



A Study on the Perceptual Span in Chinese Reading among Uyghur College Students

Xinlin Li^{1,a}, Jiayi Li^{1,b}, Naqin Zhao^{1,c}, Axu Hu^{1,2,*}

¹Northwest Minzu University, Department of Chinese Language and Literature; Key Laboratory of Language and Cultural Computing of Ministry of Education, Lanzhou 730030, China

²Northwest Minzu University, Key Laboratory of Language and Cultural Computing of Ministry of Education, Lanzhou 730030, China

^a812895436@qq.com, ^b654607656@qq.com, ^c2947225741@qq.com,
^{*}huaxu84@foxmail.com

Abstract. This paper systematically reviews the application of eye-tracking technology in studies of Chinese reading among Uyghur learners of Chinese. Existing findings are analyzed from three perspectives: the perceptual span in Chinese character and word reading, eye-movement studies of Chinese texts across different genres, and cross-linguistic comparisons. The analysis reveals the effects of language proficiency and cognitive differences on the cognitive mechanisms underlying reading. Using an experimental approach, the study finds significant differences between Uyghur and Chinese in cognitive processing. Typological features of the two languages influence the range of the perceptual span, while the dynamic adaptation mechanisms of bilingual readers still require further investigation. Future research should strengthen ecological validity, expand the application scenarios of relevant technologies, and construct a theoretical framework of Chinese reading cognition that reflects the characteristics of Uyghur learners.

Keywords: Eye Movements, Uyghur Students, Chinese Language Learning, Perceptual Span, Second Language Acquisition.

1 Introduction

As the language with the largest number of users in the world, Chinese has witnessed a rapid increase in demand as a second language in parallel with its growing international influence.^[1] Learners from diverse ethnic and cultural backgrounds have joined the community of Chinese-language learners. Among them, Uyghur learners are of particular research value because of their distinctive linguistic and cultural system. Uyghur differs markedly from Chinese in phonology, vocabulary, grammar, and other linguistic domains, thereby providing a highly representative sample for research on second language acquisition. The perceptual span in reading is a core indicator in reading-cognition research.^[2] It refers to the range of useful information that readers can obtain during a single fixation, and its size directly reflects the speed and efficiency of information

processing. It is therefore a key parameter for measuring reading-cognition ability. Eye-tracking technology provides an effective means for revealing the dynamic cognitive mechanisms of the reading process. Eye trackers can precisely record the trajectory of eye movements during reading, including fixation locations, fixation durations, and saccade amplitudes. ^[3]These data function as a “reading diary”, allowing researchers to examine how learners acquire, process, and comprehend information during reading. The findings can provide a scientific basis for optimizing Chinese-language teaching methods and improving the Chinese reading ability of Uyghur and other learner groups, thereby advancing research on the teaching of Chinese as a second language^[3].

At the theoretical level, this study helps to verify the applicability of cross-linguistic theories of reading cognition. Because languages differ substantially in phonology, vocabulary, and grammar, their reading-cognition processes also vary according to linguistic characteristics. Uyghur and Chinese belong to different language families. Investigating the perceptual span of Uyghur learners during Chinese reading can therefore test the validity and accuracy of existing cross-linguistic reading theories in explaining the reading behavior of non-native readers.^[4] If a theory can reasonably account for the reading-cognition phenomena observed in this group, it may be considered broadly generalizable; if discrepancies are found, the theory can be revised and refined accordingly. This line of research also broadens the perspective of second language acquisition studies. Traditional second language acquisition research has focused primarily on the acquisition of linguistic components such as vocabulary and grammar, while relatively less attention has been paid to the cognitive processes involved in reading.^[5] Taking perceptual span as a specific entry point makes it possible to reveal in depth the information-processing mechanisms of learners during reading, opening a new path for second language acquisition research and further enriching its theoretical system^[2]. At the practical level, the results of this study can provide a scientific basis for Chinese instruction oriented toward Uyghur learners.^[6] By understanding learners’ perceptual-span characteristics in Chinese reading, teachers can adjust teaching content and methods accordingly. For example, reading materials can be designed with appropriate length and difficulty in line with the range of the perceptual span, and the pace of instruction can be optimized so that learners can acquire and process information more efficiently, thereby improving their Chinese reading ability and overall learning outcomes.

2 Research Techniques and Methods

2.1 Principles of Eye-Tracking Technology

The system of key indicators in eye-tracking technology is an important tool for quantifying visual-cognitive processes. ^[7]First fixation duration reflects participants’ initial attentional capture by a target stimulus and can rapidly reveal the salience of the stimulus. The number of regressions reflects the degree to which participants repeatedly process information; a larger number of regressions may indicate more complex infor-

mation or the presence of cognitive conflict. Pupil diameter, as a physiological indicator, is closely related to cognitive load: as the difficulty of a cognitive task increases, pupil diameter tends to enlarge accordingly.^[8] Saccade amplitude reflects the strategy and range of visual search, with larger amplitudes suggesting a global search strategy and smaller amplitudes indicating more local, fine-grained processing^[2]. The moving-window paradigm provides an effective approach for investigating perceptual span.^[9] By controlling the size and position of the visible region, researchers can progressively reveal the range of information that participants can process simultaneously under different conditions, that is, the perceptual span. This paradigm contributes to a deeper understanding of the parallel and serial characteristics of visual information processing as well as the mechanisms underlying the allocation of attentional resources^[1]. Data collection and analysis are critical for ensuring the reliability of the findings. During data collection, all key indicators must be accurately recorded.^[10] During data analysis, the construction of mixed-effects models can fully account for within-participant and between-participant variability and improve the accuracy of statistical inference. Outlier treatment is also an indispensable step; appropriate methods for handling outliers can prevent extreme data from biasing the results and ensure that the conclusions are valid and scientifically sound.

2.2 Research Methods

Participants. The participants were 10 Uyghur college students from Northwest Minzu University, including five males and five females, with a mean age of 22 years. All 10 participants were native speakers of Uyghur and could read the Uyghur script fluently. They had all taken the Chinese Proficiency Test (HSK) and had reached an advanced level. All participants had normal or corrected-to-normal vision, no color-vision deficiency, no reading disabilities, and were unaware of the purpose of the experiment.

Selection of Materials. The experimental materials presented to the participants consisted of horizontally arranged Chinese sentences. The materials comprised 50 sentences selected from the seventh-grade Chinese-language textbook published by the People's Education Press. Each selected sentence was 16 to 17 Chinese characters in length.^[11]

3 Experimental Results and Analysis

3.1 Means of Eye-Movement Indicators under Different Window Conditions among Uyghur College Students

The means and standard deviations of the five eye-movement indicators across the eight window conditions were first calculated. The results are presented in Table 1.

An analysis of variance (ANOVA) was conducted on the five eye-movement indicators of horizontal Chinese reading among Uyghur college students to examine the window-limitation effect.^[12] The results were as follows: fixation count, $F(7, 56) =$

22.71, $p < 0.01$; total fixation duration, $F(7, 56) = 40.58$, $p < 0.01$; mean fixation duration, $F(7, 56) = 47.51$, $p < 0.01$; reading speed, $F(7, 56) = 16.39$, $p < 0.01$; and rightward saccade amplitude, $F(7, 56) = 18.46$, $p < 0.01$.

Table 1. Means and standard deviations of eye-movement indicators under different window conditions among Uyghur college students.

Window condition	Fixation count	Total fixation duration (ms)	Mean fixation duration (ms)	Reading speed (chars/min)	Saccade amplitude (°)
R0	23.79 (6.00)	10117.42 (2655.94)	279.15 (56.29)	202.00 (40.00)	1.23 (0.34)
R1	17.08 (5.10)	5713.75 (1946.49)	237.14 (63.45)	215.40 (71.47)	1.40 (0.24)
R2	15.56 (5.92)	4997.75 (2323.83)	276.37 (63.16)	265.15 (88.63)	1.63 (0.25)
R3	15.40 (5.54)	4937.30 (1854.47)	334.78 (62.40)	280.17 (86.32)	1.76 (0.35)
R4	14.96 (5.16)	4797.68 (1984.70)	286.42 (59.93)	279.62 (81.78)	1.81 (0.38)
L1R4	13.56 (3.94)	4330.06 (1909.43)	283.87 (57.58)	289.91 (109.39)	1.89 (0.37)
L2R4	13.66 (5.04)	4234.14 (1679.55)	293.53 (56.86)	291.84 (96.81)	1.94 (0.49)
Full line	13.59 (4.43)	4124.15 (1496.20)	278.44 (47.93)	286.86 (93.72)	1.98 (0.43)

Note. Standard deviations are given in parentheses. Saccade amplitude is reported in degrees of visual angle.

These results indicate that the five eye-movement indicators in this experiment exhibited a significant window-limitation effect across the eight window conditions. As shown in Table 1, with the enlargement of the visible window, participants' mean fixation duration and total fixation duration gradually decreased, whereas rightward saccade amplitude increased and reading speed accelerated.^[13]

3.2 Range of the Perceptual Span in Horizontal Chinese Reading among Uyghur College Students

To determine the range of the perceptual span in horizontal Chinese reading among Uyghur college students, two types of comparisons were required. First, the validity of the largest window setting was examined by comparing the largest window condition (L2R4) with the full-line condition, in order to verify that the largest window did not interfere with normal reading. Second, the range of the perceptual span in horizontal Chinese reading among Uyghur college students was determined.^[14]

Table 2. Paired comparison between the L2R4 and full-line conditions on five eye-movement indicators.

Comparison	Statistic	Fixation count	Total fixation duration	Mean fixation duration	Reading speed	Rightward saccade amplitude
L2R4 vs. full line	<i>t</i>	-0.57	1.27	-0.24	0.86	0.43
L2R4 vs. full line	<i>p</i>	0.59	0.54	0.43	0.35	0.69

As shown in Table 2, $p > 0.05$ for all five paired indicators. This indicates that the largest window condition used in this experiment, L2R4 (i.e., a window comprising

two Chinese characters to the left and four Chinese characters to the right of the fixation point), did not differ from the unrestricted full-line condition with respect to reading activity. Under the L2R4 condition, participants' normal reading was therefore not affected.

Table 3. Paired comparisons between window conditions on five eye-movement indicators.

Comparison	Statistic	Fixation count	Total fixation duration	Mean fixation duration	Reading speed	Rightward saccade amplitude
L1R4 vs. R4	<i>t</i>	3.12	1.89	-2.34	-2.41	-2.01
L1R4 vs. R4	<i>p</i>	0.01	0.04	0.038	0.03	0.04
L1R4 vs. L2R4	<i>t</i>	0.39	1.33	0.16	-0.42	-1.20
L1R4 vs. L2R4	<i>p</i>	0.69	0.14	0.75	0.65	0.19
R4 vs. R0	<i>t</i>	12.14	8.50	8.34	-6.34	-6.56
R4 vs. R0	<i>p</i>	0.00	0.00	0.00	0.00	0.00
R4 vs. R1	<i>t</i>	3.91	2.52	2.38	-2.82	-4.43
R4 vs. R1	<i>p</i>	0.01	0.024	0.032	0.02	0.00
R4 vs. R2	<i>t</i>	1.69	0.49	-0.42	-0.40	-2.21
R4 vs. R2	<i>p</i>	0.13	0.65	0.66	0.68	0.04
R4 vs. R3	<i>t</i>	1.02	0.74	-0.82	-0.56	-0.72
R4 vs. R3	<i>p</i>	0.25	0.38	0.35	0.47	0.46

A second set of comparisons was then conducted to determine the perceptual-span range. To determine the range to the left of the fixation point, Table 3 shows that in the paired comparison between L1R4 and R4, all five eye-movement indicators reached statistical significance:^[15] fixation count ($t = 3.12, p < 0.05$), mean fixation duration ($t = -2.34, p < 0.05$), total fixation duration ($t = 1.89, p < 0.05$), reading speed ($t = -2.41, p < 0.05$), and rightward saccade amplitude ($t = -2.01, p < 0.05$). In contrast, the paired comparison between L1R4 and L2R4 yielded no significant differences on any of the five indicators: fixation count ($t = 0.39, p > 0.05$), mean fixation duration ($t = 0.16, p > 0.05$), total fixation duration ($t = 1.33, p > 0.05$), reading speed ($t = -0.42, p > 0.05$), and rightward saccade amplitude ($t = -1.20, p > 0.05$). These results indicate that the L2R4 condition (two characters to the left and four to the right of the fixation point) did not differ significantly from the L1R4 condition (one character to the left and four to the right), suggesting that readers were unable to extract useful information from the second character to the left of the fixation point.

To determine the range of the perceptual span to the right of the fixation point, the paired comparison between R0 and R4 showed that all five eye-movement indicators reached statistical significance: fixation count ($t = 12.14, p < 0.01$), mean fixation duration ($t = 8.34, p < 0.01$), total fixation duration ($t = 8.50, p < 0.01$), reading speed ($t = -6.34, p < 0.01$), and rightward saccade amplitude ($t = -6.56, p < 0.01$). In the comparison between R1 and R4, all five indicators likewise reached statistical significance: fixation count ($t = 3.91, p < 0.05$), mean fixation duration ($t = 2.38, p < 0.05$), total

fixation duration ($t = 2.52, p < 0.05$), reading speed ($t = -2.82, p < 0.05$), and rightward saccade amplitude ($t = -4.43, p < 0.05$). In the comparison between R2 and R4, four eye-movement indicators failed to reach statistical significance: fixation count ($t = 1.69, p > 0.05$), mean fixation duration ($t = -0.42, p > 0.05$), total fixation duration ($t = 0.49, p > 0.05$), and reading speed ($t = -0.40, p > 0.05$). In the comparison between R3 and R4, all five eye-movement indicators failed to reach statistical significance, with rightward saccade amplitude ($t = -0.72, p > 0.05$) finally also reaching the baseline level of full-line reading.

4 Conclusion

The ANOVA results revealed that the eight window conditions in this experiment exerted differential effects on the eye-movement indicators, manifested as a clear window-limitation effect.^[16] The findings also indicate the presence of a parafoveal preview effect during reading.^[17] As the visible window enlarged, fixation count, mean fixation duration, and total fixation duration gradually decreased, reading speed steadily increased, and rightward saccade amplitude expanded.^[18] With respect to the perceptual-span range to the left of the fixation point, the paired comparison between L1R4 and R4 showed significant differences, indicating that participants could acquire information from one Chinese character to the left of the fixation point. With L1R4 as the baseline, the comparison between L1R4 and L2R4 showed no significant differences, indicating that participants could not extract information from the second character to the left of the fixation point. With respect to the perceptual-span range to the right of the fixation point, R4—the largest right-side window condition—was used as the reference and was paired separately with the other right-side window conditions. Significant differences were observed between R1 and R4. In the comparison between R2 and R4, four eye-movement indicators failed to reach statistical significance, and in the comparison between R3 and R4, none of the five indicators reached statistical significance. Based on the paired comparisons across the five eye-movement indicators under different window conditions, it can be inferred that the perceptual span in horizontal Chinese reading among Uyghur college students extends from one Chinese character to the left of the fixation position to two or three Chinese characters to its right.

Acknowledgments

The authors thank the participating students of Northwest Minzu University for their cooperation in this study. This paper is based on the following fund projects, and we express our gratitude here! National Social Science Fund of China (22BYY165); National Natural Science Foundation of China (62366045); Fundamental Operations Budget Project of Central Universities (31920230123); Fundamental Operations Budget Project of Central Universities (31920240027); Special Fund for Basic Scientific Research Operations of Central Universities (31920250001-9); Science Research Project Supported by Shaanxi Provincial Department of Education (23JK0329).

Disclosure of Interests

The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Yao, J.Y.: An eye-movement study on the perceptual span in Chinese reading among Uyghur college students. Master's thesis, Xinjiang Normal University (2012). (in Chinese)https://kns.cnki.net/kcms2/article/abstract?v=VrduTR4bJX4gEVvkWkCQM3l6kz-CXi_FCAEHSmGxW-AT2BV3qoIRvf9n7h9y-s66yGEhdRnHbe--KMwZ5JEJNN-4W5YLtsh3FeF3v4YuDVhH1Spd7SiJ7pdJndPXZl-RueG8BIg8v4X30UAcWi2PRdtZeOGhFIlnChGizbF-7OoSsuOdyeQFzQ==&uniplatform=NZKPT&language=CHS
2. Yan, G.L., Wu, J.G., Hu, Y.W., Bai, X.J.: A Review of Current Eye Movement Research Paradigms. *Adv. in Psychol. Sci.* 18(12), 1966–1976 (2010). (in Chinese)<https://journal.psych.ac.cn/xlkxjz/CN/Y2010/V18/I12/1966>
3. Rayner, K.: Eye movements in reading and information processing. *Psychol. Bull.* 85(3), 618–660 (1978). <https://doi.org/10.1037/0033-2909.85.3.618>
4. Chen, G.P.: A study on eye-movement characteristics in reading Chinese texts of different genres. Master's thesis, Northwest Minzu University (2013). (in Chinese)https://kns.cnki.net/kcms2/article/abstract?v=VrduTR4bJX5kKHgGj_f3Kqrau2Is2Qh8eOrEhIJ2C-EMHcEFtKY6k0ej15v8krHB1GawZzw22uXR0R6_lj714rFRfhziRhkmOIU-iNFNaGPg8d6QNgV6tLMuCog1bl8xIT7VE-sYbNePSfXCNGExJL5YAcgqb2KSNvWjAd3ibBFY83fRP2N-HTp0EwYsO_Tl&uniplatform=NZKPT&language=CHS
5. Kliegl, R., Nuthmann, A., Engbert, R.: Tracking the mind during reading: the influence of past, present, and future words on fixation durations. *J. Exp. Psychol. Gen.* 135(1), 12–35 (2006). <https://doi.org/10.1037/0096-3445.135.1.12>
6. Fu, Y.: An eye-movement study of word length and the interaction between word length and word frequency in Chinese reading. Master's thesis, Tianjin Normal University (2018). (in Chinese)https://kns.cnki.net/kcms2/article/abstract?v=VrduTR4bJX6WW_mkL1bHHwTM0sTtgDyJbF7LBRHhIkRduaxyI5YyrsG89OWPZnAWIY83HgZ9FoomHkPr1Ti_cs2tAON6snBNmoTx-HgB0vYUG-WqN3CUsl4i7_qNaaNmfYd-vbFH5xz9g3XJG2BGXWYqlyjEzMe4MrL8tBiakQX9f_Krm9ENBhEK82siyReOG&uniplatform=NZKPT&language=CHS
7. Shen, D.L.: Eye-movement studies of students' Chinese reading processes. Beijing Education Press, Beijing (2001). (in Chinese) DOI:10.3969/j.issn.1671-2277.2002.05.038.
8. Wang, J.Q.: A brief discussion on the reading of narrative texts. *Research on Science and Education* (8) (2007). (in Chinese) https://kns.cnki.net/kcms2/article/abstract?v=H26UkN0bSyStoCq23gQVTh7DSkH6jeRHXJFYD7tgb5IZi8Cby-iGDxUQXaOp823GZhxsN6eYyRaXpK0g28hS_Ydc5nyvMU5kuo63_xHzX-CUwtKz6Flbyg8hbCC_M_T6ft4KW4OXAQjN5skBLTUluQhP60CeM34tzMxfH8MuGB0hw0VvikMsGHKA==&uniplatform=NZKPT&language=CHS

9. Zhang, Y.Q.: An eye-movement study on Uyghur college students' reading of Chinese texts in different genres. Master's thesis, Northwest Minzu University (2022). (in Chinese)https://kns.cnki.net/kcms2/article/abstract?v=VrduTR4bJX7hdEqs2AKJEYjn9IjOPWP7yI64qtth745LbCebiEU0pkS-dMIKZWYQqYN-eWLCeS6mcL61YcFXEPxrUBSDx7QBs6tmhtNA9CIIZVBPowAiR2cr9yW7MfDfyTgKthwrPNg3N9tA7_ZR0LHRKyEozY5wZFFYaNwHYNgWwfQ1dRRkh89TxeVsyBUCs&uniplatform=NZKPT&language=CHS
10. Wei, C.J.: On the cultivation of thinking ability in argumentative writing. *Chinese Language Teaching Communications* (10), 22–23 (1995). (in Chinese) https://kns.cnki.net/kcms2/article/abstract?v=H26UkN0bSyQHqXqHfdDMk6ChrtMplZKLvrHStAjtrg_sermbk4uFHJiSNdJLGczrvkDMk1INYIrkulXueTAmwfdYmJR79IBp-Udlh88F71mDTVoebewetnyk-UaC-GhRAvdCe5lv4XHqQKwx4wQlGz7xu92IgMqZ6dJlqGJk7k18Gb4WgeD_v9wg=&uniplatform=NZKPT&language=CHS
11. Li, N., Chen, X.Y.: An eye-movement study on the reading of argumentative texts by middle school students of different grades. Master's thesis, Hunan Normal University (2006). (in Chinese)https://kns.cnki.net/kcms2/article/abstract?v=VrduTR4bJX7kU3djmiJXrhru9QfQkXoAGHL9oE9eMsQWIn-2mtal8Ncos5MuMaf8ePHyqWYKWH9bIxxHjLNI-yVyO7Qd3iWsKrq2MDrbk_XzfKP46_kG_cDqu8ECMNoP0hVa5tkEVjck-GiyOK1SKethdvZlyP4f4RWlq378PUvYgBD2qrD-Utlg=&uniplatform=NZKPT&language=CHS
12. Yu, P.: An eye-movement study of Korean students reading Chinese texts. Peking University Press, Beijing (2011). (in Chinese)<https://www.las.ac.cn/front/book/detail?id=080132f2ace0b2eb3c4e833010c00589>
13. Yan, G.L.: A study on the eye-movement processes of students of different grades in reading scientific texts. *Psychol. Sci.* 22(3), 226–229 (1999). (in Chinese)https://kns.cnki.net/kcms2/article/abstract?v=VrduTR4bJX6m6yE1y8s5ne0YuFsIRoXo8WsCAY9ZV1JVwsuQkI-B3BR87F1LTc2TWxgRLuZCfPxB0vrdff3mspezlc2HAW9DCIyXyKIH5M2QxPzbWSb9cG_5NRm-7fjc5wOH9vpbmaYJMPvo8fESG2CcTwsLRK-CJNZP_mfC9B3WdW7edvsR5zQ=&uniplatform=NZKPT&language=CHS
14. Tao, Y., Shen, J.L., Shen, D.L.: An eye-movement experimental study of primary and secondary school students reading illustrated texts. *Psychol. Sci.* 26(3), 199–203 (2003). (in Chinese)<https://www.cnki.com.cn/Article/CJFDTotal-XLKX200302001.htm>
15. Gough, P.B.: One second of reading. In: Kavanagh, J.F., Mattingly, I.G. (eds.) *Language by Ear and by Eye*, pp. 331–358. MIT Press, Cambridge (1972) <https://www.mendeley.com/catalogue/63fdb258-76a4-346c-b7b8-9b32a70e396c/>
16. She, X.J., Wu, J.M., Zhang, B.Y.: A psychological model for understanding the metaphorical meaning of idioms. *Psychol. Sci.* (3) (2001). (in Chinese) DOI: 10.3969/j.issn.1671-6981.2001.03.040
17. Zhao, C., Li, R.: The effects of event difficulty and language proficiency on oral sentence production in English as a second language: an eye-movement study. *Foreign Languages and Their Teaching* (1), 1–12 (2025). (in Chinese) DOI:10.13458/j.cnki.flatt.005083
18. Wang, Y.S., Zhang, N., Du, X.P., Guo, Z.L., Li, X.: The role of morphological awareness in the reading process of learners of Chinese as a second language. *Stud. Psychol. Behav.* 22(4) (2024). (in Chinese) DOI: 10.12139/j.1672-0628.2024.04.011

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 3.0 International License (<http://creativecommons.org/licenses/by-nc/3.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

