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AN INVESTIGATION OF THE INTERACTION BETWEEN THE VISUAL SPAN AND WORD SUPERIORITY EFFECT IN CENTRAL AND PERIPHERAL READING

I Thomas Kollodge, hereby release this Paper as described above to Ferris State University with the understanding that it will be accessible to the general public. This release is required under the provisions of the Federal Privacy Act.

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Date

AN INVESTIGATION OF THE INTERACTION BETWEEN THE VISUAL SPAN AND WORD SUPERIORITY EFFECT IN CENTRAL AND PERIPHERAL READING

By

Thomas Steven Kollodge

This paper is submitted in partial fulfillment of the

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AN INVESTIGATION OF THE INTERACTION BETWEEN THE VISUAL SPAN AND WORD SUPERIORITY EFFECT IN CENTRAL AND PERIPHERAL READING

By

Thomas Steven Kollodge

Has been approved

May 2015

APPROVED:

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Faculty Course Supervisor

Ferris State University

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ABSTRACT

Background: The visual span is hypothesized to be a low-level sensory bottleneck for reading. While both reading speed and visual span size decreases with increasing retinal eccentricity, the decrease in reading speed cannot be completely accounted for by the decreases in visual span size alone. This implicates an additional limitation associated with peripheral reading processes. This study investigated the qualitative and quantitative interaction between word facilitation and letter recognition in central and peripheral reading. *Methods:* The visual span for trigrams (random 3 letter strings) and words were measured in 14 subjects between the ages of 20 and 30 years old with normal reading abilities. Letter and word sequences were presented to each participant at 0, 5, and 10 degrees retinal eccentricity for 100 milliseconds (ms). Words consisting of 3 letters were also presented to each subject at the same eccentricity and time parameters as the random letter sequences. *Results:* Recognition of trigrams decreased as retinal eccentricity increased. The recognition of 3 letter words, when presented under the same experimental conditions, was better than the trigrams. A relationship was observed between the recognition of the letter sequences and words. If at least 50% of letters comprising trigrams were correctly recognized, word recognition was near 100%. *Conclusions:* Word recognition is largely dependent on the ability to recognize individual letters. Processes involved in lexical inferences appear to be both qualitatively and quantitatively similar for central and peripheral reading

processes. These results suggests that differences in the efficiency of lexical inferences do not limit peripheral reading.

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CHAPTER 1

INTRODUCTION TO READING AND THE VISUAL SPAN

Reading is a complex task which takes time to develop the skills necessary to be performed efficiently.[1,2] Many theories have been proposed for how reading takes place, but the phonologic theory is most widely accepted.[2] It states that individuals must be able to recognize each letter, letter string, and the sounds they make.[2] Readers must then be able to break down words into phonemes; distinct sounds and syllables of a word.[2] These phonemes are the building blocks of whole words. Any difficulties that someone may have within these steps will negatively affect their ability to read. In order to properly study reading, it needs to be broken down into its individual facets to decrease or eliminate influences from other aspects of the entire process.

The visual span is one component which may be a measure of a low level reading process.[3] It refers to the number of letters that are correctly recognized during a glance.[3] This process works independently of more advanced contributions to reading such as: context, vocabulary, syntax, and semantics. Typical foveal readers make numerous visual glances to work their way through text, with each glance enabling them to recognize letters and letter strings. This allows them to recognize phonemes and ultimately enables them to read. The length of the visual span can be measured by flashing up a random sequence of letters, on or near a fixation point, usually for a period less than the latency of an eye movement.[3,4] The proportion of letters seen correctly is then plotted for each letter position. Figure 1 shows the average (±95% CI) visual span for 15 normal college students.

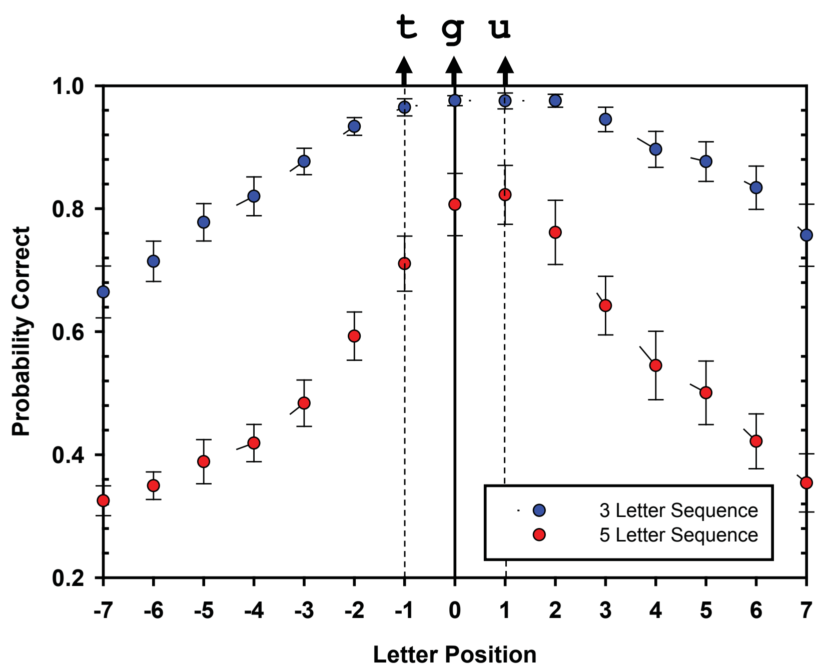

Figure 1: A plot of the visual span for trigrams (3 Letter Sequence) and pentagrams (5 Letter Sequence) at and around fixation. The y-axis plots the probability of correctly identifying a letter (±95% CI) at each letter position. The x-axis represents the 15 letter positions (-7 to 7). Letter position 0 refers to the fixation point, with negative letter positions being left of fixation and positive letter positions being right of fixation. The spacing between individual letters on the plot was about 0.86 degrees. For example, if the trigram "tgu" was presented centered at fixation, "t" would be at position -1, "g" at 0, and "u" at 1.

Notice in Figure 1 that the ability to correctly identify letters decreases as they increase in distance from the fixation point. This is not due to a reduction in visual acuity, as the size of the letters was specifically chosen to be larger than the resolution capacity of the visual system. The decrease is largely due to crowding effects and a reduction in positional accuracy in peripheral vision.[5]

The visual span has been hypothesized to be a sensory bottleneck for the process of reading.[6] Numerous experiments have decreased the size of the visual span by adjusting factors such as: contrast, letter size, letter spacing, letter string length, and duration of presentation.[6,7] Some of these factors including letter size, inter-letter spacing, and presentation duration have shown to decrease reading speed.[6-8] Developmental changes in the reading span have been shown to have a positive correlation with developmental changes in reading speed.[10] These observations have formed the basis for the visual span being the sensory bottleneck for higher level reading processes.[6] This theory states that the smaller the visual span, the less information that can be extracted at a time. Legge et al have shown that the visual span decreases in size as subjects read with their peripheral retina as opposed to with their fovea.[4] This may be part of the reason why low vision patients who use eccentric viewing, such as those with macular degeneration, are slower at reading. This reduction in the visual span forces the peripheral reader to perform more saccades to see the same amount of text compared to a foveal reader.[4]

In a recent study, it has been shown that the visual span decreases by 40% when the string length is increased from 3 letters to 5 letters for normal college-level readers.[11] However, the reading speeds of high frequency words of the same lengths were not very different. The sensory bottleneck theory would predict that longer words would be read less efficiently compared to words of a shorter length.

The inconsistency mentioned previously forms the basis for this research project. It indicates there may be more factors that affect reading speed, other than just the visual span. More specialized reading processes may exist that allows for correct word identification even though individual letter recognition is poor. Similar observations where words are more easily recognized than letters have been noted before. It has been termed the Word Superiority Effect (WSE).[12,13] While the exact mechanisms producing the WSE are still unclear, most algorithms that were proposed to model such behavior require a well-developed lexical bank. Hence, it is conceivable that qualitative and quantitative disruption to processes involved in the WSE could manifest as decreases in reading abilities. Reading with eccentric viewing has been shown to be reduced despite adequate magnification.[4, 5, 7-9] It has been hypothesized that that the reduced reading speed associated with peripheral reading is due to combined influences from a narrower visual span, and slower word processing associated with peripheral retinal regions.[14] In this study we investigated whether there exists qualitative and quantitative differences between the WSE in central and peripheral viewing in normal sighted subjects.

Applications of this study may benefit people who use eccentric viewing due to a loss of central vision, from causes such as macular degeneration, macular holes, and various other pathologies of the macula.

CHAPTER 2

METHODS

2.1 General Methods

Letter identification accuracy was calculated for 14 undergraduate and graduate students using random 3 letter trigram methods adopted from Legge et al.[3-6] All testing was performed with a program written on MATLAB™. Stimuli were presented using the Psychophysics toolbox on a 21 inch Dell Trinitron CRT monitor with a screen refresh rate of 120Hz at a screen resolution of 1024x768. Each pixel on the monitor subtended approximately 2 arc minutes at 0.57 meters, the fixation distance of the subjects. All letters were black, in lowercase Courier font, and high (0.8) contrast. Each letter subtended 0.32 degrees (lowercase x-height) at the 0.57m fixation distance for the central viewing condition, 1.38 degrees at 0.57m for the 5 degree viewing eccentricity, and 2.76 degrees at 0.29m for the 10 degree viewing eccentricity. These sizes were chosen so that they were approximately 2X the critical print size (CPS) reported by Chung et al. (1998).[9] The CPS refers to the smallest print size that yields maximum reading speed, and represents the point when reading speed is no longer dependent on print size. The bright white background of the screen had a luminance of 131 $cd.m^{-2}$. The spacing between letters was kept consistent, at approximately 1.16X the size of a lowercase letter "x", the equivalent of standard spacing. The stimulus duration was 100 milliseconds (ms) for all conditions. A photo-detector and oscilloscope was used to calibrate the temporal presentation duration.

2.2 Subject Selection

All 14 participants were college students between the ages of 20 and 30. Subjects were required to have a visual acuity of 20/25 or better OD, OS, and OU. Participants were selected who did not have a heterotropia, and only a heterophoria between 2 prism diopters esophoria and 8 prism diopters exophoria via an alternating cover test at a distance of 50 cm. The subjects needed to have at least 40 seconds or better of local stereoacuity measured by Wirt Rings, and at least 250” of global stereopsis via the Randot StereoTest™. All participants were tested for any major reading deficiencies using the Woodcock-Johnson® III Diagnostic Reading Battery (WJ III® DRB), in which all results were negative. Subjects were required to exceed a grade 12 equivalent on 5 subtests of the WJ III® DRB: letter-word identification, word attack, reading vocabulary, passage comprehension, and reading fluency. Participants were excluded if they had been previously diagnosed with a reading disability, learning disorder, or developmental delays. Table 1 shows the specific entrance criteria used for this study. During the testing, subjects wore their best spectacle or contact lens correction. The study followed the tenets of the Declaration of Helsinki and all subjects gave written consent after being informed of the nature of the project and possible consequences in order to participate.

Criteria	Specific Condition	Minimum Requirement
Visual Acuity	OD, OS, and OU	20/25 or Better
Phoric Posture	At 50cm	Between 2 Esophoria and 8 Exophoria, With No Heterotropia
Stereopsis	Local	40" or Better
	Global	250" or Better
Woodcock-Johnson® III Diagnostic Reading Battery Subtests	Letter Word Identification	Greater Than Grade 12 Equivalent
	Word Attack	
	Reading Vocabulary	
	Passage Comprehension	
	Reading Fluency	

Table 1: Requirements in order to be eligible to participate in this study. All subjects needed to have 20/25 visual acuity or better OD, OS, and OU; have a heterophoria between 2 esophoria and 8 exophoria at 50 cm; local stereopsis of at least 40”, global stereopsis of 250” or better, and score greater than a grade 12 equivalent on 5 subtests of the WJ III® DRB.

2.3 Measuring Letter Recognition Accuracy with Trigrams

This study utilized the trigram method from Legge et al. to analyze letter identification accuracy.[3-6] The letter recognition was measured for random 3 letter strings, also known as trigrams. The trigrams were presented on the computer monitor at various locations to the left and right of fixation, including the fixation point itself.

Trigrams were made by randomly selecting 3 letters from the entire 26 letter English alphabet. Repeated letters were allowed in the trigrams.

2.4 Procedure

Before testing started, participants fixated between two vertically oriented, black, 6 arc minute squares. They were separated by 72 arc minutes vertically, and located in the middle of the screen; or they fixated on a black 8 arc minute square located at 5 or 10 degrees above the center of the screen. Trigrams were randomly presented in 3 adjacent letter positions at a time, out of the total 17 positions. Only 13 positions, -6 to 6, were used for the central analysis because at these positions each letter could be represented in the 1st, 2nd, or 3rd position within the sequence. Only 9 letter positions (-4 to +4) were used for the 5 and 10 degrees eccentricity due to screen size limitations. Table 2 represents how the letter positioning for analysis was represented. Trigrams or 3 letter words were flashed on the screen for 100 milliseconds. This time was chosen to prevent a saccadic eye movement to view peripheral targets. The subjects typed on a keyboard what they believe they read in sequence from left to right. This was performed at 0, 5, and 10 degrees retinal eccentricity in separate blocks. Letters correctly identified were given a score of 1, whereas incorrectly identified letters were scored as 0. The proportion of correct responses was then calculated for each position at 0, 5, and 10 degrees retinal eccentricity. This value was the cumulative proportion correct of each letter position within a trigram or word, whether it was in the first, middle, or last position within the sequence. Each letter position had 15 repetitions per trial. Therefore, recognition accuracy for each letter position within the visual span was calculated from 45 (15 × 3) presentations for each subject. The same procedure was performed with three-hundred and six (306) 3 letter words from Kilgarriff's word frequency list, available online at: http://www.kilgarriff.co.uk/bnc-readme.html. The same sample of words were used for all 3 eccentricities. Words were randomly assigned to each letter position within each block of trials.

Letter Position																
-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
a	b	c														
	d	e	f													
		g	h	i												
			j	k	l											
				m	n	o										
					p	q	r									
						s	t	u								
							v	w	x							
								y	z	a						
									b	c	d					
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Table 2: A diagrammatical representation of trigram and word positon relative to how letter position was analyzed. Only letter positions -6 through 6 were used because at these positions each letter was sampled as a first letter, second letter, and last letter within a 3 letter sequence. Each trial had 15 repetitions when the letter was at either the 1st, 2nd, or 3rd position in the sequence. This lead to a total of 45 samplings per trial for each subject.

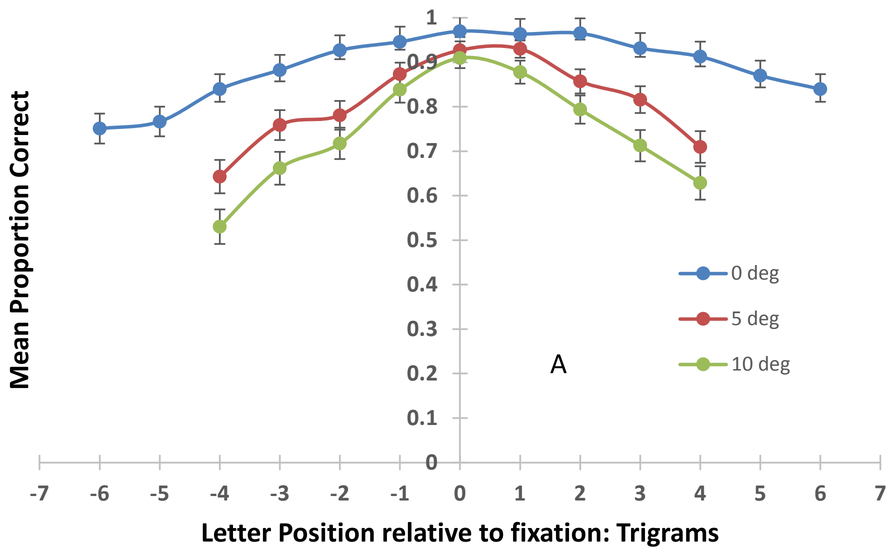
All subjects practiced on the program before data collection began in order to train them with the procedure. Before each trial began, subjects were instructed to maintain fixation at the designated target, but because eye fixation tracking was not utilized, some errors may have occurred due to small fixation discrepancies.

CHAPTER 3

RESULTS

3.1 The Interaction between Letter Sequence Recognition and Word Sense

The term word sense differentiates conditions in which letters were presented as meaningless trigrams, versus conditions in which letters were presented as meaningful 3-letter words. Figure 2 shows the relationship between the letter position relative to fixation and the proportion correct at each position at the three retinal eccentricities tested for trigrams and words. Each datum represents the average proportion correct (±95% CI) between 14 subjects. A decrease in the width of the visual span profile was observed with increasing letter positions to left and right of fixation and as retinal eccentricity increased for random 3 letter sequences. However, profiles obtained for words were consistently wider across all letter positions for each retinal eccentricity when compared to trigrams.



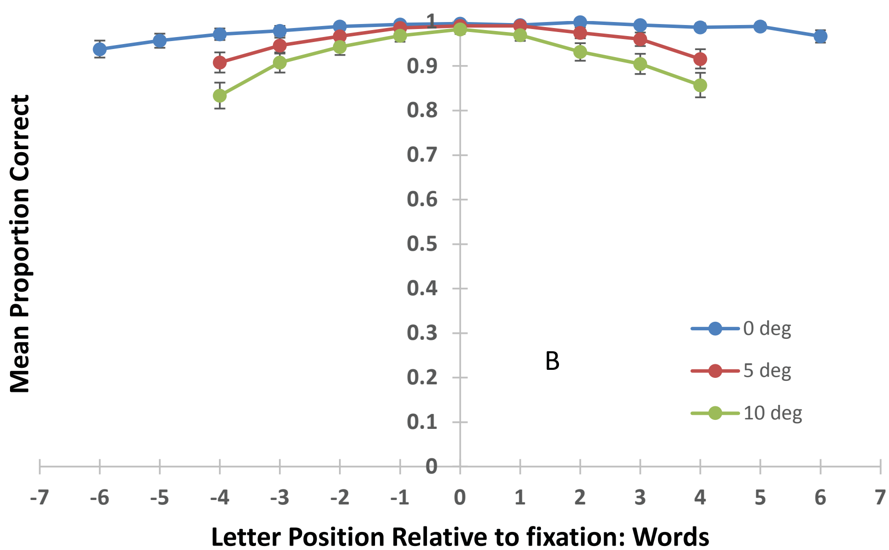


Figure 2A, B: The mean proportion correct (±95% CI) for each letter position relative to fixation for 0, 5, and 10 degrees retinal eccentricity for random 3 letter trigrams (A) and words (B). Each datum is the pooled average proportion correct across 14 subjects.

In an attempt to quantify the width of the profiles, the profiles of each subject for each condition was fitted with a 2nd order polynomial (x(ax+b) +c). The area under each curve was calculated by solving the integral of the best fit polynomial between the two abscissa values -4 to +4 using the integral form indicated below.

$$Area = \int_{-4}^{4} ax^2+bx+c.dx$$

Figure 3 plots the mean area (±95% CI) for trigrams and words for each viewing eccentricity derived from such calculations. Two observations are evident from Figure 3: trigram visual span profiles are significantly narrower than word profiles. Furthermore, as eccentricity increases, the width of the profiles become progressively narrower for both words and trigrams. A two factor repeated measures ANOVA (letter/word condition x eccentricity) on the area under the curves showed significant main effects of letter/word condition ($F(1,83) = 124.01$, $p < 0.001$) and eccentricity ($F(2,83) = 86.504$, $p < 0.001$). There was also a significant interaction effect between letter/word condition and eccentricity, in that the width of the profile depended significantly on the viewing eccentricity (($F(2,83) = 27.041$, $p < 0.001$).

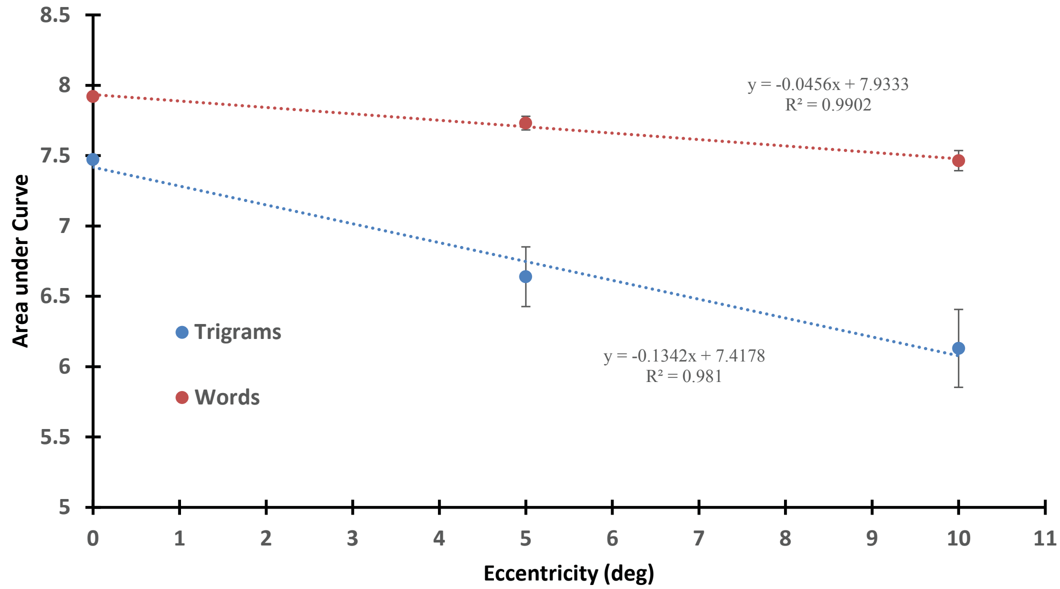


Figure 3: Mean area under the curve (±95% CI) plotted for words and trigrams presented at 0, 5 and 10 degrees of viewing eccentricity. Fine dashed lines represent linear regression fits to the data with corresponding R-square values.

3.2 The Interaction between Lexical Facilitation and Viewing Eccentricity

The Word Superiority Effect (WSE) refers to observations of higher recognition accuracy of letters when presented within words compared to conditions in which letters are presented within random letter sequences (e.g. trigrams). In the context of this study, the magnitude of increase in letter recognition accuracy when letters are presented within meaningful words compared to conditions when letters are presented within random trigrams is referred to as lexical facilitation. An inspection of Figure 3 reveals that areas derived for trigrams were consistently and significantly lower than areas derived for words regardless of viewing eccentricity. This observation is consistent with lexical facilitation. However, Figure 3 also shows that lexical facilitation is not constant across viewing eccentricities as inferred by an almost 3-fold difference in slopes of the best fit linear regression lines indicated in Figure 3. The flatter slope associated with words suggests an increasing influence of lexical facilitation associated with larger viewing eccentricities. A more direct measure of lexical facilitation can be obtained from the ratios between the areas derived for words and letters for each eccentricity. Figure 4 plots the mean ratio (±95% CI) of the areas derived for words and trigrams for their respective viewing eccentricities. While lexical facilitation was approximately 6% for central viewing, this increased progressively to approximately 23% for the 10 degree eccentricity.

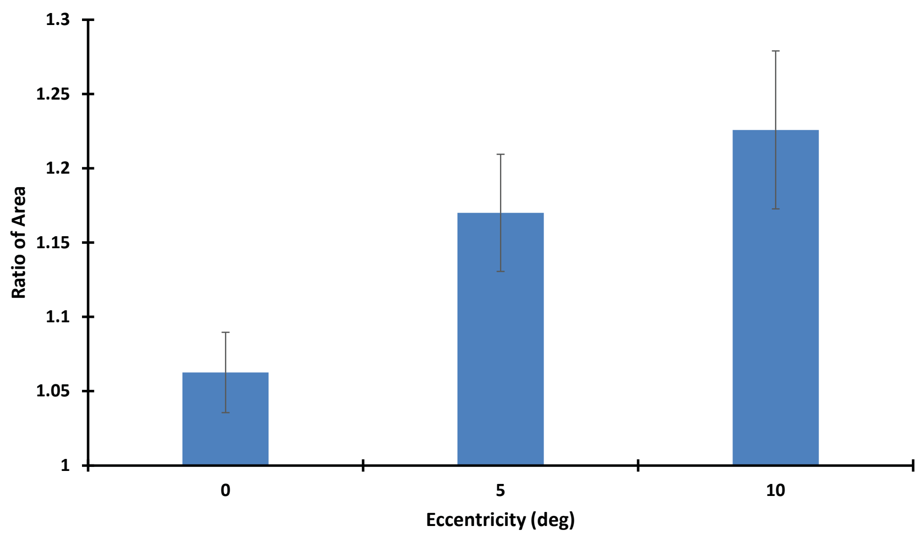


Figure 4: Mean ratio of areas (±95% CI) between words and trigrams for 0, 5, and 10 degrees eccentricity. A one-way repeated measures ANOVA on the mean ratios of areas across 3 levels of eccentricity showed a significant treatment effect ($F(2,41) = 25.91$, $p < 0.001$). There were significant differences between the ratios derived between all 3 eccentricities (Holm-Sidak method, $p < 0.05$).

Hence, lexical facilitation is of smaller magnitude for central viewing compared to peripheral viewing. This observation raises a rather interesting question: are mechanisms producing lexical facilitation equally effective in central and peripheral vision? One plausible hypothesis is that the lexical facilitation is similar in central versus peripheral vision, however, its magnitude is smaller in central vision because the higher levels of letter recognition accuracy associated with central viewing requires smaller magnitudes of lexical facilitation to reach near perfect word recognition. Although, much larger magnitudes of lexical facilitation will be required with peripheral viewing given its poorer ability to recognize individual words. This hypothesis makes two predictions: 1) there should exist a stereotypical interaction between letter recognition accuracy of words and trigrams. 2) This interaction should be invariant with viewing eccentricity.

In an attempt to test this hypothesis, Figure 5 plots the letter recognition in trigrams against the respective letter recognition in words for central viewing conditions only.

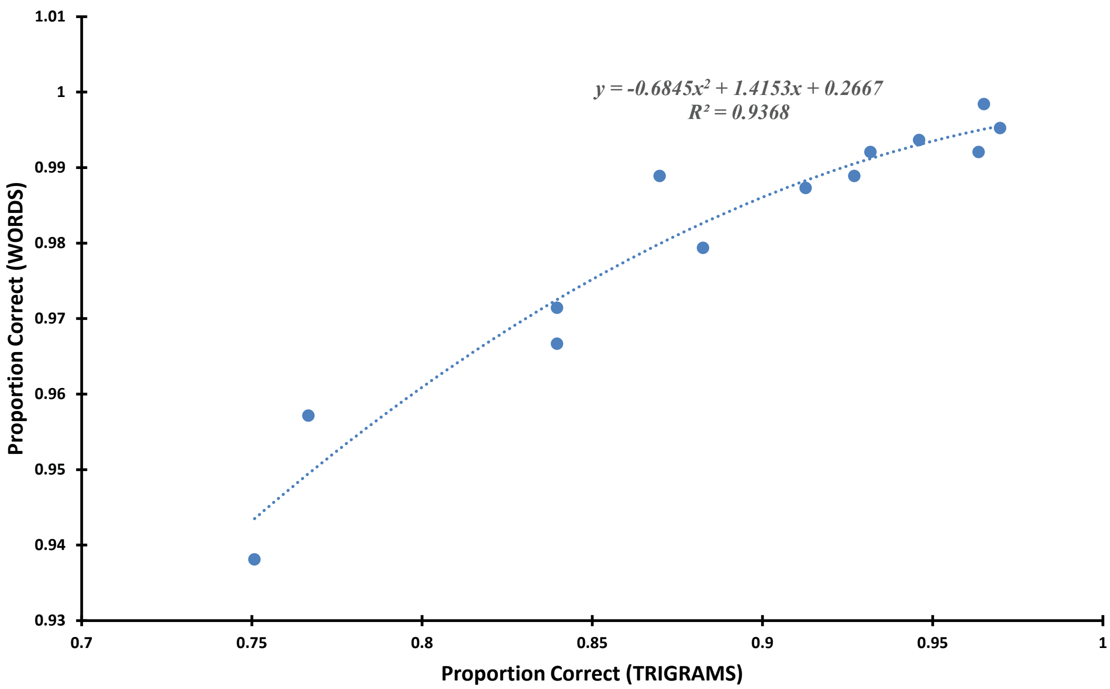


Figure 5: Mean letter recognition accuracy in trigrams is plotted against respective mean letter recognition accuracy in words for central viewing conditions only. The fine dashed line represents the best fit 2nd order polynomial function with associated R square value.

It is evident in Figure 5 that there is indeed a stereotypical relationship between letter recognition of words and trigrams that is well approximated by a non-linear quadratic function. It follows that if the same process operated at the 5 and 10 degree viewing eccentricities, then letter recognition accuracy in words at these eccentric locations should be reasonably approximated by the same nonlinear quadratic function.

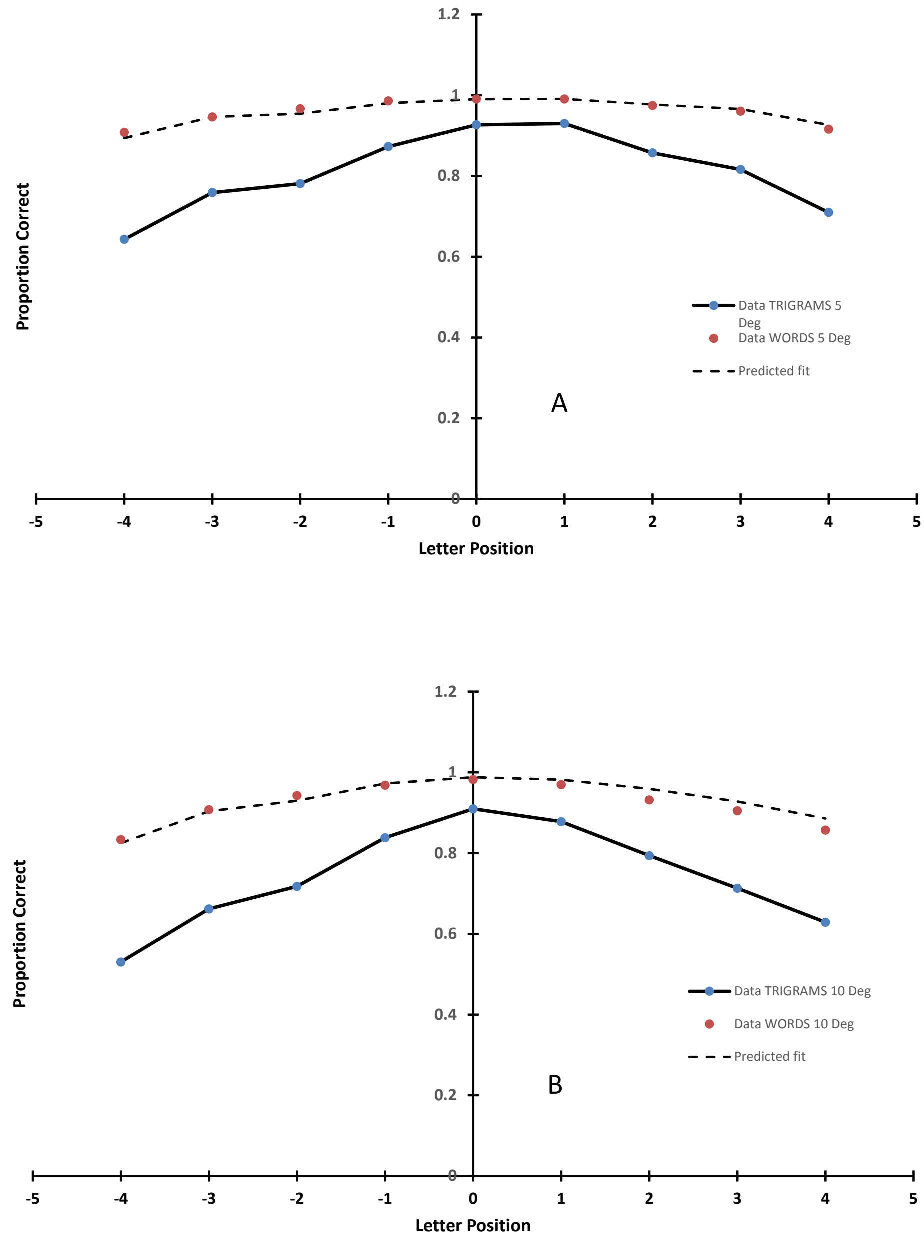


Figure 6: Mean data derived for words (red circles) and trigrams (solid line with blue circles) for the 5 degree (A) and 10 degree (B) eccentricities are plotted as symbols. The dashed line represents the prediction of letter recognition accuracy for the word data based on the polynomial fit derived for central viewing.

Figure 6 A and B plots the empirical data derived for letter recognition accuracy for the 5 degree (A) and 10 degree viewing eccentricity (B). The dashed line represents the fit predicted by the quadratic polynomial derived in Figure 5. It is clearly evident that the polynomial function derived for central viewing very closely approximates letter recognition performance in words at the 5 and 10 degree eccentricities given only letter recognition data in trigrams at that viewing eccentricity.

This result provides rather convincing evidence in support of the hypothesis that the processes producing lexical facilitation are invariant across viewing eccentricities. Furthermore, the magnitude of lexical facilitation scales with letter recognition accuracy of trigrams, i.e. word decoding processes are essentially the same for central and eccentric viewing, and the ability to decode a word primarily depends on being able to identify the individual letters.

CHAPTER 4

DISCUSSION

The visual span decreased as retinal eccentricity increased, which correlates with other studies.[13] The word span also decreased with increasing retinal eccentricity due to the contraction of the visual span. The ability to recognize a word largely depends on the ability to recognize its individual letters, but not completely. This occurs in a mathematically predictable fashion for central and eccentric viewing. The observation that words are recognized easier than trigrams supports the words superiority effect.

The difference in slopes between trigrams and words shown in Figure 3 suggests there are lexical inferences that allow letters within words to be recognized easier than letters within meaningless strings. This result is not surprising as whole words can be inferred from partial or incomplete letter information given a well-developed lexical bank. However, lexical inferences had an exaggerated effect as retinal eccentricity increased. This suggests that effective word recognition in peripheral vision depends significantly on the processes producing lexical facilitation given the poor letter information available at these regions. That is, it seems that peripheral regions must employ best guess strategies to a greater extent to decode words from incomplete or unreliable letter information. Lee at al. (2003) have postulated slower lexical processing of peripheral retinal regions as an additional source for the slower readings speed noted with peripheral vision.[14] The findings of this study suggests it is conceivable that increased perceptual processing delays may be related to the large reliance on lexical inferences of peripheral regions during word decoding. Furthermore, the results of this study also suggest that word decoding is intimately related to the recognition of letters within a string, and this relationship is invariant across retinal or viewing eccentricities.

In conclusion, the ability to decode words is largely dependent on the ability to identify the individual letters. However, as the visual span decreased with increasing retinal eccentricity, the word span did not decrease proportionately. The visual span is likely to be a sensory bottleneck for reading, but lexical facilitation plays a greater role in word decoding with increasing retinal eccentricity. This helps compensate for the reduction in visual span size. As mentioned previously, these results imply that the decline in reading speed for those with low vision who read by eccentric fixation is not likely due to the reduced visual span, but may be due to increased processing time. Lexical facilitation is likely caused by the same processes ultimately responsible for the Word Superiority Effect. Based on the results from this study, the influence of lexical facilitation/Word Superiority Effect is believed to be qualitatively and quantitatively similar for central and peripheral reading.

REFERENCES

1. Adams, MJ. Analyzing the Reading Process: Orthographic Processing. In: Beginning to Read: Thinking and Learning about Print. Cambridge. Bradford. 1994:107-135
2. Shaywitz, S., & Shaywitz, B. (2005). Dyslexia (Specific reading disability). Biological Psychiatry, 57, 1301–1309.
3. Legge, G. E., Ahn, S. J., Klitz, T. S., & Luebker, A. (1997). Psychophysics of reading—XVI. The visual span in normal and low vision. Vision Research, 37(14), 1999–2010.
4. Legge, G. E., Mansfield, J. S., & Chung, S. T. L. (2001). Psychophysics of reading—XX. Linking letter recognition to reading speed in central and peripheral vision. Vision Research, 41(6), 725–743.
5. Legge 2007 - Legge, G. E. (2007). Psychophysics of reading in normal and low vision. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
6. Legge, G. E., Cheung, S.-H., Yu, D., Chung, S. T. L., Lee, H.-W., & Owens, D. P. (2007). The case for the visual span as a sensory bottleneck in reading. Journal of Vision, 7(2):9, 1–15,
7. Latham, K., & Whitaker, D. (1996). A comparison of word recognition and reading performance in foveal and peripheral vision. Vision Research, 36, 2665–2674.
8. Chung, S. T. (2002). The effect of letter spacing on reading speed in central and peripheral vision. Investigative Ophthalmology & Visual Science, 43(4), 1270–1276.
9. Chung, S. T., Mansfield, J. S., & Legge, G. E. (1998). Psychophysics of reading—XVIII. The effect of print size on reading speed in normal peripheral vision. Vision Research, 38(19), 2949–2962.
10. Kwon, M-Y., Legge, G.E. & Dubbels, B. (2007). Developmental changes in the visual span for reading. Vision Research, 47, 2889-2900.
11. Sewell, A., Raghunandan, A. (2011). The effect of string length on the size of the visual span and reading speed. American Academy of Optometry, Boston, MA.
12. Cattell, J. M. (1886). The time it takes to see and name objects. Mind. 11, 63-65.
13. Reicher, G.M. (1969). Perceptual recognition as a function of meaningfulness of stimulus material. Journal of Experimental Psychology, 81, 275-280.
14. Lee, H. W., Legge, G. E., & Ortiz, A. (2003). Is word recognition different in central and peripheral vision? Vision Research, 43(26), 2837–2846.

APPENDIX A

IRB APPROVAL LETTER

Ferris State University

Institutional Review Board (FSU - IRB)
Office of Academic Research
Ferris State University
1201 S. State Street-CSS 310 H
Big Rapids, MI 49307
(231) 591-2553
IRB@ferris.edu

To: Dr. Avesh Raghumandan
From: Dr. Stephanie Thomson, IRB Chair
Re: IRB Application #100704 (Title: *The Effect of Word Length and Word Name on the Reading Span*)
Date: January 28, 2014

The Ferris State University Institutional Review Board (IRB) has reviewed your request for revisions and an extension to continue using human subjects in the study, "*The Effect of Word Length and Word Name on the Reading Span*" (#100704) and approve these requests. This approval has an expiration date of one year from the date of this letter. **As such, you may collect data according to the procedures outlined until January 28, 2015.**

Your project will continue to be subject to the research protocols as mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) for using human subjects in research. It is your obligation to inform the IRB of any changes in your research protocol that would substantially alter the methods and procedures reviewed and approved by the IRB in your application. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,
Ferris State University Institutional Review Board
Office of Academic Research, Academic Affairs