An eye-movement study of the parafoveal preview effect from words n+2 in Tibetan reading

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Abstract: The research on perceptual span shows that in the reading process, readers not only process the information of the current fixated words, but also extract information from the words that have not been fixed at on the right side of the fixated words for word recognition, which is called the parafoveal preview effect. The relevant studies using the boundary paradigm to examine the preview effect show that readers can obtain font, phonetic and semantic preview information from the parafoveal word n+1 in both alphabetic and Chinese reading. However, the results of the research on n+2 preview effect of the parafoveal words are not consistent, which provides evidence for the existence of n+2 preview effect in Chinese reading, while the results of the research on alphabetic characters are still controversial. Therefore, as far as the present is concerned, there is no consistent result in the research on the preview effect of the word n+2. Tibetan is a special language, which has the characteristics of both alphabetic and ideographic characters. A study of the preview effect of the parafoveal words n+2 in Tibetan reading can further investigate whether the prediction of eye movement control model is correct in the reading process.

Keywords: perceptual span; preview effect; boundary paradigm; eye-movement model

From the perspective of the physiological structure of the eye, the fovea visual area is the area with the highest visual sensitivity, and the viewing angle is about 2°. The information input by the visual channel can be analyzed in the most detail and processed in the fastest way. Around the foveal visual area is the parafoveal visual area, with a viewing angle of about 10°. Visual acuity begins to decline, and the rest is the marginal visual area. Therefore, the physiological structure of the visual system limits the range of information that readers perceive when reading text. When the reader fixes at a word, it will appear in the central foveal visual area of the reader, and the reader will get the most lexical information. With the distance from the fovea visual area getting farther and farther, the visual acuity gradually declines, and the information that readers get is also getting less and less.

In the reading process, when the reader fixes at the central concave words, the reader can not only process the target word that is currentlyfixing at, but also start to preprocess the parafoveal words. Therefore, when the reader directly looks at the sub central concave words, because the parafoveal words have been preprocessed in previous reading, the recognition time will be faster, which is called the parafoveal preview effect, and is usually reflected in the recognition time of words.

In the boundary paradigm, how the parafoveal preprocessing of words on the right side of fixation affects eye movement in reading has been widely studied. In this paradigm, the researcher sets an invisible boundary in front of the target word to manipulate the words the subjects see before looking at the target word in the parafoveal visual area. The boundary is generally located at the last letter of the current looking word. Under controlled conditions, the subjects saw the same target words (effective preview) in the parafoveal visual area. Under experimental conditions, the target word is masked (for example, using an X string, similar words or false words), and the subject's eyes will not get any useful information from the sub fovea before crossing the boundary (invalid preview). Once the eyes cross the invisible boundary, the masking words in the sub foveal will be permanently replaced by the target word. However, under the condition of effective preview, no physical changes will occur on the screen, that is, the changes of the masking words replaced by the target words will not occur on the reader's screen.

At the beginning, the research on the preview effect of parafovea mainly focused on the word N+1. The interest in the n+2 preview effect has only recently emerged. The research on the preview effect of the word n+2 is obviously more challenging, and it is also possible to observe more dynamic features of attention span. However, so far, many attempts to study the preview effect of the word n+2 in alphabetic reading have failed. It seems that the study of the spatial limitation of parafoveal preprocessing in the boundary paradigm is a logical result of the size of perceptual breadth in the reading process. Rayner, Juhasz and Brown first introduced a boundary paradigm experiment. In this experiment, they studied whether the preview effect of the word n+1 could be extended to the word n+2. Compared with the earlier research, the difference of this experiment is that the location of the invisible boundary is different. The boundary is either in front of the target word (word n+1) or in front of the target word (word n+2). The first case describes the classic case of the preview type of the manipulation word n+1. In the latter case, compared with the word n before the boundary, there is an additional word n+1 after the boundary before the target word n+2, which is called the word n+2 boundary paradigm. The preview type of the target word (i.e. the word n+1 or n+2) can be the same word as the target word, a similar replacement word, or a non word. Consistent with previous studies, when the target word is n+1, significant preview effect can be observed. If the boundary moves forward one word, that is, the target word is the word n+2, no evidence of the existence of the preview effect is observed. In order to increase the possibility of the word n+2 entering the perceptual breadth, Rayner et al. used three to four letter short words n+1 and n+2 in the second experiment. However, even under this optimized condition, they did not find any evidence about the parafoveal of the target word n+2.

In order to further study the preview effect of the word n+2, the researchers manipulated the preview types of the word n+1 and the word n+2 at the same time, and found no evidence for the existence of the preview effect of the word n+2.

However, some studies have extended the dynamic attention span to the preprocessing of the word n+2. Kliegl, Risse and Laubrock manipulated the preview type of the word n+2, analyzed the fixation time of the word n+2, and found no preview effect, but found the sub foveal foveal effect of the word n+2 on the word n, indicating that readers can extract information from the word n+2. Risse et al. found that the word frequency and length of word n+2 had significant interaction on the fixation time of word n, proving that readers can extract parafoveal preview information from word n+2. If the word n+2 is a low frequency word rather than a high frequency word, the fixation time of the word n is longer, which is called the sub foveal foveal effect of the word n+2. However, this effect is limited to short words n+2 (about 7 letters or less) and words n+1 composed of 2-3 letters. If the length of the word n+1 is 4 or 5 letters, the sub foveal foveal effect of the word n+2 is not significant. This experimental result shows that the preview effect of the word n+2 seems to be very small (about 15ms), and highly depends on the word length of the word n+1.

Radach, Inhof, Glover and Vorstius used English words with high predictability as experimental materials, and the word n+1 was the definite article “the”. The results reported the existence of the word n+2 preview effect. The simulation study conducted by Risse et al. with SWIFT model has confirmed that this model can simulate the preview effect of the word n+2, and it is not necessary to directly fit this model with such effects. Interestingly, the simulation study using the E-Z reader model also proves that the preview effect of the word n+2 exists in theory, although their preview amount may be small. When the word n+1 is a short word or a high-frequency word, it is very easy for the reader to process the word n+1. The word n+1 will be recognized quickly in the parafoveal. Before crossing the boundary, the reader may skip the word n+1 and preprocess the word n+2 in the visual area of the parafoveal. However, it is not clear how well the results of these simulation studies agree with the experimental data. Vasilev and Angele (2017) conducted Bayesian meta-analysis on 93 experiments using the boundary paradigm, and found that the preview of the second word on the right side of the fixation (the word n+2) may exist, but the preview benefit is quite small; Chinese readers seem to be able to more effectively preprocess the parafovea, so in Chinese reading, the word n+2 preview effect is more likely to exist.

Compared with alphabetic characters, the information distribution space of Chinese script is more intensive, and the position of sub central concave words is closer to the central concave visual area, so Chinese text will provide better reading materials to study n+2 preview effect. For example, Yang, Wang, Xu and Rayner (2009) used the double boundary paradigm to manipulate the boundary position and the preview type of the word n+2 in order to explore whether the word n+2 preview effect can be obtained in Chinese reading. The results showed that there was n+2 preview when the word n+2 was a single word; When the word n+2 is a two word word, only when the word n+1 is a high-frequency word can n+2 preview exist . Hu(2017) used the double boundary paradigm to study the existence of n+2 preview, and found the preview effect of the existence word n+2 in Chinese reading.

Bai, Wang et al. believed that if the preview of word n+2 has an impact on the processing of word n+1, it indicates that readers can obtain preview information from word n+2. They manipulate the processing load of parafoveal of word n+1 and the preview type of word n+2. The results showed that when the preview processing load of word n+1 is low, the preview of word n+2 significantly affects the processing of word n+1, indicating that there is a word n+2 preview effect in Chinese reading. The research results of Wang, Zhao and others also proved this. They manipulated the preview types of the word n+1 and n+2 at the same time in the experiment, respectively, target preview and non-words preview. The results showed that when the word n+1 is non-words preview, the preview processing of the word n+2 does not affect the selection of saccade target; When the word n+1 is the target preview, the preview processing of the word n+2 will affect the subsequent saccade target selection, providing evidence for the existence of the character n+2 preview effect in Chinese reading, and the preview effect of the character n+2 will be affected by the character n+1 preview processing load. However, due to the lack of consistent reporting results in pinyin and Chinese reading, it is still impossible to verify whether the preview effect of the word n+2 is widespread.

Although a large number of studies have been conducted on the preview effect of the word n+2 in the past 20 years, the results of these studies are not consistent. In alphabetic reading, the research on the scope of preview mainly focuses on whether the reader can preprocessing the word n+2. Therefore, at present, there is no clear consensus on whether the word n+2 preprocessing occurs in the parafoveal visual area.

The study of n+2 preview effect can examine whether the prediction of eye movement control model is correct. Sequential processing models such as E-Z reader model usually predict that there is no preview effect of the word n+2. The important assumption of this model is that during the reading process, attention is allocated to words in a continuous processing manner, and each word is processed from left to right in a sequential processing manner. Only one word can be processed at a time. After processing the current fixation word n, the eyes will point to the next word n+1. Therefore, the E-Z reader model is less likely to predict the existence of the word n+2 preview effect, because the preprocessing of the word n+2 will only start after the word recognition of word n+1 is completed. Therefore, when the reader’s eyes are fixed on the foveal word n, the parafoveal preprocessing of the word n+2 should not be started.

Different from E-Z reader model, parallel processing models such as SWIFT model believe that multiple words around fixation point are processed in parallel within the range of perceptual span, and the processing of current target word and other words is conducted at the same time, or one fixation can perceive the information of multiple words within the range of perceptual span at the same time , but it should

be noted that attention is not evenly distributed on each word. A more accurate description of the rapid processing mechanism of word is that the processing speed of word depends on the position and length of word in the perceptual span. Therefore, word processing is usually limited to one or two words within the perceptual range. According to the SWIFT model, the preview effect of the word n+2 exists.

As an important communication tool for Tibetan people to communicate, modern Tibetan belongs to the Tibetan branch of the Tibeto Burman language family of the Sino Tibetan language family. In essence, it is a kind of alphabetic writing, which belongs to the type of consonant letter. It consists of 30 consonant letters, 4 vowel symbols and 5 reverse letters as the basic word formation/word unit. At the same time, the spacer character " ་ " is used as the marks between words and the sentence separator " ། " is used as the marks between sentences. Tibetan has the common characteristics of alphabetic script, linear structure and transparent pronunciation. In addition, Tibetan and Chinese are cognates, so there is not a distant relationship between them. In the long-term common development of Tibetan and Chinese, it is inevitable that similar changes have taken place in Tibetan and Chinese, forming a three-dimensional structure in the font structure . In Tibetan, each syllable has a base character as the core, which is the basis of spelling. The rest of the letters are added back and forth and overlapped on the basis of the base character to form a complete structure.

It can be seen from the above that Tibetan is a special language with the characteristics of both alphabetic word and Chinese characters. In such a special script, does there exist the parafoveal preview effect? What kind of preview information can readers obtain from the parafoveal preprocessing and the scope of the parafoveal preprocessing? In Experiment 2, Gao et al. used Tibetan as experimental material, and Tibetan college students as experimental subjects. With the help of the boundary paradigm, they examined the effect of sub central foveal preview in Tibetan reading. The results showed that Tibetan college students could advance from sub central foveal preview to low-level preview information of the word n+1 (such as phonological and orthographic information). So, can Tibetan readers get preview information from the parafoveal word n+2? It is necessary to conduct further research on this.

On the one hand, the research on the preview effect of the parafovea is the further research on the perceptual span and cognitive processing. The scope of perceptual span and the information processing mechanism behind it is one of the hot issues in psycholinguistic research, and also the focus of controversy between the two eye movement theoretical models. Tibetan is a special language, and its cognitive processing mechanism also has some particularity. Therefore, the research on the word n+2 preview effect in Tibetan reading is not only a supplement to the research on the scope of perception, but also can better understand the information processing mechanism in the reading process, and to a certain extent, provide corresponding experimental support for the construction of the two eye movement theoretical models.

On the other hand, studying the common language phenomena in Tibetan, a unique language, is undoubtedly a new perspective, which is conducive to further understanding the cognitive processing mechanism of this special language, complementing the relevant research of our national language to a certain extent, and providing a certain basis and reference for Tibetan language research.

Rreferences:

[1] Rayner K, Inhoff A W, Morrison R E, et al. Masking of foveal and parafoveal vision during eye fixations in reading.[J]. J Exp Psychol Hum Percept Perform, 1981, 7(1):167-179.

[2] Rayner K, and, et al. Integrating information across eye movements - ScienceDirect[J]. Cognitive Psychology, 1980, 12(2):206-226.

[3]Rayner K. The perceptual span and peripheral cues in reading[J]. Cognitive Psychology, 1975, 7(1):65-81.

[4] Rayner K, Juhasz B J, Brown S J. Do readers obtain preview benefit from word N + 2? A test of serial attention shift versus distributed lexical processing models of eye movement control in reading.[J]. J Exp Psychol Hum Percept Perform, 2007, 33(1):230-245.

[5] Angele B, Slattery T J, Yang J , et al. Parafoveal processing in reading: Manipulating n+1 and n+2 previews simultaneously[J]. Vis Cogn, 2008, 16(6):697-707.

[6] Angele B, Rayner K. Parafoveal processing of word n + 2 during reading: do the preceding words matter?[J]. Journal of Experimental Psychology Human Perception & Performance, 2011, 37(4):1210.

[7] Vasilev M R, Angele B. Parafoveal preview effects from word N + 1 and word N + 2 during reading: A critical review and Bayesian meta-analysis[J]. Psychon Bull Rev, 2017, 24(3):666-689.

[8]Kliegl R, Risse S, Laubrock J. Preview benefit and parafoveal-on-foveal effects from word n + 2.[J]. J Exp Psychol Hum Percept Perform, 2007, 33(5):1250-1255.

[9] Risse S, Engbert R, Kliegl R. Eye-movement control in reading : experimental and corpus-analysis challenges for a computational model. 2008.

[10] Radach R, Inhoff A W, Glover L, et al. Contextual constraint and N+2 preview effects in reading.[J]. Quarterly Journal of Experimental Psychology, 2013, 66(3):619-633.

[12] Risse S, Hohenstein S, Kliegl R , et al. A theoretical analysis of the perceptual span based on SWIFT simulations of the n + 2 boundary paradigm[J]. Visual Cognition, 2014, 22(3-4):283-308.

[13] Schotter E R, Reichle E D, Rayner K. Rethinking parafoveal processing in reading: Serial-attention models can explain semantic preview benefit and N+2 preview effects[J]. Visual Cognition, 2014, 22(3-4):309-333.

[14] Yang J, Wang S, Xu Y , et al. Do Chinese readers obtain preview benefit from word n + 2? Evidence from eye movements.[J]. Journal of Experimental

Psychology Human Perception & Performance, 2009, 35(4):1192.
[15] Hu Qianqian. An eye movement study on the preview effect of Chinese reading words n+2 [D]. Zhengzhou University, 2017
[16] Xuejun Bai, Yongsheng Wang, Zhiying Guo, et al. An eye movement study on the influence of the preview of words N+2 in Chinese reading on the processing of high-frequency words N+1 [J]. Journal of Psychology, 2015, 47 (2): 143-156
[17] Wang Yongsheng, Chen Mingjing, Zhao Bingjie, et al. The role of sub central concave characters N+1 and N+2 in saccade target selection [J]. Psychological and Behavioral Research, 2017, 15 (6): 10
[18] Schotter E R, Angele B, Rayner K. Parafoveal processing in reading[J]. Attention, Perception, & Psychophysics, 2012. 18
[19] Reichle E D, Pollatsek A, Fisher D L, et al. Toward a Model of Eye Movement Control in Reading[J]. Psychological Review, 1998, 105(1):125-157. 19
[20] Engbert R, Nuthmann A, Richter E M, et al. SWIFT: A Dynamical Model of Saccade Generation During Reading[J]. Psychological Review, 2005, 112(4):777-813.
[21] Xuejun Bai, Xiaolei Gao, Lei Gao, et al. An eye movement study on the perceptual breadth of Tibetan reading [J]. Journal of Psychology, 2017, 49 (5): 8
[22] Xiaolei Gao, Xiaowei Li, Min Sun, et al. The word frequency effect of the central fovea and its influence on the preview effect of the sub central fovea in Tibetan reading [J]. Journal of Psychology, 2020, 52 (10): 13

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