The Effect of Experience on Cognitive Mechanisms of Classical Poetry Learning: Evidence from Eye Movements

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Abstract

Traditional classical poetry appreciation predominantly employs theoretical analysis from a literary perspective to conduct speculative analysis of poets and texts, often neglecting the complex psychological processing mechanisms involved in readers' appreciation processes. This study, for the first time, investigates the cognitive differences in poetry appreciation among learners with varying levels of poetry experience, utilizing eye-tracking technology to record readers' eye movement trajectories in real-time during the reading of complete poems. From the perspective of polished characters at the textual level of classical poetry, it examines both the early-stage and late-stage processing mechanisms during natural reading of entire poems. The results demonstrate that experience significantly affects poetry learning outcomes. No significant differences were observed between learners with different experience levels during the early-stage processing of textual elements. During the late-stage processing, however, learners with different experience levels exhibited distinct reading patterns, which were also influenced by poem difficulty. Specifically, when poem difficulty was low or moderate, the low poetry experience group demonstrated significantly higher fixation counts and regression counts on "polished characters" in the poetry compared to the high poetry experience group. When poem difficulty was high, no significant differences were observed in late-stage eye-movement metrics between the high and low poetry experience groups. This research holds significant importance for constructing cognitive learning theories of Chinese classical poetry and exploring effective methods for poetry learning.

Full Text

Effects of Prior Knowledge on Cognitive Mechanisms in Classical Poetry Learning: Evidence from Eye Movements

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Abstract

Traditional approaches to classical poetry appreciation have primarily employed theoretical analysis from literary perspectives, often neglecting the complex psychological processes involved in readers' appreciation. This study represents the first investigation into cognitive differences in poetry appreciation among learners with varying levels of prior poetry knowledge. Using eye-tracking technology to record real-time eye-movement trajectories during natural reading of complete poems, we examined both early and late processing stages by focusing on the textual refinement of words (炼字) in classical poetry. Results demonstrate that prior knowledge significantly influences poetry learning outcomes. No significant differences emerged between learners with different experience levels during early processing of textual elements. However, during late processing stages, distinct reading patterns emerged that were moderated by poetry difficulty. Specifically, when poetry difficulty was low or moderate, the low prior knowledge group exhibited significantly higher fixation counts and regression counts on "refined words" compared to the high prior knowledge group. When poetry difficulty was high, no significant differences in late-stage eye-movement indices were observed between groups. This study holds important theoretical significance for constructing a cognitive learning theory of Chinese classical poetry and offers practical implications for exploring effective poetry learning methods.

Keywords: Classical Poetry Appreciation; Prior Knowledge; Refined Words (炼字); Eye Movements

1 Introduction

Poetry represents one of the earliest literary forms in human history. Chinese classical poetry embodies both vast, profound dimensions that encompass the universe and delicate, emotional nuances that nourish all things, constituting a treasured gem of Chinese national culture. Learning and appreciating Chinese classical poetry not only helps adolescents acquire linguistic knowledge and competence but also cultivates their imagination and thinking methods, enhances creativity, and fosters noble sentiments, aesthetic tastes, and proper values. However, most poetry appreciation approaches analyze authors and texts from literary perspectives, often overlooking the complex psychological processing in-

volved in readers' appreciation. Therefore, employing psychological research methods to investigate the poetry appreciation process holds important significance for constructing a cognitive learning theory of Chinese classical poetry and exploring effective poetry learning methods.

1.1 Related Research on Poetry Semantic Processing

Arzouan, Goldstein, and Faust (2007) employed ERP technology to investigate the processing of novel metaphorical words in poetry. Their experimental materials consisted of two-character words divided into four types: literal expressions, conventional metaphors, novel metaphors, and unrelated words, with novel metaphors selected from poetry. Participants performed meaningfulness judgments on these four word types while EEG activity was recorded. Results revealed that compared to literal expressions and conventional metaphors, metaphors from poetry elicited larger N400 amplitudes. Moreover, compared to conventional metaphors, poetry metaphors showed a right-hemisphere lateralized distribution and a smaller late negative wave. Both the larger N400 amplitude and smaller late negative wave indicated that comprehending metaphors in poetry required greater cognitive effort. Although this study identified the difficulty in understanding novel metaphors in poetry, it did not provide more specific evidence regarding the neural mechanisms underlying novel semantic processing in poetry.

Pobric, Mashal, Faust, and Lavidor (2008) used the same experimental paradigm and applied repetitive transcranial magnetic stimulation (rTMS) to more specifically investigate the role of the right hemisphere in processing metaphorical expressions during poetry semantic processing. Researchers presented participants with four types of word pairs, with metaphorical pairs selected from poetry: literal, conventional metaphor, novel metaphor expressions, and unrelated pairs, requiring participants to perform semantic judgment tasks. The experiment demonstrated that the right posterior superior temporal sulcus primarily processed novel metaphors, while the left inferior frontal gyrus mainly processed conventional rather than novel metaphors. The study also found that the right hemisphere activated a broader range of related meanings than the left hemisphere, indicating substantial right hemisphere involvement in poetry metaphor processing. These findings align with results on hemispheric lateralization in distant semantic association and comprehension (Zhao et al., 2017).

Li and Yang (2011) examined prosodic boundary issues in poetry reading. Using the uniquely Chinese poetic form of quatrains, the study investigated the cognitive processes and EEG effects evoked by intonational phrase boundaries within quatrains. Results showed that intonational phrase boundaries within five-character quatrains evoked CPS components with identical time courses, scalp distributions, and amplitudes, indicating that processing of prosodic boundaries within discourse is not influenced by their position in the text. In contrast, boundaries at the ends of five-character and seven-character quatrains evoked P3

components, with smaller P3 amplitudes for five-character than seven-character quatrains, though no differences emerged in time course or scalp distribution. These findings suggest that the type of EEG effect evoked by sentence-final intonational phrase boundaries depends on their function: boundaries that both terminate previous information and anticipate subsequent information evoke CPS, whereas boundaries that only terminate information evoke P3.

Bao (2012) used five-character ancient poems with clear "poetic eyes" (诗眼) as experimental materials. Building upon the "guesswork-catalysis" task paradigm, she established a research paradigm for insight in poetry appreciation and employed advanced eye-tracking technology to examine the processes and insight mechanisms involved in appreciating ancient poetry lines with different characteristics. In the experiment, line length, poetic form, and response type were within-subject variables. Participants first read two lines of poetry, with key characters removed from the second line, and were required to carefully consider appropriate characters to fill in the blanks. After formulating an answer, they pressed a key to reveal the answer and then indicated whether they experienced insight. The eye-tracker recorded eye movements during both poetry reading and response phases. Analysis of eye-movement patterns preliminarily revealed that the insight process in ancient poetry appreciation resembles that in problem-solving. Furthermore, across different types of ancient poetry lines, the overall poetic context proved more important for appreciators than external form, with the resulting strong subjective experience influencing the type of response made.

Zhang (2015) employed ERP technology, using five-character ancient poems with clear poetic eyes as materials and adopting the guesswork-catalysis paradigm to investigate the cognitive mechanisms of insight occurrence during poetry appreciation. Results indicated that after poetic eyes were presented as clues, lines that evoked insight showed more significant activation in parieto-occipital brain regions compared to lines that did not evoke insight, producing a more positive P600 deflection. The researcher proposed that the P600 component might reflect semantic integration triggered by poetic eye information and the resulting updating of semantic representations, marking the specific processing mechanism of insight in poetry comprehension. Insight in poetry appreciation represents a process of reorganizing imagery to integrate and update the original representation of poetic lines into a new representation.

An (2013) investigated the effects of segmentation on poetry semantic processing in regulated verse. By manipulating four segmentation conditions during reading of couplets (no segmentation, word-based, prosodic, and semantic segmentation), the study examined the effects on poetry semantics under visual and auditory conditions. Results revealed that under visual presentation, semantic segmentation most facilitated reading comprehension, while word-based segmentation least facilitated it. Under auditory presentation, the pattern differed: word-based segmentation most facilitated comprehension, while prosodic segmentation least facilitated it. Thus, segmentation effects in regulated verse

semantic processing show modality differences, with different patterns under visual versus auditory input, possibly reflecting activation of different working memory structures that lead to different semantic processing pathways.

Zhang (2014) selected Tang Dynasty seven-character poetry lines as experimental materials and used event-related potential technology to examine the neurophysiological characteristics of rhyme rule processing and semantic processing during poetry reading, exploring the relationship between prosody and semantic processing to advance understanding of the psychological mechanisms underlying poetry prosody processing. The study employed a 2 (rhyme consistency) $\times$ 2 (semantic plausibility) within-subjects design, creating four experimental conditions by replacing the final character of original lines. Poetry lines were presented segment-by-segment at the center of the screen, with participants required to make judgments about rhyme consistency and semantic plausibility. Results indicated that rhyme rules received immediate processing during Chinese poetry reading, primarily through the right hemisphere. The study also found immediate interactive effects between rhyme rules and line semantics, with inconsistent rhyme rules potentially hindering semantic comprehension.

Chen and Yang (2017) employed eye-tracking technology to investigate the cognitive mechanisms of rhyme and poetic meaning comprehension during ancient Chinese poetry reading. Their experiment revealed the existence of full-time-course rhyme expectancy effects, manifesting as early-stage rhyme regularity effects independent of semantic processing and late-stage rhyme modulation effects that constrain semantic processing.

Ke (2016) used seven-character object-chanting poems as experimental materials to preliminarily explore the psychological processes and influencing factors of imagery formation during creative poetry comprehension. Results indicated that the process of appreciating object-chanting poems includes understanding literal meaning, imagery formation, and artistic conception exploration. Effective emotional cues facilitated appropriate imagery formation during poetry appreciation, while ineffective emotional cues hindered it, with this influence occurring during early stages of imagery formation.

In summary, research has begun to examine novel metaphors, novel vocabulary, prosodic features, prosodic boundaries, poetic eyes, the effects of prosodic segmentation on poetic meaning comprehension, and imagery processing in poetry.

1.2 Research Innovation and Significance

First, this research topic is highly innovative. Traditional analyses of poetry appreciation have mostly employed theoretical speculation from literary perspectives, with few interdisciplinary empirical studies bridging literature and psychology to investigate readers' poetry appreciation processes. To date, no research has examined cognitive differences in poetry appreciation among learners with different levels of poetry experience. Therefore, introducing learners with varying poetry experience levels not only emphasizes the unique experiences

and psychological processes of different learners during poetry appreciation but also holds important practical significance for exploring effective poetry learning methods and improving poetry appreciation abilities. Moreover, it contributes to investigating the internal mechanisms of poetry appreciation and constructing a cognitive learning theory of Chinese classical poetry within traditional Chinese culture.

Second, this research offers ecological validity through its technology. This study uses eye-tracking technology to examine early and late processing stages during natural reading of complete ancient poems. Previous research on poetry appreciation has primarily employed theoretical analysis methods; however, poetry appreciation is a real-time process. Although EEG provides high temporal resolution, it imposes substantial constraints on participants. Eye-trackers, by contrast, offer both high spatial resolution and temporal precision while enabling real-time recording of readers' eye-movement trajectories during complete poem reading.

Third, this research focuses on the textual refinement of words (炼字) in ancient poetry. As Lu Yanrang wrote in his poem "Chanting in Agony," "To settle on one word, I twist off several beard hairs." Poets often devote great attention to refining key words to achieve artistic expression and emotional conveyance. For poetry appreciators, grasping these refined words greatly facilitates overall poem appreciation. Do learners with different poetry experience levels show cognitive processing differences for these "refined words" in poetry? If differences exist, do they reflect varying appreciation levels among learners with different poetry experience?

2 Method

2.1 Participants

Thirty-five valid participants (10 male, 25 female) with a mean age of 20.5 years (SD = 1.53) completed the experiment. Using the "Ancient Poetry Interest Questionnaire," participants were divided into high and low poetry knowledge experience groups (maximum score = 21). The high experience group consisted of 13 participants (scores > 10), while the low experience group comprised 22 participants (scores < 9). All participants had normal or corrected-to-normal vision, were native Chinese speakers, right-handed, and had no prior experience with similar experiments. Participants signed informed consent forms before the experiment and received compensation upon completion.

2.2 Experimental Materials

Based on Bao's (2012) "Ancient Poetry Interest Questionnaire" (homogeneity reliability $\alpha = 0.76$), which consists of five dimensions including self-rated poetry interest, self-rated poetry proficiency, poetry interest questionnaire items, poetry proficiency questionnaire items, and appreciation level questionnaire items.

Poetry learning materials were selected from 21 lyric ancient poems containing refined word appreciation collected from two high-experience poetry enthusiasts. Two spring-themed poems were chosen. The first poem was "Spring Day" by Wang Zao of the Song Dynasty: "A spring without ten days of clear skies, / Floating clouds everywhere bringing rain. / Spring water in wild fields greener than a mirror, / Human shadows crossing beside unstartled gulls. / Peach blossoms smile beyond the fence, / Most affectionate when half-open. / Thatched cottage smoke darkening travelers' wet clothes, / A noon rooster' s cry breaking dreams." This poem expresses the poet' s love for spring, with the refined word being "smile." The second poem was also titled "Spring Day," by Wu Xichou of the Song Dynasty: "Most of the glorious spring passes in haste, / Some deep feelings cannot be conveyed. / Swallows not yet settled, Cold Food Festival rain, / People like drunkards in falling flower wind. / One window of grass remembering Master Lianxi, / Five acres of garden thinking of Lord Sushui. / No rhapsody to summon souls, alone I chant, / And compose spring verses to answer spring' s work." This poem expresses the poet' s sorrow for spring and concern for the nation, with refined words being "resist" and "private."

The post-test questionnaire included poetry learning effect tests and subjective feeling assessments. The poetry learning effect test evaluated four dimensions: poetic text translation, refined word appreciation, technique appreciation, and poet' s emotional expression.

2.3 Experimental Apparatus

The experiment used an EyeLink 1000 eye-tracker (SR Research, Canada) with a sampling rate of 250 Hz. Stimuli were presented on a 19-inch monitor with a resolution of 1280 × 1024 and a refresh rate of 100 Hz. Experimental materials subtended a horizontal visual angle of 28.7° and a vertical angle of 15.3°, with participants seated 75 cm from the screen.

2.4 Experimental Procedure

First, participants completed the "Ancient Poetry Interest Questionnaire." During the experiment, participants read the following instructions on screen: "To ensure smooth experimental progress, please remember the following requirements; otherwise, the experiment may be terminated and restarted. (1) Before the experiment: Please adjust to a comfortable sitting position and then remain still, especially keeping your head stationary. Try not to blink forcefully or frequently until the experiment ends. (2) Calibration phase: During eye movement calibration, keep both eyes accurately fixated on the black dots on screen. (3) Formal experiment phase: You will study two ancient poems about spring, with one minute allocated for reading and studying each poem, after which we will test your learning outcomes. Please maintain high concentration." After pressing the spacebar, nine randomly positioned circles appeared on screen for eye movement calibration, followed by the formal experiment. Each spring-themed poem was presented for 60 seconds.

3 Results

3.1 Behavioral Results

For the first poem, high-experience participants (M = 18.77, SD = 1.03) showed significantly better learning outcomes than low-experience participants (M = 16.55, SD = 1.53), t(33) = -2.27, p = 0.03 < 0.05, ^{2} = 0.14. Low-experience participants rated the poem as significantly more difficult (M = 5.82, SD = 1.53) than high-experience participants (M = 4.69, SD = 1.03), t(33) = -2.35, p = 0.002 < 0.05, ^{2} = 0.14. No significant difference emerged between groups in rating of question difficulty (low experience: M = 6.14, SD = 1.52; high experience: M = 5.38, SD = 1.56), t(33) = 1.40, p = 0.17 > 0.05.

For the second poem, high-experience participants (M = 11.83, SD = 4.67) again showed significantly better learning outcomes than low-experience participants (M = 8.86, SD = 2.57), t(32) = -2.41, p = 0.02 < 0.05, ^{2} = 0.15. No significant difference emerged between groups in poetry difficulty ratings (low experience: M = 6.14, SD = 1.42; high experience: M = 6.38, SD = 1.04), t(33) = -0.55, p = 0.58 > 0.05. However, low-experience participants rated question difficulty as significantly higher (M = 6.83, SD = 1.64) than high-experience participants (M = 8.00, SD = 0.82), t(32) = 2.78, p = 0.009 < 0.05, ^{2} = 0.19.

3.2 Eye-Tracking Results

Eye-movement analysis of ancient poetry was divided into global analysis, focusing on overall eye-movement trajectories across entire poems, and local analysis, focusing on eye-movement trajectories specifically on "refined words." To further investigate temporal processing differences among readers with different poetry knowledge experience when reading the same poem, eye-movement indicators were selected for two processing stages: early processing indicators such as first fixation duration, and late processing indicators such as fixation count, regression count, fixation ratio, total fixation time, and total fixation time ratio.

Global analysis of the first poem revealed no significant differences between high and low poetry experience readers on either early or late processing indicators. Local analysis of the refined word "smile" showed no significant difference in early processing first fixation duration between high-experience readers (M = 249.09, SD = 134.58) and low-experience readers (M = 268.31, SD = 136.11), t(33) = -0.41, p = 0.68 > 0.05. However, significant differences emerged in late processing indicators. Specifically, low-experience readers showed significantly higher fixation counts (M = 7.14, SD = 2.58) than high-experience readers (M = 5.38, SD = 2.10), t(33) = 2.06, p = 0.047 < 0.05, and significantly higher regression counts (M = 7.14, SD = 2.58) compared to high-experience readers (M = 5.38, SD = 2.10), t(33) = 2.06, p = 0.047 < 0.05.

Global analysis of the second poem similarly revealed no significant differences between high and low poetry experience readers on early or late processing indicators. Local analysis of the refined words "resist" and "private" showed no

significant differences in early processing first fixation duration between groups, and no significant differences emerged in late processing indicators either.

4 Discussion

First, the results demonstrate that prior knowledge significantly influences poetry learning outcomes. Specifically, during identical learning processes, high-experience readers achieved significantly better learning outcomes than low-experience readers. Eye-tracking research on natural reading of complete poems revealed no significant differences between learners with different experience levels during early processing of textual elements. However, during late processing stages, distinct reading patterns emerged. When poetry refinement difficulty was low, prior knowledge affected cognitive processing patterns: low-experience learners showed significantly higher fixation and regression counts than high-experience learners. When poetry refinement difficulty was high, this pattern disappeared, and prior knowledge no longer affected cognitive processing patterns. This indicates that the influence of poetry experience on late processing of "refined words" is moderated by comprehension difficulty. When poetry difficulty was low or moderate, the low prior knowledge group showed higher fixation frequencies on "refined words" than the high prior knowledge group. When poetry difficulty was high, no significant differences in late-stage eye-movement indices emerged between groups.

Second, this study has limitations. The high-experience group was relatively small, with only 13 participants. Additionally, the experimental materials were limited to only two lyric poems describing spring scenery. Future research should incorporate poems with different lyrical styles or philosophical themes to further investigate how poetry experience level influences cognitive mechanisms in ancient poetry learning.

Finally, this study focused on early and late processing stages during natural reading of complete poems from the perspective of textual "refined words." Future research should examine other textual variables, such as inverted sentence structures and rhetorical devices, to further explore interactions between experience and other poetic variables. Additionally, different eye-tracking experimental paradigms could be employed to investigate various poetry reading questions. Furthermore, EEG, near-infrared spectroscopy, fMRI, and computational modeling could be used to explore the neural mechanisms of cognition, emotion, and aesthetics, deepening the interdisciplinary integration of psychology and literature.

Author Contributions

Research Conceptualization: Ma Anran proposed, Zhou Zhijin supervised. **Data Collection and Analysis:** Ma Anran analyzed, Zhou Zhijin interpreted results and provided conclusions. **Manuscript Writing:** Ma Anran.

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Note: Figure translations are in progress. See original paper for figures.