition compared with the control condition. This effect was not influenced by word type; hence, there was no evidence of morphological pre-processing. In conclusion, the results from the current study indicate that although Malay is a morphologically rich language with a relatively transparent orthography, readers do not necessarily utilise early morphological processes. The results are discussed in terms of* *language and orthography-specific differences in early morphological processing.*

Keywords: eye movements, Malay, reading, morphological processing

INTRODUCTION

Eye-movement tracking is an increasingly popular method for studying reading across different languages and their writing systems. This method is particularly informative because eye movements provide a window into the underlying cognitive processes and mechanisms involved in reading (Rayner, 1998). The majority of research investigating eye movements and reading has been conducted on European languages such as English and German. The scope of research is gradually being expanded as we conduct research investigating reading in diverse orthographies. If we are to understand the common language or orthography-specific mechanisms and processes in reading, this expansion is essential. In the current study, we investigate early morphological processing during the reading of Malay. Malay is of particular interest because of its rich derivational morphology, which is more structurally and semantically transparent than English. We investigate whether there is evidence of a morphological parafoveal preview benefit effect in Malay using an eye-contingent display change known as the boundary paradigm (Rayner, 1975). We first present relevant background information regarding eye-tracking technology and reading and then explicate some of the concepts and terminology used in this specialised area before explaining the details of the experiment that we conducted.

INTRODUCTION TO EYE-TRACKING AND READING RESEARCH

Eye-Movement Measures

Three major components of eye movements are particularly informative when tracking eye movements during reading: saccades, fixations and regressions. Saccades are rapid eye movements that move the eyes from one position to another in the text during reading. Each saccade brings a new region of text into foveal or central vision for detailed analysis (Rayner, 1998; Rayner et al., 1981). The eyes of skilled readers of Roman script typically move in a rightward direction, with approximately seven to nine letter spaces with each saccade. Typically, the initial landing position occurs between the beginning and the centre of a word, which is considered the preferred viewing location (PVP). Information is encoded only during fixations because vision is suppressed during saccades. Fixations on words typically last approximately 200–250 ms, although fixations can range from approximately 100 ms to over 500 ms in individual readers. This variability in fixation duration is related to the ease or difficulty associated with understanding and processing the words in the text by the reader (Rayner, 1998; Reichle, Rayner and Pollatsek, 2003). When readers encounter words that are more difficult to identify such as low-frequency words or sentences that are syntactically complex, fixations are typically longer in duration.

Regressions, or movements back to previously read text, are typically reported in eye movement studies because they reflect processing difficulty during encoding (Rayner and Pollatsek, 1989). In general, approximately 10% to 15% of the saccades of skilled readers are backward regressions. Short within-word regressive saccades may be the result of problems that the reader has processing the currently fixated word, whereas longer regressions or larger movements back along the line of text or to a previous line of text may occur because of comprehension difficulties (Rayner, 1998). Good readers are quite accurate in locating the portion of the text that caused them difficulty, whereas poor readers exhibit more backtracking and unsystematic eye movements. Thus, as text becomes conceptually more difficult, readers in general have longer fixations, shorter saccades, and more regressions.

Typically, in eye-movement and reading experiments involving single sentences, several processing measures are computed at the sentence and target word levels (Juhasz, Inhoff and Rayner, 2005). The "target word" is the word in the sentence that is manipulated or changed in some manner and is of particular interest in the experiment. For sentence level measures, the total sentence reading time and fixation count measures are typically computed. For the target word, first fixation duration, gaze duration, and total viewing fixation duration are frequently measured. First fixation duration is the duration of the first fixation on the target word, irrespective of other additional fixations occurring on the target word. Gaze duration is the sum of all fixations on the target region prior to moving to another word. Total viewing fixation duration comprises the cumulative fixation durations on the target word in the entire trial including time spent re-reading the critical word. These different measures can present a picture of how word processing occurs while reading unfolds over time.

Foveal and Parafoveal Processing When Reading

When reading, information is obtained from two sources: the word that is currently being fixated (the foveal word) and the next word in the text (the parafoveal word). Acuity tends to be quite good in the *fovea* (the central 2° of vision) and less so in the *parafovea* (which extends to 5° on either side of fixation). In the absence of foveal information, information solely from the *parafovea* is not sufficient for reading (Just and Carpenter, 1987). Conversely, many high-frequency words can be lexically processed by the *parafovea* (i.e.

without fixating on the word). Hence, such words are more likely to be skipped than low-frequency words, especially when the eyes are close to the target word on the fixation prior to the skipping (Drieghe et al., 2004; Henderson and Ferreira, 1990; Hyöna and Bertram, 2004). Alternately, many difficult or long (or low-frequency) words are lexically processed using multiple fixations and longer durations.

When a word is previewed in the parafovea before being fixated, the subsequent processing time of that word is shorter than if it had not been previewed (Kambe, 2004). This preview benefit is typically on the order of 30–50 ms and has been demonstrated using an eye contingent display known as the boundary paradigm (introduced by Rayner, 1975). This involves rapidly changing a preview word or stimulus to the target word when the eyes cross an invisible boundary. The word change occurs rapidly during the saccade so that the reader is largely unaware of the change and cannot consciously identify the preview word or nonword that the reader had actually begun to process parafoveally.

The parafoveal preview benefit effect is greatest when the entire word is available in the parafovea but can also be observed under some manipulated preview conditions. That orthographic components of language are able to enhance word processing when viewed parafoveally has been widely reported (e.g. Johnson, Perea and Rayner, 2007; Tsai et al., 2004; Williams et al., 2006). In addition, phonological components of words have been observed to enhance word processing when viewed in the parafovea prior to fixation (e.g. Ashby et al., 2006; Chace, Rayner and Well, 2005; Slattery, Pollatsek and Rayner, 2006; Tsai et al., 2004). Evidence for a semantic preview benefit effect has so far not been identified in alphabetic orthographies (Altarriba et al., 2001; Rayner, Balota and Pollatsek, 1986; Rayner and Morris, 1992). This research on European languages supports the view that parafoveal preview benefit effects are driven primarily by the orthographic and/or phonological features of the previews and target words (e.g. Balota, Pollatsek and Rayner, 1985; Inhoff, 1989; Kambe, 2004; Lima, 1987; Morris, Rayner and Pollatsek, 1990; Pollatsek et al., 1992; Rayner and Morris, 1992; Williams et al., 2006).

Morphological Processing When Reading

Studies investigating morphological processing when reading single words have shown support for early stages of processing across a range of languages: Arabic, Hebrew, German, French, Italian, English and Chinese (Boudelau and Marslen-Wilson, 2001; Deutsch, Frost and Forster, 1998; Drews and Zwitserlood, 1995; Grainger, Cole and Segui, 1991; Laudana, Cermele and Caramazza, 1997; Marslen-Wilson et al., 1994). However, relatively few studies have investigated early morphological processing when reading continuous text using eye-tracking technology. Recent research has identified a morphological preview benefit effect for Hebrew, a morphologically rich and distinctive language (Deutsch et al., 2003; Deutsch et al., 2005), but not for English, which has a morphology that is sparser and more limited (e.g. Inhoff, 1989; Kambe, 2004; Lima, 1987). These differences in results across languages indicate that there are language-specific differences in morphological processing.

Deutsch et al. (2003) observed a morphological preview benefit effect in Hebrew for root morphemes. Hebrew has two basic types of derivational morphemes: a root morpheme and a verbal or nominal morpheme. In contrast to European languages, Hebrew root morphemes and word patterns are not concatenated in a linear fashion; instead, the consonants of the root are intertwined with the phonemes and corresponding letters of the word pattern. Thus, the root morpheme is distributed throughout the word and does not occur at the beginning or end of the word as the root morpheme occurs, for example, in English. The roots and word patterns in Hebrew are bound morphemes and cannot stand independently as a word or be pronounced separately (refer to Frost et al., 2005; Velan and Frost, 2011, for a more detailed description). The importance of the preservation of the sequence of root letters is reflected in research that did not identify letter transposition effects in Hebrew (Velan and Frost, 2007) or Arabic which is another Semitic language (Perea, Abu Mallouh and Carreiras, 2010). The transposition of two letters of the consonantal root in Semitic languages renders it difficult to access the actual word (Velan and Frost, 2007; 2011). According to Velan and Frost (2011: 153) root-derived words in Hebrew have a "well-defined set of conditional probabilities that rigidly determine few open slots for the consonants of the root only". This also implies that the root morpheme has a high degree of saliency for readers of Hebrew.

In a more recent study, Deutsch et al. (2005) observed a selective morphological parafoveal benefit effect in Hebrew for verbal morphemes, but not for nominal morphemes. The authors explain these differences in results in terms of the number of verbal patterns and frequency of usage. There are only seven different verbal patterns in Hebrew, whereas there are many nominal patterns. Furthermore, verbal patterns are more frequent in usage and convey more semantic and grammatical information than nominal patterns.

In Finnish, a highly inflected language with concatenative morphology, Bertram and Hyönä (2007) investigated whether a morphological preview benefit could be obtained using the eye-contingent display change paradigm. Compound words (e.g. HÄÄ-SEREMONIA, "wedding ceremony") with short and long first constituents were embedded in sentence frames. The compound word is either in a full preview condition or in a partial morphological preview condition. The authors did not identify a beneficial effect of parafoveal preview of short first constituents compared with long first constituents or differences in fixation duration on the pre-target word of these two constituent types. Thus, results revealed no evidence supporting parafoveal morphological pre-processing.

Though Finnish is a morphologically rich and highly inflected language, readers do not appear to utilise parafoveally available morphological codes.

Contrasting results for Hebrew, English and Finnish suggest that the role of morphological components in word processing is language-specific and that the manners in which the two lexicons are organised are different. Deutsch et al. (2005: 369) suggested that for English, "lexical organisation could be guided primarily by orthographical principles based on letter sequentiality and letter position", whereas in Hebrew, lexical organisation could be guided more by morphological principles. These effects may be specific to highly inflected languages in which morphological information is more informative. Languages such as English make relatively limited use of morphology.

MALAY MORPHOLOGY

Because Malay has a rich derivational morphological system, most words are morphologically complex (Zaharani, 2009). The average word length in Malay exceeds seven letters, and most high-frequency words are multi-morphemic. In fact, a vast majority of Malay words are affixed. Malay uses the same Roman script as English but has a more regular or transparent orthography. In contrast to English, which has both inflectional and derivational morphologies, Malay has only a derivational morphology. Malay has a rich transparent system of affixations. It has approximately 25 derivational affixes but only two inflectional affixes (Prentice, 1987). Affixation is structured in an agglutinative manner using prefixes (e.g. *peN*-, *meN*, *terN*), suffixes (e.g. -*an*, *wati*), infixes (e.g. -*el*-, *em*-), and circumfixes (*peN*...-*an*, *meN*...-*an, ke*-...-*an*). Although there are various prefixes, the prefix *peN*- is the most productive class- changing prefix in Malay that changes a verb to a noun (e.g. *tulis* "write" [verb] > *penulis* "writer" [noun]) (Asmah, 1980).

Although superficially there appear to be many prefixes that begin with *pe*- (i.e. *pe*-, *pen*-, *peng*-, *penge*-, *pel*-, and *per*-), they are all, in fact, allomorphs of the morpheme *peN*-, performing the same function, i.e. changing verbs to nouns. The "N" that comes with the prefix *peN*- is phonetically conditioned (Nik Safiah, Farid and Hashim, 1989) (Table 1 illustrates how *peN*- is phonetically conditioned). Semantically, *pe*-*N* changes a verb to a noun to form (1) a do-er (e.g. *pembaca*, "a reader"), (2) a profession (e.g. *pengarang*, "a composer"), or (3) a tool (e.g. *penyapu*, "a broom").

Table 1: Manifestations of Malay *peN*- prefixes

Prefix *peN*-		Examples
Pe-	*m*	*masak* "to cook" > *pemasak* "cook"
	n	*naik* "to raise" > *penaik* "raising"
	ny	*nyanyi* "to sing" > *penyanyi* "sing"
	ng	*ngiau* "to meow" > *pengiau* "something that meows"
	r	*ragut* "to snatch" > *peragut* "snatcher"
	l	*layan* "to serve" > *pelayan* "server"
	p	*pukul* "to hit" > *pemukul* "tool to hit"
	t	*tahan* "to resist" > *penahan* "resistance"
	k	*karang* "to compose" > *pengarang* "composer"
	s	*sapu* "*to* sweep" > *penyapu* "broom"
Pem-	*b*	*baca* "to read" > *pembaca* "*reader*"
	f	*fatwa* "to give a fatwa" > *pemfatwa* "one who releases *fatwa*"
	v	*veto* "to veto" > *pemveto* "one who has the veto power"
Pen-	*d*	*dapat* "to possess" > *pendapat* "opinion"
	c	*curi* "to steal" > *pencuri* "thief"
	j	*jaja* "to sell" > *penjaja* "hawker"
	sy	*syarah* "to lecture" > *pensyarah* "lecturer"
	z	*ziarah* "to visit" > *penziarah* "visitor"
	t	*tadbir* "to adminster" > *pentadbir* "administrator"
	s	*stabil* "to stabilise" > *penstabil* "stabiliser"
Peng-	*g*	*gulung* "to wrap" > *penggulung* "wrapping"
	kh	*khianat* "to commit treason" > *pengkhianat* "treason"
	h	*hubung* "to connect" > *penghubung* "connection"
Penge-		*exclusive for mono-syllabic words,* e.g. *cat* "paint" > *pengecat* "painter"

The Malay suffix *-an,* in contrast, is not phonetically conditioned. It is the original Malay suffix in Malay nouns (Asmah, 1980). Other Malay affixes such as *-wan* (*angkasawan*, "astronaut"), *-ism* (*nasionalism*, "nationalism", *-in* (*hadirin,* "audience"), and *-ah* (*sultanah*, "consort") are borrowed suffixes from Arabic, Sanskrit, English, and Greek. The suffix *-an* is also class-changing in nature and changes a verb to a noun (e.g., *tulis* "write" [verb] > *tulisan* "writing" [noun]). Semantically, *-an* means "a result of" (e.g., *tulisan*, many [e.g. *rangkaian*], and patient [e.g., *suruhan*]).

Given the rich system of inflections in the Malay language, it is likely that readers of Malay are more sensitive to morphemes than are readers of English (Rickard and Choo, 2004).

In the current study, two commonly used affixes were utilised, i.e. the prefix *pe*- and the suffix -*an*, both of which convert a verb into a nominal (e.g. *lakon*, "to act", with the prefix *pe*- becomes *pelakon*, "actor"; and *makan*, "to eat", with the suffix -*an* becomes *makanan*, "food"), to investigate whether there is a morphological parafoveal preview benefit effect when reading Malay. The prefix *peN*- and the suffix -*an* are the most common and most productive noun-forming affixes of Malay (Asmah, 1980). These affixes are semantically transparent because they serve only this function of converting verbs into nouns and are attached to free stem words. There are only two additional prefixes, *me*- and *ke*-, that can serve a similar function, that is, convert a verb into a noun. However, these two prefixes are not as widely used as *peN*-. The more common prefixes are those that change a noun to a verb (e.g. *merotan*, *merumput*). The prefix *ke*- does not change a verb to a noun unless the prefix co-occurs with the suffix -*an* (e.g. *kedatangan, kemasukan*), which in this case, renders them circumfix *ke*-...-*an*, rather than prefix *ke*-. The words that have *ke*- as a prefix are limited to *kekasih* and *kehendak* (Nik Safiah, Farid and Hashim, 1989: 75; Asmah, 1980: 46).

Because Malay is a morphologically rich language with a relatively regular or transparent orthography, it can be argued that Malay is a good candidate for early morphological processing to occur. Extracting a morphological unit in Malay with its structurally and semantically transparent short affixes could potentially be simpler than doing so in Finnish, with its longer morphological constituents, or in English.

THE CURRENT STUDY

Eye-movement measures provide precise information regarding the time-course of the processing of words during reading (Rayner, 1998). Typically, two primary measurements are recorded that reveal precise clues regarding the early processing of words; first fixation duration, which represents the duration of the first and/or only fixation on a word on the first pass, and gaze duration, which is the sum of the total fixations on a word before the reader moves to another word. Regressions back to the word are therefore not included in the gaze-duration measure.

The current study seeks to investigate (1) whether morphological information is obtained from the parafovea and (2) whether there is a parafoveal preview benefit effect of prefixes and/or suffixes when reading continuous text in Malay. An orthographic control condition is used. If there is a morphological parafoveal benefit effect in Malay, then we expect a processing benefit effect for affixed words as opposed to pseudo-affixed words occurring in the orthographic control condition. However, if morphological information is not available in the parafovea prior to fixation in Malay readers, then there should not be significant differences between reading measures for affixed and pseudo-affixed words.

METHOD

Participants

The participants were 30 Malaysian students who were studying at Sydney University and the University of Western Sydney as international students. All were native speakers of Malay who participated in the experiment for payment. All participants had been studying in Australia between six months and three years. The participants were aged between 18 and 23 years. All participants had normal or corrected vision.

Stimuli and Design

There were 72 trials presented to each participant (Table 2 presents samples of the sentences). In the morphological condition, the target words consisted of an equal number of words with the prefix *pe-* and the suffix *-an*, both of which serve the function of transforming a verb into a noun. In the orthographic control condition, the pseudo-affixed words contained the same word-initial or word-final letters as the prefixed and suffixed words; however, the letters were components of the full word and could not be removed to alter the word's meaning. Paired target words in the morphological and orthographic control conditions were matched according to word length, with the prefixed words ranging from six to nine letters in length (M = 7.13) and the suffixed words ranging from six to eight letters in length (M = 7.13). Word frequencies for the target words were obtained from a 4.6-million-word database (Malay Concordance project, http://online.anu.edu.au/asianstudies/ahcen/proudfoot/MCP supplemented by a corpus selected from *Utusan Malaysia*, http://www.utusan .com.my). The mean frequencies of affix and pseudo-affix words per million words were calculated; prefix words = 27, pseudo-prefix words = 30, suffix words = 29 and pseudo-suffix words = 25 words per million, which were not significantly different (ps > .1). A sentence frame was prepared for each pair so that the sentences was identical up to the target word. Target words were placed near the centres of short sentences, never at the beginnings or ends of the sentences. Preceding each target word was a pre-target word ranging from 5–9 letters (M = 7.10). These words were selected to be relatively long to improve the reader's chances of landing on rather than skipping the pre-target word, hence allowing the boundary change to be triggered. The boundary was placed immediately after the final letter of the pre-target word so that the change occurred before the reader fixated on the target word.

Table 2: Mean of first fixation duration and gaze duration in milliseconds on the target word

Pe- prefix	Suffix *–an*
1. *Dia ada pelakon baru.* "He has a new actor".	1. *Dia suka akan tarian Malaysia.* "She enjoys Malaysian dance".
Dia ada pelamin baru. "He has a new bridal dais".	*Dia suka akan durian* Malaysia.* "She enjoys Malaysian durian".
2. *Jangan dilupa pelari itu.* "Don't forget that runner".	2. *Ali belum tahu tekanan baru itu.* "Ali isn't aware of the new pressure".
Jangan dilupa perigi itu. "Don't forget that well".	*Ali belum tahu peranan baru itu.* "Ali isn't aware of the new role".
3. *Mereka rindu akan pelajar cantik itu.* "They miss that pretty student".	3. *Mereka membawa bekalan baru.* "They bring new supplies".
Mereka rindu akan pelangi cantik itu. "They miss that pretty rainbow".	*Mereka membawa berlian baru.* "They bring new diamonds".
4. *Dia kenal perintis berbakat itu.* "She knows that talented apprentice".	4. *Mereka menerima sambutan itu dengan hati terbuka.* "They accept the celebration with an open heart".
Dia kenal pelanduk berbakat itu. "She knows that talented mousedeer".	*Mereka menerima rambutan* itu dengan hati terbuka.* "They accept the rambutan with an open heart".
5. *Mereka bangga akan peraih baru mereka.* "They are proud of their new acquirer".	5. *Salmah tidak nampak garisan halus itu.* "Salmah couldn't see the fine line"
Mereka bangga akan perahu baru mereka. "They are proud of their new boat".	*Salmah tidak nampak gentian halus itu.* "Salmah couldn't see the fine fibre".
6. *Jangan disorok perusuh bahaya itu.* "Don't hide that dangerous rioter".	6. *Abu yakin angkatan itu kuat.* "Abu is confident the movement is strong".
Jangan disorok pelikat bahaya itu. "Don't hide that dangerous chequered sarong".	*Abu yakin jambatan itu kuat.* "Abu is confident the bridge is strong".
7. *Ali tidak suka pelayan yang mahal-mahal.* "Ali doesn't like high-paying attendants".	7. *Dia tidak suka akan pameran itu.* "She doesn't like the exhibition".
Ali tidak suka perabot yang mahal-mahal. "Ali doesn't like expensive furniture".	*Dia tidak suka akan pasukan itu.* "She doesn't like the team".
8. *Siapa pengarang muda itu?* "Who is that young writer"?	8. *Mereka menerima kawalan yang luar biasa dari polis.* "They receive unusual surveillance from the police".
Siapa pengantin muda itu? "Who is that young bride"?	*Mereka menerima banduan yang luar biasa dari polis.* "They receive an unusual prisoner from the police".

Note:
* "Durian" and "rambutan", are considered monomorphemic words rather than "derived"/polymorphemic words because the mapping between the word "durian" and "rambutan" to their respective objects is almost automatic to native speakers of Malay.

Each of the morphological and orthographic target words were paired with three preview types: (1) identical (in which the preview and target words were identical), (2) affix (in which the affixed or pseudo-affixed component of the target word was previewed while a string of lower case x's replaced the word stem), and (3) control (in which a string of x's was previewed instead of the target word) (see Figure 1 for an example).

Morphological Condition
Target word: *pelari*, "the runner"
Previews
Identical = *pelari*
Affix = pexxxx
Control = xxxxxx
Tak mungkin nampak ***pelari*** *itu dari stadium besar ini.*
Their children won't be able to see **the runner** from this big stadium.

Orthographic Control Condition
Target word: *pelita*, "the lamp"
Previews
Identical = *pelita*
Pseudo-affix = pexxxx
Control = xxxxxx
Tak mungkin nampak ***pelita*** *itu dari belakang pokok tersebut.*
Their children won't be able to see **the lamp** from behind the tree.

Figure 1: Example of a target word sentence with the three preview types presented to participants.

The sentences were divided into three lists of 72 sentences presented in a fixed random order. The stimuli were rotated within the three conditions in a Latin-square design. Ten participants were tested on each list, thus allowing participants to provide data in each of the experimental conditions. Twenty-five per cent of the sentences were followed by a yes/no question to ensure that sentences were being read for meaning. The mean accuracy rate for these comprehension questions was 96% (range: 83%–100%).

Procedures and Equipment

Eye movements were recorded using the Eyelink 1000 Tower Mount eyetracker (SR Research Ltd – Canada), a video based eye-tracking device that uses an infrared mirror to optimise eye-tracking range. The cameras sample pupil location at a rate of 1000 Hz. The monitor used to display the sentences was a 21-inch ViewSonic G225fB with a refresh rate of 160 Hz. The sampling rate of the eye tracker resulted in display changes occurring within 8 ms. The movements of the right eye were monitored, although viewing was binocular. Participants were seated 61 cm from the monitor, and sentences were presented in a single line of text. Three letters approximately subtended 1° of visual angle.

Each participant was required to sit in front of the computer monitor, placing his or her face on the chin and forehead rest of the eye-tracker. The eye-tracker and seating were adjusted to ensure the participant's comfort. Each trial began with a fixation point on the left-hand side of the monitor; the location corresponded to the first letter of the sentence.

The instruction requested participants to read the sentence silently to themselves for comprehension and then when they had finished reading the sentence, to press a game-pad button to trigger the next trial. Before proceeding, the eye tracker was calibrated, and then 10 practice sentences were displayed. Following re-calibration, 72 experimental sentences were displayed to the participant. The eye tracker was checked and re-calibrated on a regular basis.

RESULTS

The two eye-movement measures computed were (1) first fixation duration and (2) gaze duration. Loss of data occurred because of display changes occurring too early or track loss or blinks occurring. Prior to conducting the analyses, trials were removed if first fixation duration or gaze duration on the target or pre-target words was skipped or fixation duration was less than 100 ms or if first fixation duration on the target word was greater than 800 ms. This resulted in 86.65% of the data remaining for analysis. Furthermore, separate means were calculated for each participant and item for first fixation duration and gaze duration. For each of these measures, outliers of more than 2.5 *SD* above the mean were replaced by the cut-off value. The percentage of times the target word was skipped was examined because this percentage could be affected by the preview manipulation. For the identical, 4.2% of trials were skipped; for the affix, 2.9% of trials were skipped; and for the control, 4.7% of trials were skipped, which were not significantly different from one another ($p > .1$). The skipping rate for target affix words, 2.3%, and for pseudo-affix words, 4.7%, was not significantly different ($p > .1$).

A 3 (preview type: identical, affix, control) x 2 (target word type: morphological, orthographic control) X 2 (affix type: prefix, suffix) analysis of variance (ANOVA) was conducted for first fixation duration and gaze duration with error variance computed within participants (F_1) and between items (F_2). Planned contrasts were also performed to compare preview effect sizes. The results of the reading time measures are presented in Table 3. There was no effect of target word type, that is, between morphological and orthographic or between prefix and suffix conditions for first fixation or gaze duration (Fs < 1). Significantly, there was no interaction effect between preview type and target word for first fixation or gaze duration (Fs < 1). These results indicate that there is not a morphological preview benefit effect when reading Malay, which is consistent with the results identified in English (Lima, 1987; Kambe, 2004) and

Finnish (Bertram and Hyönä, 2007) but is not consistent with results in Hebrew (Deutsch et al., 2003; 2005).

Table 3: Mean of first fixation duration and gaze duration in milliseconds on the target word

	Morphologically related preview		Orthographic control preview	
Dependent variable	First fixation duration	Gaze duration	First fixation duration	Gaze duration
Preview condition				
Identical	247	269	242	271
Affix only	265	304	265	309
Control	276	326	279	329

There was a significant effect of preview type for first fixation duration, $F_1(2, 28) = 11.51$, $p < .001$, $\eta_p^2 = .284$; $F_2(2,70) = 16.72$, $p < .001$, $\eta_p^2 = .285$ and gaze duration, $F_1(2,28) = 16.26$, $p < .001$, $\eta_p^2 = .359$, $F_2(2,70) = 23.54$, $p < .001$, $\eta_p^2 = .359$. For first fixation duration, the identical preview was significantly shorter than the affix preview (20 ms), $t_1(29) = 3.22$, $p < .01$; $t_2(71) = 4.53$, $p < .001$ and control preview (33 ms), $t_1(29) = 4.01$, $p < .001$; $t_2(71) = 5.33$, $p < .001$. Similarly, for gaze duration, the identical preview was significantly shorter than the affix preview (37 ms), $t_1(29) = 4.72$, $p < .001$; $t_2(71) = 5.45$, $p < .001$, and control preview (58 ms), $t_1(29) = 4.90$, $p < .001$; $t_2(71) = 6.36$, $p < .001$. The affix preview was marginally significantly shorter than the control preview for both first fixation duration (13 ms), $t_1(29) = 2.11$, $p<.05$; $t_2(71) = 1.91$, $p = .06$, and gaze duration (21 ms), $t_1(29) = 1.97$, $p = .06$; $t_2(71) = 1.91$, $p = .06$. Thus, partial word information from the affix appears to have had a beneficial although small effect on subsequent target word processing.

DISCUSSION

In the current study on reading in Malay, there was no difference between affix words and pseudo-affix words in the morphological and orthographic control conditions for first fixation or gaze duration. If morphological information influences initial processing, then we expect shorter reading durations for affixed words compared with pseudo-affixed words. However, the preview benefit effect was similar for both morphological and orthographic conditions, and there was no interaction effect between target word type and preview condition. Hence, the results obtained for Malay failed to show any evidence of a preview benefit effect because of morphological pre-processing, which is consistent with research conducted on English (Lima, 1987; Kambe, 2004) and Finnish (Bertram and

Hyönä, 2007), but not Hebrew (Deutsch et al., 2003; 2005). As in previous research, the identical preview condition had the greatest parafoveal benefit effect (e.g. Deutsch et al., 2005; Kambe, 2004). Thus, readers benefitted the most by having the entire word available in the parafovea. The affix preview condition did have shorter fixation durations on the target word than in the control condition, although the effect was small. An additional finding was that there was no difference between the parafoveal preview benefit effects in word-initial and word-final constituents because similar trends or patterns were exhibited. This could be because of the relatively short length of the suffix target words used in the current study.

It appears from these contrasting results that early morphological processing is language- or orthographic-specific. These results on Malay and Finnish (Bertram and Hyönä, 2007) suggest that morphological benefit effects are not necessarily associated with highly inflected languages per se but are a result of the particular morphological characteristics of the language. Hebrew has root and verbal or nominal morphemes, which are not concatenated or affixed, but are instead interwoven to form words. Research on Hebrew indicates that frequency and usage are also important factors to consider, as is the amount of information conveyed within the morphological constituent (Deutsch et al., 2005). It appears that lexical space in Hebrew (and Arabic, another Semitic language: [Perea, Abu Mallouh and Carreiras, 2010]) is structured according to morphological roots, whereas European languages are structured according to full orthographic/phonological forms (Frost et al., 2005). Notably, this does not appear to be the case for Maltese, another Semitic language, which represents both consonants and vowels in the Latin-based orthography, unlike Hebrew and Arabic. In addition, Maltese appears to have quite a productive non-Semitic (mostly Romance) morphology (Perea et al., 2012).

In conclusion, the results from the current study indicate that morphological constituents do not facilitate early word processing in the parafovea when reading Malay. It appears that although Malay is a morphologically rich language and has a relatively transparent orthography, readers do not necessarily use early morphological processes. This is consistent with research conducted on English (Lima, 1987; Kambe, 2004) and Finnish (Bertram and Hyönä, 2007). In contrast, morphological pre-processing does occur in Hebrew because of its distinctive non-concatenated morphology. Language-specific characteristics thus appear to play an important role in morphological pre-processing. Although this study is clearly preliminary, it does indicate the necessity of investigating morphological pre-processing in diverse languages with different morphological structures and characteristics. In the future, we intend to conduct further experiments on reading in Malay.

ACKNOWLEDGEMENTS

We would like to thank Professor Sally Andrews for the use of the laboratory facilities at the School of Psychology, University of Sydney, Bernard Lo and Shazli Mahmood from the Malaysian Student Society at the University of Sydney and Peter Sammut for research assistance. This study was supported by Universiti Kebangsaan Malaysia (ERGS/1/2011/SSI/UKM/02/5).

REFERENCES

Asmah Hj. Omar. 1980. *Nahu Melayu mutakhir*. Kuala Lumpur: Dewan Bahasa dan Pustaka.

Altarriba, J., G. Kambe, A. Pollatsek and K. Rayner. 2001. Semantic codes are not used in integrating information across eye fixations in reading: Evidence from fluent Spanish-English bilinguals. *Perception and Psychophysics* 63: 875–890.

Ashby, J., R. Treiman, B. Kessler and K. Rayner. 2006. Vowel processing during silent reading: Evidence from eye movements. *Journal of Experimental Psychology: Learning, Memory and Cognition* 32: 416–424.

Balota, D. A., A. Pollatsek and K. Rayner. 1985. The interaction of contextual constraints and parafoveal visual information in reading. *Cognitive Psychology* 17: 364–390.

Bertram, R. and J. Hyönä. 2007. The interplay between parafoveal preview and morphological processing in reading. In *Eye movements: A window on mind and brain*, eds. R. G. van Gompel, M. H. Fischer, W. S. Murray and R. L. Hill, 391–407. Oxford: Elsevier Science.

Boudelau, S. and W. D. Marslen-Wilson. 2001. Morphological units in the Arabic mental lexicon. *Cognition* 81: 65–92.

Chace, K. H., K. Rayner and A. D. Well. 2005. Eye movements and phonological parafoveal preview: Effects of reading skill. *Canadian Journal of Experimental Psychology* 59: 209–217.

Deutsch, A., R. Frost, A. Pollatsek and K. Rayner. 2005. Morphological parafoveal preview benefit effects in reading: Evidence from Hebrew. *Language and Cognitive Processes* 20: 341–371.

Deutsch, A., R. Frost, S. Pelleg and K. Rayner. 2003. Early morphological effects in reading: Evidence from parafoveal preview benefit in Hebrew. *Psychonomic Bulletin & Review* 10: 415–422.

Deutsch, A., R. Frost and K. Forster. 1998. Verbs and nouns are organised and accessed differently in the mental lexicon: Evidence from Hebrew. *Journal of Experimental Psychology: Learning, Memory & Cognition* 24: 1238–1255.

Drews, F. and P. Zwitserlood. 1995. Morphological and orthographic similarity in visual word recognition. *Journal of Experimental Psychology: Human Perception & Performance* 21: 1098–1116.

Drieghe, D., M. Brysbaert, T. Desmet and C. De Baecke. 2004. Word skipping in reading: On the interplay of linguistic and visual factors. *European Journal of Cognitive Psychology* 16: 79 –103.

Frost, R., T. Kugler, A. Deutsch and K. I. Forster. 2005. Orthographic structure versus morphological structure: Principles of lexical organization in a given language. *Journal of Experimental Psychology: Learning, Memory and Cognition* 31: 1293–1326.

Grainger, J., P. Cole and J. Segui. 1991. Masked morphological priming in visual word recognition. *Journal of Memory & Language* 30: 370–384.

Henderson J. M. and F. Ferreira. 1990. Effects of foveal processing difficulty on the perceptual span in reading: Implications for attention and eye movement control. *Journal of Experimental Psychology: Learning, Memory & Cognition* 16: 417–429.

Hyöna, J. and R. Bertram. 2004. Do frequency characteristics of non-fixated words influence the processing of non-fixated words during reading? *European Journal of Cognitive Psychology* 16: 104–127.

Inhoff, A. W. 1989. Parafoveal processing of words and saccade computation during eye fixations in reading. *Journal of Experimental Psychology: Human Perception and Performance* 15: 544–555.

Johnson, R. L., M. Perea and K. Rayner. 2007. Transposed-letter effects in reading: Evidence from eye movements and parafoveal preview. *Journal of Experimental Psychology: Human Perception and Performance* 33: 209–229.

Juhasz, B. J., A. W. Inhoff and K. Rayner. 2005. The role of interword spaces in the processing of English compound words. *Language and Cognitive Processes* 20: 291–316.

Just, M. A. and P. A. Carpenter. 1987. The psychology of reading and language comprehension. Boston: Allyn and Bacon.

Kambe, G. 2004. Parafoveal processing of prefixed words during eye fixations in reading: Evidence against morphological influences on parafoveal preprocessing. *Perception and Psychophysics* 66: 279–292.

Laudana, A., A. Cermele and A. Caramazza. 1997. Morpho-lexical representation in naming. *Language & Cognitive Processes* 12: 49–66.

Lima, S. D. 1987. Morphological analysis in sentence reading. *Journal of Memory and Language* 26: 84–99.

Marslen-Wilson, W., L. K. Tyler, R. Waksler and L. Older. 1994. Morphology and meaning in the English mental lexicon. *Psychological Review* 101: 3–33.

Morris, R. K., K. Rayner and A. Pollatsek. 1990. Eye movement guidance in reading: The role of parafoveal letter and space information. *Journal of Experimental Psychology: Human Perception & Performance* 16: 268–281.

Nik Safiah Karim, Farid M. Onn and Hashim Hj. Musa. 1989. *Tatabahasa Dewan. Jilid 2: Perkataan*. Kuala Lumpur: Dewan Bahasa dan Pustaka.

Perea, M., R. Abu Mallouh and M. Carreiras. 2010. The search of an input-coding scheme: Transposed-letter priming in Arabic. *Psychonomic Bulletin & Review* 17: 375–380.

Perea, M., A. Gatt, C. Moret-Tatay and R. Fabri. 2012. Are all Semitic languages immune to letter transpositions? The case of Maltese. *Psychonomic Bulletin and Review* 19: 942–947.

Pollatsek, A., M. Lesch, R. K. Morris and K. Rayner. 1992. Phonological codes are used in integrating information across saccades in word identification and reading. *Human Perception & Performance* 18: 148–162.

Prentice, D. J. 1987. Malay (Indonesian and Malaysian). In *The world's major languages*, ed. B. Comrie, 913–935. London: Croom Helm.

Rayner, K. 1998. Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin* 124: 372–422.

______. 1975. The perceptual span and peripheral cues in reading. *Cognitive Psychology* 7: 65–81.

Rayner, K. and R. K. Morris. 1992. Eye movement control in reading: Evidence against semantic preprocessing. *Journal of Experimental Psychology: Human Perception and Performance* 18: 163–172.

Rayner, K. and A. Pollatsek. 1989. *The psychology of reading*. New York: Prentice-Hall.

Rayner, K., D. A. Balota and A. Pollatsek. 1986. Against parafoveal semantic preprocessing during eye fixations in reading. *Canadian Journal of Psychology* 40: 473–483.

Rayner, K., A. W. Inhoff, R. E. Morrison, M. L. Slowiaczek and J. H. Bertera. 1981. Masking of foveal and parafoveal vision during eye fixations in reading. *Journal of Experimental Psychology: Human Perception and Performance* 7: 167–179.

Reichle, E. D., K. Rayner and A. Pollatsek. 2003. The E-Z reader model of eye movement control in reading: comparisons to other models. *Behavioral and Brain Sciences* 26: 445–476.

Rickard, L. S. J. and L. L. Choo. 2004. Metalinguistic awareness and semi-syllabic scripts: Children's spelling errors in Malay. *Reading and Writing: An Interdisciplinary Journal* 17: 7–26.

Slattery, T. J., A. Pollatsek and K. Rayner. 2006. The time course of phonological and orthographic processing of acronyms in reading: Evidence from eye movements. *Psychonomic Bulletin & Review* 13: 412–417.

Starr, M. S. and K. Rayner. 2001. Eye movements during reading: Some current controversies. *Trends in Cognitive Sciences* 5: 156–163.

Tsai, J.-L., C.-Y. Lee, O. J. L. Tzeng, D. L. Hung and N.-S. Yen. 2004. Use of phonological codes for Chinese characters: Evidence from processing of parafoveal preview when reading sentences. *Brain and Language* 91: 235–244.

Velan, H. and R. Frost. 2011. Words with and without internal structure: What determines the nature of orthographic and morphological processing? *Cognition* 118: 141–156.

______. 2007. Cambridge University versus Hebrew University: The impact of letter transposition on reading English and Hebrew. *Psychonomic Bulletin & Review* 14: 913–918.

Williams, C. C., M. Perea, A. Pollatsek and K. Rayner. 2006. Previewing the neighbourhood: The role of orthographic neighbours as parafoveal previews in reading. *Journal of Experimental Psychology: Human Perception and Performance* 32: 1072–1082.

Zaharani Ahmad. 2009. Memasyarakatkan kajian morfologi dalam dunia Melayu. *Jurnal Bahasa* 9(1): 118–136.

Zhou, X., W. Marslen-Wilson and M. Taft. 1999. Morphology, orthography, and phonology in reading Chinese compound words. *Language and Cognitive Processes (Special issue: Processing East Asian languages)* 14(5–6): 525–565.