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Effects of aging on word position encoding in Chinese reading

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Abstract

Recent research has highlighted a growing interest in word position coding during sentence reading, with young adults demonstrating flexible encoding of word positions. However, normal aging is associated with the visual and cognitive changes, which may impact this flexibility – particularly in Chinese reading, where word boundaries are not explicitly marked. This study examined age-related differences in the flexibility of word position encoding by investigating the transposed-word effect in young and older adults. Participants read sentences containing transposed words and control sentences while performing a rapid grammaticality decision task. Both age groups exhibited the transposed-word effect, with longer response times and higher error rates in the transposed-word condition compared to the control condition, indicating that the flexibility of word position coding is preserved across adulthood. Crucially, young adults showed a more pronounced transposed-word effect than older adults, suggesting an age-related reduction in the flexibility of word position coding. These findings suggest that while the flexibility of word position coding is preserved across adulthood, older adults display reduced flexibility compared to young adults in Chinese reading.

Keywords Chinese reading, Aging, Word position encoding, Transposed-word effect

Introduction

Reading involves the integration of visual, attentional, and linguistic processes to extract meaning from written text. While substantial research has investigated the development of reading skills in childhood and reading performance in adulthood, relatively less is known about how reading abilities change in older adulthood. Given that normal aging is associated with declines in visual and cognitive functioning, it is important to understand how these changes affect fundamental reading processes. One such process is position encoding, which allows readers to maintain the correct order of linguistic units – letters in alphabetic languages, characters in Chinese, and words within sentences.

Position encoding plays a crucial role in reading by enabling readers to recognize words accurately and process syntactic structures efficiently. However, the mechanisms underlying letter/character position encoding (within words) and word position encoding (within sentences) are distinct, and their roles in reading comprehension differ. Given that aging affects multiple cognitive domains, it is possible that both letter/character and word position encoding are also affected in older adults, which could have implications for reader fluency and comprehension.

Positionality effects in reading: letters/characters vs. words

At the sublexical level, letter/character position encoding refers to the ability to identify and maintain the correct order of letters/characters within a word. In alphabetic languages, studies using transposed-letter priming have shown that words remain recognizable even when internal letters are swapped [1]. For example, previous

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research has demonstrated that primes created by letter transpositions (e.g.,"jugde") are more advantageous than primes created by letter replacements (e.g.,"jupte") for a target word (JUDGE), indicating a heightened sensitivity to letter order in lexical units [2]. Similarly, in Chinese, transposing characters within words can disrupt reading fluency, indicating that character position encoding plays a crucial role in efficient word recognition [3, 4]. However, these findings pertain to intra-word processing and do not necessarily extend to word position encoding at the sentence level. While letter/character position encoding is essential for lexical access, readers must also encode word positions within sentences to construct grammatically coherent structures.

At the syntactic level, word position encoding ensures that words appear in the correct order to form meaningful sentences. Unlike letter/character position encoding, which affects word recognition, word position encoding governs syntactic parsing and sentence comprehension. Research suggests that word position encoding is flexible, as skilled readers can process sentences with some positional disruptions [5]. This flexibility is evident in the transposed-word (TW) effect, where sentences containing transposed words (e.g., " The white was cat big" instead of "The white cat was big") disrupt reading fluency but do not necessarily prevent comprehension [6–8].

Various theoretical frameworks have been proposed to explain the TW effect. The noisy-channel model suggests that the parser initially encodes word order faithfully but may revise or reorder elements based on higher-level constraints, such as syntactic and semantic cues, to construct a coherent sentence representation [9]. Readers may reorder transposed words because the brain assumes some level of distortion in input processing, using probabilistic inference to reconstruct the intended sentence structure. Moreover, some accounts argue that the TW effect arises due to parallel word processing, where multiple words are processed simultaneously and their exact positions are not rigidly encoded [10]. However, research has also demonstrated that the TW effect occurs in serial word processing, where words are read one by one, suggesting that word position encoding is inherently flexible and does not necessarily rely on parallel processing [11–13]. Additionally, the OB1 reader model [14] proposes that word identities and their positions are not encoded in a strictly serial manner but instead mapped into a spatiotopic sentence-level representation. This model suggests that syntactic expectations and word length information guide that activation of words in a sentence, influencing word position encoding [5, 15]. However, recent research found that word length alone does not modulate the TW effect, indicating that syntactic constraints may play a more critical role in determining word order [16, 17].

This distinction between character position encoding (which influences word recognition) and word position encoding (which governs sentence comprehension) is particularly relevant in Chinese reading, where word boundaries are not explicitly marked. Readers must rely on contextual cues and word position encoding mechanisms to parse sentences accurately [18].

Aging Effect on Position Encoding

Previous studies have investigated the aging effect on letter and character position encoding, revealing significant differences between young and older adults in various aspects of visual word recognition [19, 20]. Research suggests that as individuals age, their ability to accurately process and encode the positions of letters within words declines. For instance, in alphabetic language reading, older adults were less accurate and longer latencies than young adults in identifying letter positions in briefly presented letter strings, suggesting a diminished ability to encode letter positions with age [19, 21]. In Chinese reading, where characters are densely packed and visually complex, older adults struggle more with recognizing closely spaced characters [22]. This decline has been attributed to multiple cognitive factors, including decreased processing speed and reduced working memory capacity [20, 23].

The flexibility of word position encoding in sentence reading has been observed in young skilled adults [8, 24]. However, it remains unclear how aging affects word position encoding flexibility in Chinese reading. Given that older adults experience greater difficulty in identifying word boundaries due to age-related declines in visual processing [22] and cognitive slowing [20], their ability to flexibly encode word positions may also be reduced. While previous studies have primarily focused on young adults, little is known about whether older Chinese readers exhibit the same degree of adaptability in word position encoding or whether they show greater sensitivity to word transpositions. Investigating word transpositions in sentences provides insight into how readers maintain sentence-level coherence despite disruptions in word order and how aging impact this ability. Older adults, who have greater difficulty and rely more on contextual cue for sentence reading [25, 26], may exhibit reduced flexibility in detecting and adapting to transposed-word structures.

The present study

The current study aimed to address the research gap in understanding the effects of aging on the flexibility of word position encoding in Chinese reading. By examining how older adults process and adapt to the variations in word position compared to young adults, we seek to shed light on the underlying mechanisms that contribute to age-related changes in reading performance. This study is guided by the following research question: Do older Chinese readers exhibit reduced flexibility in word position encoding compared to young adults? Based on the reading difficulties observed among older adults in Chinese reading, we hypothesized that while both older and young adults can flexibly encode word positions, older adults will show reduced flexibility compared to their young counterparts. This reduced adaptability may manifest as larger transposed-word effects (i.e., greater differences in reading times and error rates between transposed and control conditions) in young adults compared to older adults.

Researchers have employed various experimental paradigms to investigate the flexibility of word position encoding. One such paradigm is grammaticality judgment task, in which participants determine whether a sentence is grammatically correct [5]. Another approach is the same-different task, where participants compare two sentences to decide whether they are identical [15]. Eye-tracking paradigms have also been used to measure fixation times and gaze patterns, assessing how transposed words affect reading fluency [7, 27].

In this study, we employed a grammaticality judgment task following the methodology used by Liu et al. (2020). This task was chosen for several reasons. First, it directly measures sensitivity to word position encoding, making it a suitable tool for evaluating the flexibility of word position encoding. Second, it allows for controlled manipulation of word order, ensuring that observed effects are driven by transpositions rather than other reading difficulties. Moreover, this task has been successfully used in previous studies on the TW effect in Chinese reading [8, 24, 28], providing a validated approach for investigating word position encoding in this language.

Methods

The research was approved by the research ethics committee in the Academy of Psychology and Behavior at Tianjin Normal University and conducted in accordance with the principles of the Declaration of Helsinki.

Participants

A power analysis was conducted using G*Power (version 3.3.9.7) [29] to determine the required sample size for detecting a significant interaction effect between age group (young vs. older adults) and sentence condition (control vs. transposed-word condition) in a mixed-design analysis of variance. Based on previous studies examining the TW effect in Chinese reading [8], we assumed a medium effect size of 0.25. Power was set at 0.95 with an alpha level of 0.05. The computation indicated that a minimum of 27 participants per group (54 in total) was required. To account for potential exclusions due to data loss or participant non-compliance, we recruited 70 participants for this study. Thirty older adults (range = 65–75 years, M = 69.2, SD = 3.1, 9 male) and forty young adults (range = 18–24 years, M = 20.9, SD = 1.9, 23 female) were recruited from Tianjin Normal University and the surrounding community. Participants were native Chinese speakers who reported no history of reading impairment and read for several hours per week. While no formal cognitive screening tool was administered, all older adults were independent community dwellers with no self-reported cognitive impairments. Additionally, our sample characteristics (age range: 65–75 years) are consistent with previous studies on healthy aging and reading [30, 31], suggesting that our participants were representative of cognitively healthy older adults.

Participants reported no serious eye diseases and were screened for high-contrast acuity (> 20/40 in Snellen values) using a Tumbling-E eye chart [32]. The young adults had higher visual acuity (M = 20/26, range = 20/18–20/32) than the older adults (M = 20/34, range = 20/28–20/38), as is typical for these age groups [33]. Differences in years of formal education between the two age groups (older, M = 14.6 years, SD = 1.0; young, M = 14.5, SD = 1.0; $t(68) = 0.49$, $p = 0.629$) did not reach a significant level.

Stimuli and design

Sentences were adapted from Liu et al. (2020) used in experiment 2. A total of 160 sentences were presented in two conditions, forming a 2 (age group: older, young) × 2 (sentence condition: transposed-word, control) mixed design. Each sentence contained five words. The stimulus set included: 40 sentences in the transposed-word condition, created by transposing the third and fourth words in a grammatically correct base sentence; 40 sentences in the control condition, created by transposing the third and fourth words in an ungrammatical base sentence; 80 grammatically correct filler sentences, included to reduce predictability and balance the overall design. Following previous studies [5, 34], we used a Latin-square design to assign stimuli to different presentation lists. This ensured that each participant saw only one version (either TW or control) of each transposed-word stimulus, while across the participant group, both versions were presented equally often in the experiment. Additionally, all participants were exposed to all grammatically correct stimuli. The stimuli were previously normed by Liu et al. (2020), where an independent group of native Chinese speakers (N = 50) rated the sentences. Results confirmed that all grammatical stimuli were consistently judged as grammatically correct, and all transposed-word stimuli were judged as grammatically incorrect, validating the sentence manipulation.

Although word frequency differences between conditions were not explicitly controlled, this approach is consistent with previous studies on word position encoding in reading [5, 6, 8], which also did not control for word frequency. Moreover, all words (except the last one) remained identical and in the same positions across both transposed-word and control conditions, reducing potential lexical variability. Examples of each type of sentence are shown in Table 1.

Apparatus and procedure

To account for individual differences in linguistic knowledge, we assessed participants' vocabulary size using the Vocabulary Knowledge Test from the WAIS-III Digit Span subtest [35]. This measure was included as a covariate in our analysis to examine potential influences of lexical knowledge on word position encoding. Additionally, participants' working memory capacity was assessed using the WAIS-III Chinese version [36]. Scores for the digit span test were higher for young adults ($M = 16.5$, $SD = 2.2$) than older adults ($M = 12.4$, $SD = 1.7$; $t(68) = 8.32$, $p < 0.001$), typical for the two age groups [37]. Vocabulary scores were lower for young adults ($M = 14.8$, $SD = 1.2$) than older adults ($M = 15.6$, $SD = 1.1$; $t(68) = 5.12$, $p < 0.001$), consistent with a vocabulary disadvantage for young adults [38].

A 14-in. LCD screen and E-Prime (Version 2.0.10; Psychology Software Tools, Pittsburgh, PA, USA) were used to present stimuli. Sentences were in the 30-pt Song font, and each character in sentences subtended approximately 1° of a horizontal visual angle and, therefore, was of normal size for reading. A keyboard connected to the computer was used to record responses, using the 'J' key for ungrammatical decisions and the 'F' key for grammatical decisions.

The display and data acquisition procedures were the same as in Liu et al. (2020). Participants were asked to press the 'F' or 'J' key to make grammaticality decisions as quickly and as accurately as possible whether each stimulus was grammatically correct. A feedback dot was presented following the response, in red if it was incorrect or in green if it was correct. The experiment lasted approximately 20 min.

Analysis

All data processing and statistical analyses were conducted using the lme4 package [39] in the R environment [40].

Trials with incorrect responses were excluded from the RT analysis. Extreme RT outliers were removed using a trimmed range approach, excluding RTs above 2.5 standard deviations from the grand mean in each group (resulting in the removal of 2.75% of trials). This approach is consistent with previous studies on Chinese reading [24, 34]. Log transformation was applied to RTs to correct for positive skewness in the data, ensuring normality in residual distributions.

Working memory and vocabulary scores were included as covariates in the analysis. These cognitive scores were z-scored before entering the models to facilitate comparability across participants. Means-centering was applied to all continuous predictors to improve model interpretability and reduce collinearity.

A linear mixed-effects model (LMM) was used to analyze response times, while a generalized linear mixed-effects model (GLMM) with a binomial distribution [41] and a logit link function was used to analyze accuracy (correct $= 0.5$, incorrect $= -0.5$). Fixed effects included age group (older, young), sentence condition (transposed-word, control), and their interaction. Random intercepts were included for both participants and items in all models. Random slopes were initially included where appropriate (e.g., by participant slopes for sentence condition). If a model failed to converge, random slopes were gradually removed in a stepwise manner while maintaining the

Table 1 Example stimulus for each condition

	Base Sentence	Base Sentence in English		Stimuli
Grammatical	他的公司生产鞋	His company produces shoes	Transposed-word Condition	他的生产公司鞋
	她的笑容非常美	Her smile is very beautiful		她的非常笑容美
Ungrammatical	他的公司生产美	His company produces beauty	Control Condition	他的生产公司美
	她的笑容非常鞋	Her smile is very shoes		她的非常笑容鞋

Words in the base sentences that were transposed to create the conditions are shown using wavy and solid underlines, although stimuli were presented without any underlining in the study

Table 2 Means (SEs) for the primary measure in conditions and groups

	Error Rates (%)		Response Times (ms)	
	Transposed-word	**Control**	**Transposed-word**	**Control**
Young Adults	25.06 (1.11)	4.65 (.54)	1482 (15)	1291 (14)
Older Adults	37.76 (1.44)	15.72 (1.07)	3063 (48)	2969 (41)

maximal random effects structure possible to ensure a well-fitting model.

Following convention, z or t values greater than 1.96 were considered statistically significant, with higher values indicating larger effects [41]. The mean error rates and response times of the correct responses are shown in Table 2 and Fig. 1.

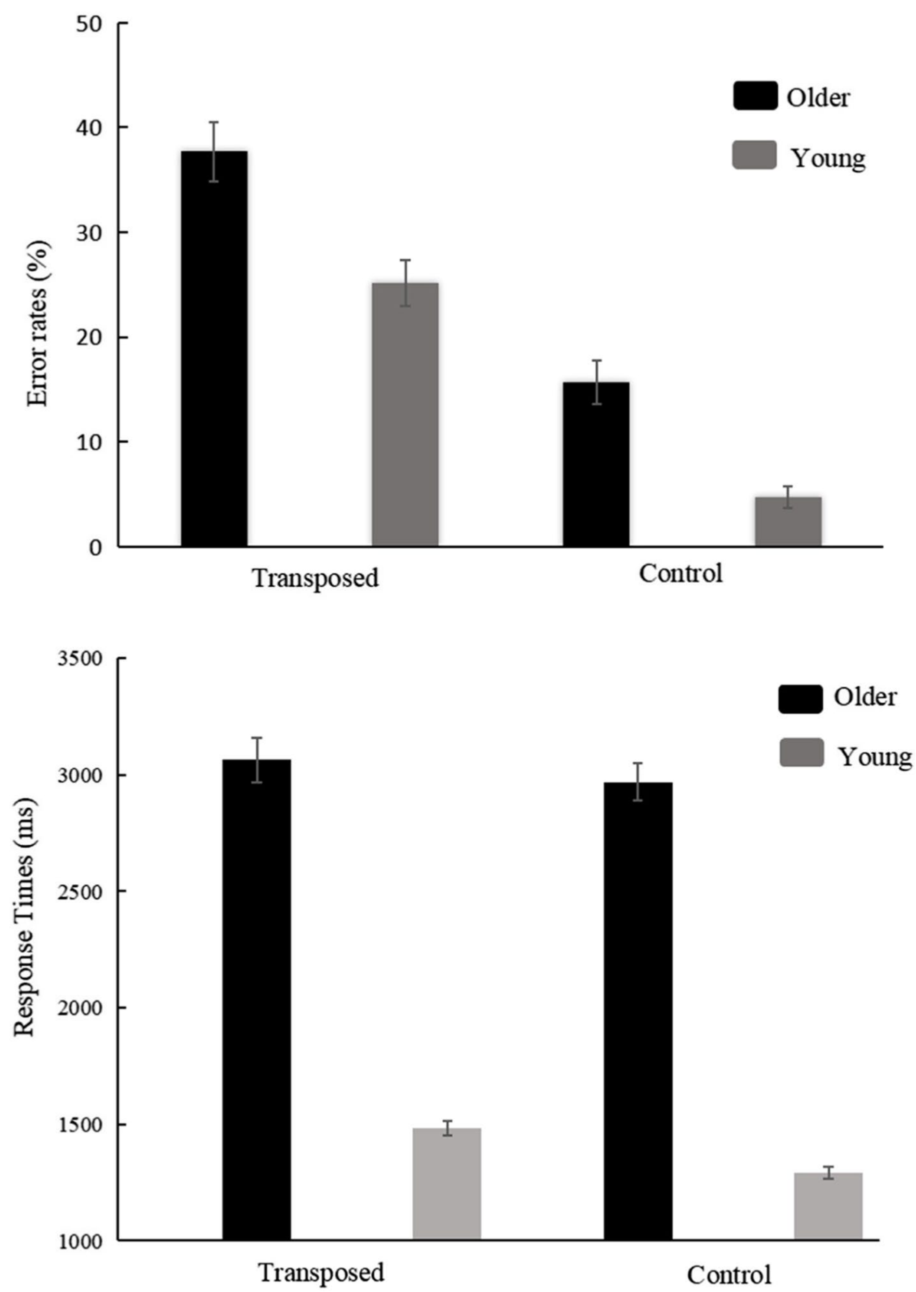

Fig. 1 Mean error rats and response times for older and young adults in transposed and control conditions. Error bars show 95% confidence intervals

Table 3 Summary of the Generalized Linear Mixed-Effects Model (GLMM) for Accuracy

	β (Estimate)	*SE*	*z*	*p*-value	95% CI
Intercept	− 2.18	0.23	− 9.5	<.0001	[− 2.65, − 1.73]
Age group	− 1.4	0.3	− 4.68	<.0001	[− 2.01, − 0.81]
Sentence Condition	1.53	0.16	9.39	<.0001	[1.21, 1.86]
Age group × Sentence condition	0.64	0.18	3.51	0.0005	[0.28, 1.01]

Results

Error rates

As shown in Table 3, the main effects of the age groups and sentence conditions reached significant level. More importantly, a significant interactive effect was found between the two independent variables. Following the significant interaction, planned follow-up tests were conducted to examine the effect of sentence type (control vs. transposed-word) within each age group. It has revealed that the transposed-word effect was greater in the young adult group ($b = 2.17$, $SE = 0.18$, $z = 12.01$) than in the older adult group ($b = 1.53$, $SE = 0.16$, $z = 9.39$, $p < 0.001$). Additionally, working memory capacity did not have a significant main effect ($b = -0.12$, $SE = 0.07$, $z = -1.78$; $p = 0.077$) or interactions with age group and sentence condition ($b = 0.11$, $SE = 0.28$, $z = 0.40$; $p = 0.689$). Similarly, vocabulary size did not show a significant main effect ($b = 0.07$, $SE = 0.07$, $z = 0.91$; $p = 0.362$) or interactions with age group and sentence condition ($b = 0.25$, $SE = 0.16$, $z = 1.36$; $p = 0.178$).

Response times

The pattern for response times mirrored that observed in error rates. Participants took longer to make a correct grammaticality decision in the transposed-word condition compared to the control condition (Table 4). Furthermore, older adults required more time than young adults to make correct decisions. A significant interaction was also found between age group and sentence condition (Table 4). A planned follow-up test revealed that the transposed-word effect was greater in the young adult group ($b = 0.14$, $SE = 0.02$, $t = 8.35$) than in the older adult group ($b = 0.07$, $SE = 0.02$, $t = 3.61$). Moreover, working memory capacity did not show a significant main effect ($b = 0.02$, $SE = 0.02$, $t = 0.91$; $p = 0.331$) or interactions with age group and sentence condition ($b = -0.01$, $SE = 0.03$, $t = -0.20$; $p = 0.841$). Similarly, vocabulary size did not have a significant main effect ($b = -0.02$, $SE = 0.02$, $t = -0.82$; $p = 0.414$) or interactions with age group and sentence condition ($b = 0.04$, $SE = 0.03$, $t = 1.14$; $p = 0.253$). These results suggest that, at least in the current task, individual differences in working memory capacity and vocabulary size did not substantially modulate the transposed-word effect.

Discussion

The present study investigated the effects of aging on the flexibility of word position coding in Chinese reading, addressing the gap in research on how older adults process word transpositions at the sentence level. By employing transposed-word stimuli in a rapid grammaticality decision task, we examined whether older adults exhibit the same flexibility in word position encoding as young adults. Our findings revealed that both young and older adults demonstrated the transposed-word effect, as evidenced by higher errors and longer response times in the transposed-word condition compared to the control condition. This indicates that word position encoding remains functional across adulthood in Chinese reading, despite age-related changes in cognitive processing.

However, a crucial finding of this study is that the magnitude of the transposed-word effect is smaller in older adults than in young adults. This suggests that while older adults retain the ability to flexibly encode word positions, they do so to a lesser extent than young

Table 4 Summary of the Linear Mixed-Effects Model (LMM) for Log-Transformed RTs

	β (Estimate)	*SE*	*t*	*p*-value	95% CI
Intercept	7.9	0.06	141.52	<.0001	[7.79, 8.01]
Age group	− 0.81	0.07	− 11.07	<.0001	[− 0.95, − 0.66]
Sentence Condition	0.07	0.02	3.61	0.0003	[0.03, 0.11]
Age group × Sentence condition	0.07	0.02	3.55	0.0004	[0.03, 0.11]

Marginal R^2 (Fixed Effects Only): 0.434, Conditional R^2 (Full Model, Including Random Effects): 0.711

adults. Rather than concluding that aging leads to a complete impairment or that word position encoding is fully preserved, our results indicate that this ability remains intact but exhibits reduced flexibility with age.

Reconditing the preservation vs. decline in word position encoding

The presence of a significant transposed-word effect in older adults suggests that word position encoding mechanisms are maintained to support reading across adulthood. This finding aligns with previous research demonstrating that certain core linguistic processes, such as lexical access and syntactic parsing, tend to be relatively preserved with age [42]. However, the smaller transposed-word effect in older adults implies that this ability becomes less efficient, which may contribute to reading difficulties in later adulthood.

One possible explanation for this reduced flexibility is an age-related decline in attentional processing and reading strategies. Older adults tend to exhibit more frequent and prolonged fixations, as well as increased regressions during reading [26, 31, 43], which may reflect greater difficulty in encoding and maintaining word positions across saccades. Additionally, older adults often adopt a more cautious reading strategy, such as increased reliance on re-reading [44], slower reading speed [31] and greater dependence on contextual information [25, 26]. These strategies may help compensate for reduced flexibility in word position encoding but could also contribute to slower sentence processing.

The noisy-channel model suggests that sentence comprehension involves probabilistic inference, where readers assume some distortion in input and reanalyze word order based on syntactic and semantic constraints [9]. The fact that older adults still exhibit the TW effect supports the idea that they might engage in reanalysis processes, but their smaller TW effect suggests that these processes may be less efficient with age. This decline in efficiency may be due to age-related reduction in cognitive flexibility, which is critical for detecting and resolving word position ambiguities. Cognitive flexibility refers to the ability to adapt processing strategies when encountering unexpected or ambiguous linguistic input [45]. Young adults may rapidly adjust their expectations when word order deviates from standard sentence structures, allowing for efficient reinterpretation of transposed words. In contrast, older adults may rely more on habitual reading patterns and have difficulty adapting to unexpected word positions, making reanalysis slower and less effective [46].

Although age-related visual acuity decline has been widely documented [22, 47], we did not directly examine the relationship between individual differences in visual acuity and performance on the transposed-word task. While it is possible that reduced visual precision or increased visual crowding effects could contribute to less efficient word position encoding, our study does not provide direct evidence for this link. Future research should explicitly test whether variations in visual acuity predict individual differences in word position encoding flexibility by including young adults with reduced visual acuity.

The role of working memory and vocabulary in word position encoding

An interesting aspect of our findings is that working memory and vocabulary scores did not significantly predict the transposed-word effect in either age group. These results suggest that working memory and vocabulary do not play a central role in modulating the transposed-word effect. However, it is important to note that this does not necessarily mean these abilities are irrelevant to word position encoding or reading performance in general. Future studies could explore this issue further by employing different task designs that place greater demands on working memory or by using eye-tracking methods to examine the real-time interplay between cognitive resources and word position flexibility.

The role of declarative memory in grammaticality judgments

Grammaticality judgment tasks are explicit decision-making tasks that rely on declarative memory, as they require participants to consciously assess sentence structure, compare it to stored syntactic knowledge, and make deliberate judgments. Unlike implicit linguistic processing, which may rely on procedural mechanism, grammaticality judgments require access to explicitly learned grammatical rules and stored linguistic knowledge. Our findings may reflect not only differences in word position encoding flexibility but also broader age-related changes in metalinguistic awareness and decision-making while reading.

Given that declarative memory is known to decline with age [48], this raises an interesting question: to what extent does age-related decline in declarative memory contribute to the observed reduction in the transposed-word effect? While our study did not directly assess declarative memory, previous research suggests that older adults often experience difficulties in tasks that require explicit syntactic judgments or conscious recall of linguistic rules [49]. This could partially explain why their transposed-word effect was smaller than that of young adults, as they may struggle more with consciously recognizing grammatical disruptions caused by word transpositions.

While working memory and vocabulary scores did not significant predict transposed-word performance in our study, it remains possible that individual differences in declarative memory capacity could influence word position encoding in older adults. Future research should explore this issue by incorporating explicit tests of declarative memory (e.g., sentence recall tasks, syntactic rule learning paradigms) to assess whether declines in declarative memory correlate with reduced flexibility in word position encoding. Moreover, implicit assessments —such as eye-tracking measures (e.g., first-pass reading times, regressions, or fixation durations) — could provide a more nuanced understanding of how aging affects word position encoding during natural reading. Future studies should consider incorporating such measures to better capture both implicit linguistic processing and real-time reading strategies across different age groups.

Limitations and future directions

One limitation of this study is that we did not control for potential differences in reading experience between age groups. Previous research suggests that lifelong reading experience can influence word recognition efficiency and sensitivity to orthographic regularities [50, 51]. Future studies should measure and control for reading exposure to determine whether individual differences in reading habits influence the degree of flexibility in word position encoding.

Moreover, the present study focused on Chinese reading, where word boundaries are not explicitly marked, making word position encoding particularly crucial. However, it remains unclear whether similar age-related changes in word position flexibility occur in alphabetic languages. Future research should explore how writing system properties interact with aging to shape word position encoding across different languages.

Additionally, by focusing solely on mid-sentence transpositions, our study may not have fully captured the effects of word order disruptions in other sentence regions. The flexibility of word position encoding likely varies depending on the location of the transposed words within a sentence, as contextual cues and the predictability of upcoming words differ across sentence positions [24, 52] To gain a more comprehensive understanding of how aging influences word position encoding, future research should systematically manipulate transposed-word positions at the beginning, middle, and end of sentences, examining how these variations interact with different contextual constraints.

Conclusion

In conclusion, this study provides novel insights into how aging affects the flexibility of word position encoding in Chinese reading. Our findings demonstrate that while both older and young adults can flexibly encode word positions, older adults exhibit reduced flexibility compared to their young counterparts. This reduced adaptability may contribute to reading difficulties observed in older Chinese readers.

Abbreviation

TW Transposed Word

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Authors' contributions

ZL designed the study with the help from JW, ZL collected the data with the help from YL, ZL wrote the manuscript with the help from YL and with critical comments from JW.

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Data availability

Data files are available from online Figshare repository: https://doi.org/10.6084/m9.figshare.22032575.

Declarations

Ethics approval and consent to participate

This study was performed in line with the principles of the Declaration of Helsinki. The Faculty of Psychology Ethics Committee at Tianjin Normal University granted approval. Written informed consent was obtained from all individual participants included in the study.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interest.

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