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Asymmetry in Perceptual Span in Reading English as L2

Aparna Pandey and Prakash Padakannaya

Abstract

Effective visual field in reading, called perceptual span (PS), is a language / orthographic dependent feature. PS has been found to be asymmetric towards left or right depending on the directionality in which languages are written. PS for English is found 3-4 character spaces to the left of fixation and around 14-15 character spaces to the right of the fixation (asymmetric towards right). PS for Chinese, on the other hand, is one character space to the left and three character spaces to the right of the fixation. PS for Hebrew, however, is asymmetric towards left as it is read right to left. In the present study we examined asymmetry in PS for a group of Indian students reading English. Using a moving window paradigm, we found that the extent of asymmetry was four character spaces to the left of fixation as has been reported for native readers of English. Thus, the study supports the view that PS for reading a language does not vary across cultures.

Keywords: *Perceptual span, asymmetry, moving window paradigm.*

Introduction

Perceptual span (PS) or span of effective visual field refers to how much information a reader gathers while focusing on a region of text. It is influenced by the properties and characteristics of language/orthography (DenBuurman, Roersma, & Gerrissen, 1981; Ikeda & Saida, 1978; McConkie & Rayner, 1975, 1976b; O'Regan, 1979, 1980; Pollatsek, Rayner, Balota, 1986; Rayner, 1975, 1986; Rayner & Bertera, 1979; Rayner, Well, Pollatsek, & Bertera, 1982; Schotter, & Rayner, 2013; Underwood, & McConkie 1985; Underwood & Zola, 1986). PA for alphabetic orthographies (e.g. English, French, and Dutch etc) is larger than for syllabic (Japanese), alphasyllabic (Indic system), and morphosyllabic orthographies (Chinese) (Ikeda & Saida, 1978; Osaka, 1987, 1992; Osaka & Oda, 1991; Pandey & Padakannaya, in press). The span is asymmetric towards the direction of reading. In languages which are read left to right PS is asymmetric towards right and for the languages that are read right to left (e.g. Hebrew) PS is asymmetric towards left (Inhoff & Liu, 1997, 1998; McConkie & Rayner; 1976a; Osaka 1993; Pandey & Padakannaya, in press; Pollatsek, Bolozky, Well, &

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Rayner, 1981; Rayner, 1986, Rayner, Well, & Pollatsek, 1980; Shen, Bai, Yan, & Liversedge, 2009). In English, PS was observed about 3-4 characters to the left and 14-15 characters to the right of fixation point. In Chinese PS extends from one character space to the left to three character spaces to the right (Inhoff & Liu, 1998).

Eye gaze contingent paradigm developed by Rayner and McConkie (1975) called moving window paradigm is generally employed method in such studies. In this paradigm only fixed number of characters is visible for readers to read; rest of the text is replaced by any common character per se 'X' (see Rayner, 1998). Rayner and McConkie (1975) using 13, 17, 21, 25, 31, 37, 45 and 100 character window sizes recorded reading time, number of regressive movements, saccade lengths for forward saccades, fixation durations and number of fixations. They concluded from their results that readers gain information from a limited area during a fixation that is about 17 to 19 character spaces to the either side of the fixation.

In a subsequent study, McConkie and Rayner (1976a) compared eye movements using the following windows: (1) 20 character to the left and 20 characters to the right, (2) 20 characters to the left and four characters to the right, and (3) four characters to the left and 20 characters to the right. They found that reading was seriously disrupted in second condition while it was normal in the other two conditions.

In another study, Rayner et.al (1980) used asymmetric windows such as 14 characters to the right and 0, 1, 3, and 14 characters to the left and vice versa. They found that asymmetry in English can extend up to 3-4 characters to the left and then breaks down. Pollatsek, et. al. (1981) repeated the experiment with English- Hebrew bilinguals for the languages. They used the following window sizes: (1) 14 characters to the left and 14 characters to the right, (2) 14 characters to the left and four characters to the right, and (3) four characters to the left and 14 characters to the right. They found that reading in English was disrupted in condition 2 while it was

condition 3 for Hebrew. Similarly PS was found skewed in the direction of scanning in other languages also like Chinese and Japanese (Chen & Tang, 1998; Ikeda & Saida, 1978; Inhoff, & Liu, 1998; Osaka, 1987, 1992; Osaka & Oda, 1991).

In fact, directional scanning effect has been observed even in other cognitive tasks like picture naming and recall. Readers of Urdu and Arabic (which are read right to left) showed right to left directional scanning effect where as readers of Kannada (which is read left to right) showed the effect in the opposite direction (Padakannaya, Devi, Zaveria, Chengappa & Vaid, 2002).

Focus of This Study

Present study was conducted to examine the asymmetry of perceptual span in reading English for a group of Indian adults for whom English was not their mother tongue. However, they were proficient in the Language as they studied the language from their very beginning of the school.

Method

Participants

Thirteen University students with an average age of 23.8 yrs (age range 18- 30) participated in the study. All the participants had studied the schools where medium of instruction was English but their mother tongue was other than English. All the participants had normal or corrected to normal vision.

Stimulus Material

A large number of sentences were selected from the English text books of grades I to V. 150 simple sentences (with one independent clause and no dependent clause) and 150 syntactically complex sentences (with one independent clause and one dependent clause) were selected. All the sentences were cross verified with experts and modified according to their suggestions. Out

of the 300 sentences 150 sentences (half from the simple and half from the complex sentence groups) were selected and words were jumbled to make another set of 150 sentences with jumbled words. Finally we had 450 sentences (150 sentences each of three types mentioned) for use in the experiment.

Procedure

Moving window paradigm was used in the study. In this paradigm a window size (measured in terms of character spaces) will be visible to either side of fixation while the rest of sentence is substituted with letter x (xxxxx). As eyes move further and participant makes new fixations, text will be visible in a new window of the same size and the process continues until participants read the whole sentence. The window sizes used in this study were 2(L)-16 (R) (two characters to the left of fixation and 16 characters to the right of fixation), 3(L)--16 (R), 4(L)--16 (R), 5(L)--16 (R), and 16-16 (R). Sixteen characters to the right of fixation was decided based on previous observations that PS in skilled English readers cover about 16 characters to the right of fixation.

Participants were seated in front of a high speed SMI eye tracker with the sampling rate of 1250 Hz. They were instructed not to move their head and body. To ensure it we tied an elastic band to their head and the eye tracker. Further they were asked to make minimal or no eye blink specially during sentence reading. Vision was binocular but data was recorded from the left eye only. Stimulus sentences were presented through PRESENTATION software and data were recorded with iViewX software.

Data Analysis

Eye movement data were viewed in BeGaze software. Reading time, fixation count, average fixation duration, total fixation duration, and scanpath length were calculated and analyzed. These raw scores were analyzed with MANOVA using SPSS.

Results

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For eye movement measures minimum fixation duration was 50 ms and peak velocity threshold was 40 deg/sec. Trials which showed track loss (around 2.34 % of trials) were removed prior to the analysis. Trials in which the mean eye movement measures fell above or below 2 standard deviations of the participants' mean for a given window size (about 4.24 % of trials) were also removed prior to analysis. Trials exclusions affected all conditions similarly ($F < 1$).

Table 1 shows summary of MANOVA results on reading time (time taken to read in ms), fixation count (number of eye fixations), total and average fixation duration, average saccade amplitude (saccade distance in terms of degrees), and scanpath length (sum of all saccade amplitudes in scanpath measured in pixels) measures. Window size had significant effect on reading time, fixation count and total fixation duration measures while other measures did not show significant differences. However, our concern was to see which of the window sizes did not differ from the referential 16 (L) -16 (R) window size. Pair wise post hoc comparisons (Tukey's HSD test) revealed that that four and more character window size at the left was not significantly different from 16-16 condition.

Table 1. Summary of MANOVA Results

Measures	Window Size										F-value
	2L-16R		3L-16R		4L-16R		5L-16R		16L-16R		F WS
	M	SD	M	SD	M	SD	M	SD	M	SD	
RT	7801.64	2717.70	7116.59	205604	6362.76	1521.22	6209.30	1269.99	5400.37	961.73	11.76***
FC	25.00	7.58	23.15	6.59	20.89	3.95	20.19	3.68	18.51	3.01	11.06***
TFD	6059.31	2453.19	5551.94	1650.22	4941.22	1547.79	4886.29	1307.64	4199.58	1086.97	7.76***
AFD	238.85	40.81	242.73	26.09	237.74	45.14	242.62	41.71	229.76	43.11	0.65
ASA	2.84	0.64	2.85	0.83	3.28	1.31	3.40	2.51	3.05	1.16	1.14
SPL	1839.99	734.22	1816.43	1018.09	1756.39	1234.04	1532.08	466.55	1372.04	301.68	2.30

Note: RT = Reading time; FC = Fixation count; TFD = Total Fixation Duration; AFD = Average fixation duration; ASA = Average saccade amplitude; SPL = Scanpath length; FL = full length condition; L = Left; R = Right.

* $p < 0.05$; ** $p < 0.005$; *** $p < 0.000$.

Table 2. Summary of Tukey's HSD multiple comparison test

Pair-wise comparison for window size		16L16R-2L16R	16L16R-3L16R	16L16R-4L16R	16L16R-5L16R
RT	S	S	NS	NS	
FC	S	S	NS	NS	
TFD	S	S	NS	NS	
AFD	NS	NS	NS	NS	
ASA	NS	NS	NS	NS	
SPL	NS	NS	NS	NS	

Note: RT = Reading time; FC = Fixation count; TFD = Total Fixation Duration; AFD = Average fixation duration; ASA = Average saccade amplitude; SPL = Scanpath length; L = Left; R = Right.
NS = Not significant.

Discussion

The obtained results suggest that the Indian skilled readers of English show similar eye movement patterns as native speakers, though English is not their mother tongue. The results also suggest that the probably the proficiency level of language determines the eye movements pattern in reading a language even if the language is acquired in school going age. The present study also supports the view that the perceptual span in reading is a language dependent measure. All proficient readers of the language across cultures exhibit comparable perceptual size and directional asymmetry. In this case, perceptual span for English was observed to be about 4 characters to the left and 16 characters to the right to the fixation, which is in accordance with published literature (Inhoff & Liu, 1998).

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