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How Vietnamese tackle Japanese kanji: key factors behind handwriting competence in Japanese

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This study explored kanji handwriting behavior of Vietnamese learners of Japanese as a Foreign Language (JFL), focusing on single-kanji words with Kun-readings to minimize phonological overlap between Japanese and Vietnamese. Participants completed a real-time handwriting task using a stylus and tablet. The study analyzed writing latency, duration, and accuracy, examining how these were influenced by lexical knowledge, kanji frequency, visual complexity, and difficulty level. Results showed that higher lexical proficiency and more frequent kanji led to faster initiation times. Writing duration increased with visual complexity, as kanji with more strokes took longer to execute. Accuracy decreased for complex and difficult kanji (e.g., N2 level), especially among lower proficiency learners. Notably, learners with stronger lexical knowledge could better compensate for complexity during writing. These findings highlight the distinct cognitive and motor demands of kanji production and underscore the value of combining vocabulary exposure with structured handwriting practice in JFL instruction.

KEYWORDS

Japanese-as-a-Foreign-Language (JFL), kanji handwriting behavior, lexical knowledge, Vietnamese learners, visual complexity

1 Introduction

In an age where typing has become the norm, handwriting skills have become more important than ever to improve memory retention of scripts, as it activates multiple brain systems involved in fine motor control and spatial awareness (James and Engelhardt, 2012; Ose Askvik and Van der Weel, 2020; Vinci-Booher et al., 2016). This is particularly important for orthographically deep scripts such as Chinese hanzi and Japanese *kanji*. Unlike shallow orthographies, where sounds can mostly be predicted from spelling, kanji is highly irregular, requiring a thorough understanding and practice of stroke order and structural balance to master (Besner and Smith, 1992; Chang et al., 2015; Giovanni, 1994; Katz and Frost, 1992; Law et al., 1998). As a result, handwriting kanji is more difficult and slower to learn compared to shallow orthographies, presenting challenges for both native speakers and foreign-language learners. For Vietnamese learning Japanese as foreign language (JFL learners), whose native writing system is alphabetic (i.e., a shallow orthography) mastering

kanji poses difficulties due to significant orthographic differences, yet, Vietnamese do encounter kanji relatively often in daily life (e.g., contrasting English speaking countries) due to historical and cultural aspects. To investigate the factors influencing *kanji* writing behavior among Vietnamese JFL learners, this study focused on their handwriting of Japanese single-*kanji* words pronounced with Japanese-origin Kun-readings which have no phonological resemblance to Vietnamese. The study aimed to measure *kanji* handwriting behavior independently of phonological influence as Vietnamese does share some morphological and phonological similarities with Chinese and Vietnamese (e.g., the word “embassy” 大使馆 is /da4shi3guan3/ in Mandarin, /taishikan/ in Japanese and /đại sứ quán/ in Vietnamese). The study examined how Japanese lexical knowledge and *kanji* characteristics, such as usage frequency and visual complexity, affected *kanji* writing behavior, providing insights into the unique challenges faced by Vietnamese JFL learners which constitute a group of special interest due to their exposure but not active usage of kanji.

1.1 Background

Historically, the Vietnamese language utilized Chinese characters (*chữ Hán*) as its primary writing system which were brought to Vietnam from China at some point during its rule over Vietnam (~111 BC to 939 AD) (De Francis, 2019) and remained dominant in administration and literature until the 19th century. Consequently, many Vietnamese words, particularly in formal and academic contexts, are derived from Chinese. It is likely that Vietnamese were using *chữ Hán* to write down Vietnamese as early as the eighth century (De Francis, 2019). Later, under French colonial rule, *chữ Quốc ngữ*, a Latin-based script developed by missionaries in the 17th century, gained prominence and became the official writing system by the early 20th century.

In a similar way, Japan adopted Chinese characters (*kanji* in Japanese) and Chinese words into its writing system as well, with the difference being that kanji remain an integral part of Japanese today. When *kanji* were first introduced in Japan, they were used in their original Chinese forms. Over time, however, the Japanese adapted kanji to fit their language, developing two distinct types of pronunciation: *On*-readings, derived from the original Chinese pronunciation and *Kun*-readings, based on native Japanese words (Hirose, 1998; Kess and Miyamoto, 2000; Leong and Tamaoka, 1995). For example, the single-*kanji* word 山, meaning “mountain,” is pronounced *son* (/shon/) in Vietnamese and *shān* in Mandarin Chinese. In Japanese, it is pronounced *san* when using the Chinese-derived *On*-reading (e.g., 富士山 Fuji-san, “mount Fuji”) and *yama* when using the native Japanese *Kun*-reading (e.g., 山梨県 Yamanashi-ken “Yamanashi prefecture”). Native Japanese speakers can typically distinguish between the *On*- and *Kun*-readings with relatively high accuracy (Tamaoka and Taft, 2010).

Although Japanese kanji *reading* has been amply investigated, only a few studies have explored Japanese kanji *handwriting*. In a real-time handwriting study with auditorily presented stimuli, Tamaoka and Takahashi (1999) examined how word frequency

and kanji visual complexity influence handwriting among native Japanese speakers. They focused exclusively on two-kanji compound words and found that for low-frequency words, kanji with more strokes took longer to *initiate* writing (e.g., 酪農 > 余白), as visual complexity significantly affected the writing process. Yet, high-frequency words were seemingly *not* influenced by visual complexity (i.e., 優勝 = 以上), as they were likely processed more holistically. Similarly, the interval between writing the two kanji was affected by visual complexity only for low-frequency words, indicating that these words required additional processing time. Additionally, the left-side kanji was influenced by both word frequency and visual complexity, while the right-side kanji was less affected. These findings suggest that native Japanese speakers rely on orthographic representations during handwriting, with both word frequency and visual complexity playing important roles in how kanji are processed and written.

Hatta et al. (2002) investigated kanji handwriting errors among Japanese school children, college students, and Australian JFL learners (native English speakers). Japanese college students primarily made errors involving phonology (e.g., 精心 instead of 精神) rather than orthographically or semantically related ones. In contrast, Japanese Grade 7 students predominantly made orthographically related errors (e.g., 委節 instead of 季節), as they were still in the process of mastering kanji. Australian JFL learners with no prior kanji knowledge often produced non-existent kanji, creating figures that resembled kanji or kanji elements but did not actually exist in Japanese. This likely occurred because they had not yet fully learned the orthographic structures of kanji. These findings suggest that the types of kanji writing errors vary depending on the learner’s stage of kanji acquisition, reflecting differences in their familiarity with kanji phonology, orthography, and semantics. Jackson and Malone (Jackson and Malone, 2009) stated that for native English speakers to “develop general professional-level proficiency” Chinese and Japanese belonged to “the most challenging” languages to learn (over 4 times as long with daily instruction as languages such as French, Dutch or Spanish). This is likely at least partly due to the task of mastering an orthographic script with such a large number of novel and complex characters.

Vietnamese learners of Japanese present a particularly interesting group for examining kanji writing behavior because they seem to occupy a sort of intermediate position between learners from purely alphabetic backgrounds, such as Australian English speakers, and learners whose native language actively uses Chinese characters, such as Chinese (and Japanese) speakers. As stated earlier, Vietnamese shares numerous Sino-Vietnamese words derived from Chinese, embedding structural features similar to Chinese into the language. Historically and culturally, Vietnamese still have significantly more exposure to Chinese characters (*chữ Hán*) than JFL learners with purely alphabetic backgrounds persisting through historical artifacts, temples, and traditional contexts (e.g., weddings and other celebrations), even though these characters are no longer involved in everyday use. Thus, studying this group can provide valuable insights into how partial linguistic and cultural familiarity with logographic scripts influences handwriting and learning behaviors when acquiring Japanese kanji.

1.2 The present study

This study only used single-kanji words with Kun-readings as experimental stimuli, as the Kun-reading has no phonological resemblance to Vietnamese. This approach aims to eliminate any potential influence of phonological similarity (Wang and Zhang, 2015, 2022; Zhang and Wang, 2016) between Vietnamese and Japanese and to exclusively measure kanji handwriting behavior. While handwriting production involves multiple cognitive stages, such as lexical access, orthographic retrieval, and motor execution (Bonin et al., 2001; Han et al., 2012), the present study simplified the task to investigate two key time-based aspects and accuracy of writing behavior: (1) *kanji writing latency* measured from the time from the auditory presentation of the target kanji to the initiation of writing, (2) *kanji writing duration* measured from the time from the initiation of writing to the completion of the kanji (i.e., the total time taken to complete writing the target kanji), and (3) *accuracy* as a result of writing behavior. Kanji writing latency reflects the time required for preparatory processes prior to writing initiation, such as lexical access, retrieval of the orthographic representation of the kanji, and preparation of the motor program necessary for handwriting. In contrast, kanji writing duration primarily reflects processes occurring during the execution of writing, including the sequential production of strokes and the motor implementation of the orthographic representation (including online changes). By examining these temporal measures together with accuracy, the present study investigates how Japanese lexical knowledge and kanji characteristics—such as usage frequency and visual complexity—affect the efficiency of kanji handwriting production in Vietnamese learners of Japanese as a foreign language (JFL).

2 Methods—single kanji writing behavior experiment

2.1 Participants

A total of 35 Vietnamese JFL learners (seven males, 28 females) from Ho Chi Minh City, Vietnam, participated in the experiment. The average age of the participants was 24 years and 8 months ($SD = 3$ years and 6 months). The Japanese Language Proficiency Test (JLPT) consists of five levels, ranging from N5 (lowest) to N1 (highest). Among the participants, six had passed N3, 23 had passed N2, and six had achieved N1. Participants had been studying Japanese for an average of 5 years and 3 months ($SD = 2$ years and 7 months), with study durations ranging from 2 to 10 years. Regarding residency in Japan, three participants had lived in Japan for over a year, while seven had stayed in Japan for less than a year, and none of the N3 participants had any experience living in Japan. The study was reviewed and approved by the Research Ethics Committee of Nagoya University (approval number: NUHM-22-015). Recruitment period was from December 16, 2023 to January 1, 2024. All participants provided written informed consent and received monetary compensation for their participation. The collected data were securely stored, and participants' identities were anonymized using numerical pseudonyms to ensure privacy.

Given that the data were to be analyzed using trial-level linear mixed-effects (LME) models with crossed random effects for participants and items, a conventional G*Power analysis was not suitable for the present design. Instead, sample size is described in terms of both participants and item-level observations resulting in 1,400 responses (35 participants \times 40 items) for the accuracy analysis.

2.2 Lexical knowledge test

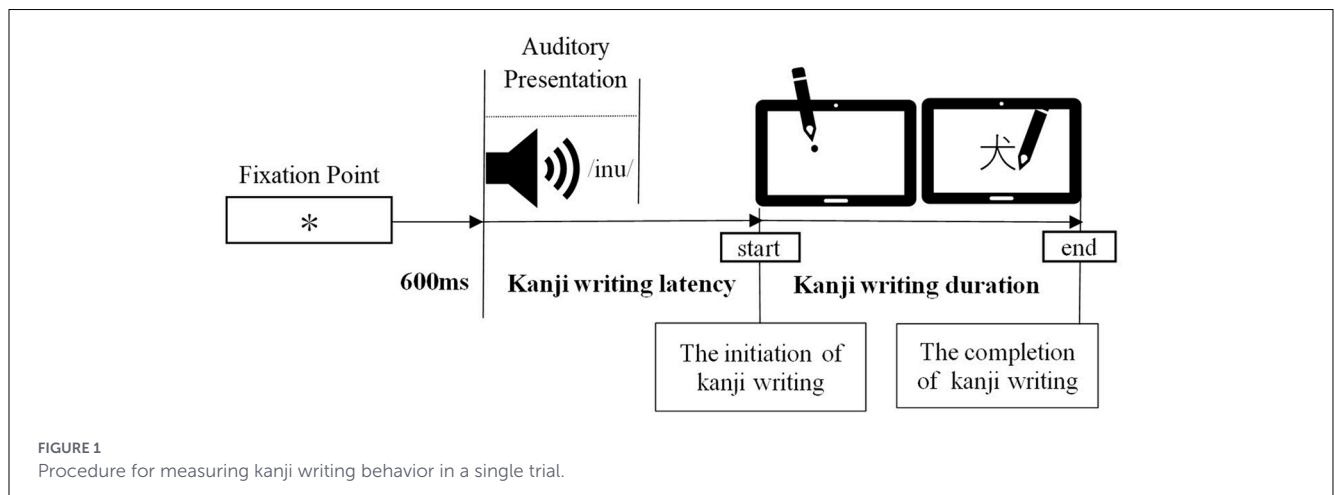
To evaluate participants' Japanese lexical knowledge, the Lexical Knowledge Test for JFL Learners with Non-Kanji Backgrounds (Yamato et al., 2016) was administered. The test consisted of three subcategories: Japanese-origin words (*wago*), Chinese-origin words (*kango*), and function words. Each subcategory included 12 questions, resulting in a total of 36 questions. Despite the small sample size of 35 participants in the present study, the test demonstrated relatively high reliability, with a Cronbach's alpha coefficient of 0.74. The participants' scores ranged from 28 to 36, with a mean score of 33.53 ($SD = 1.65$). These test scores were included as a fixed factor in the subsequent analysis.

2.3 Stimuli for investigating kanji writing behavior

Due to the abundance of homonyms in two-kanji compound words in Japanese (Tamaoka, 2007; Tamaoka et al., 2012), this study constrained its stimuli to single-kanji words. These *kanji* are used independently as single words and are typically all Japanese-origin words (*wago*). Notably, these single-kanji words are pronounced using Kun-readings (Japanese-origin pronunciations) and have no phonological or orthographic equivalents in Vietnamese. Based on these criteria, 40 single-kanji words frequently used in daily life were selected as stimuli (see Appendix). The selected *kanji* were classified within JLPT levels N2 to N4, which were used as a fixed factor for kanji difficulty. The number of strokes ranged from 2 (e.g., 人 “person”) to 18 (e.g., 顔 “face”), with a mean of 8.58 ($SD = 3.89$). Stroke count was used as a fixed factor for visual complexity. Kanji frequencies were obtained from the 2,136 *Joyo kanji* database, accessible online at <http://www.kanjidatabase.com> (Tamaoka et al., 2017). This database reports frequencies using 11 years of the all-Japanese version of the *Mainichi Shimbun* newspaper (2000–2010). For this study, kanji frequency values excluding proper nouns were used, resulting in a mean frequency of 138,818 occurrences ($SD = 304,888$).

2.4 Procedure

This study conducted a real-time experiment on kanji writing behavior using a computer tablet (Microsoft Surface Pro) with a stylus pen. The experiment was programmed using *PsychoPy* software (Peirce et al., 2019), allowing continuous measurement of kanji writing behavior with millisecond (ms) precision. The kanji stimuli were presented auditorily using the Tokyo standard accent,



recorded by a male native Japanese speaker from Tokyo, Japan. As shown in Figure 1, a fixation point (“*”) appeared at the center of the tablet screen for 600 ms. Following this, a Japanese kanji word was presented aurally. Participants were instructed to write the corresponding kanji as quickly and accurately as possible using the stylus pen. The experiment recorded three key time points: (1) the auditory stimulus onset, (2) the initiation of writing when the participant first touched the pen to the tablet, and (3) the completion of writing when the pen was finally lifted from the tablet. Using these time points, the study calculated two measures: (1) kanji writing latency (the time from auditory stimulus onset to the initiation of writing) and (2) kanji writing duration (the time from the initiation of writing to the completion of the kanji). After each kanji was written, the experimenter recorded its accuracy (correct = 1, incorrect = 0). The next kanji stimulus was presented 3,000 ms after the completion of the previous trial. All stimuli were presented in a pseudo-randomized order for each participant. Before beginning the main experiment, participants completed eight practice trials to familiarize themselves with the task. All kanji writing data were recorded and securely stored on the tablet computer.

2.5 Data analysis

Kanji writing accuracy, initiation latency, and writing duration were analyzed using linear mixed-effects (LME) models (Baayen et al., 2008) with the *lme4* package (Bates et al., 2015) in R. Fixed effects included both participant and stimulus-related factors. The participant factor consisted of lexical knowledge [lex.z; scores from the Yamato et al. (2016) lexical knowledge test, centralized]. The stimulus factors included visual complexity (stroke.z; number of strokes, centralized), kanji frequency (lnfreq; natural log-transformed, centralized), kanji difficulty [jlpt; based on Japanese Language Proficiency Test (JLPT) levels], and trial order (trial.z). Random effects were specified for participants and kanji stimuli to account for individual and item variability. *p*-values were calculated using Satterthwaite’s approximations via the *lmerTest* package (Kuznetsova et al., 2017) with restricted maximum likelihood estimation (Harville, 1977). For binomial accuracy data, the *glmer* function (with a logit link function) was used to

compute the *z*-distribution via maximum likelihood estimation (Laplace approximation). The best-fitting LME model was selected through Akaike’s Information Criterion (AIC) (Anderson et al., 2000) comparisons of the models. We aimed to provide the best fit for the data while maintaining interpretability and avoiding excessive complexity.

3 Results

3.1 Result of the accuracy analysis

A total of 1,400 responses (35 participants × 40 items) were analyzed. The mean accuracy of kanji writing among Vietnamese JFL learners was 62.43% (*SD* = 48.45%). Based on model comparisons using Akaike’s Information Criterion (AIC) (Anderson et al., 2000), the best-fitting linear mixed-effects model (LME) is summarized in Table 1.

Three fixed factors significantly influenced kanji writing accuracy: kanji difficulty ($z = 3.198, p < 0.01$), visual complexity ($z = -3.212, p < 0.01$), and kanji frequency ($z = 2.007, p < 0.05$). These effects are summarized in Figure 2. Accuracy differed markedly across JLPT levels, with the lowest accuracy observed for N2 kanji (43.57%), followed by N3 kanji (62.08%), and the highest accuracy for N4 kanji (83.59%). This trend suggests that learners encounter increasing difficulty with kanji classified at higher proficiency levels. Kanji with a greater number of strokes were associated with lower writing accuracy, indicating that increased visual complexity hinders accurate reproduction. Conversely, more frequently encountered kanji (based on frequency counts from the *Mainichi Shimbun* corpus, which reflects usage by native Japanese) were written with higher accuracy, suggesting that repeated exposure facilitates kanji learning and retention. Despite the corpus being native-focused, it is likely that non-native speakers (e.g., Vietnamese learners) also encounter higher-frequency characters more often, whether through formal study, media, or daily use. There was no significant main effect of participants’ lexical knowledge on writing accuracy, indicating that overall performance on the writing task did not depend on vocabulary size. Furthermore, no significant interaction effects were found between

TABLE 1 Results of the LME model analysis for kanji writing accuracy.

Variables	Estimate	SE	z value	Pr(> z)	p
(Intercept)	-3.894	1.517	-2.566	0.010	*
Kanji difficulty (jlpt)	0.753	0.236	3.198	0.001	**
Visual complexity (stroke.z)	-0.538	0.167	-3.212	0.001	**
Kanji frequency (lnfreq)	0.304	0.151	2.007	0.045	*
Lexical knowledge (lex.z)	0.223	0.722	0.309	0.757	
lnfreq:lex.z	0.005	0.067	0.079	0.937	
stroke.z:lex.z	-0.072	0.066	-1.089	0.276	

* $p < 0.05$. ** $p < 0.01$. Participants = 35. Items = 40. Observations = 1,400. $g\text{mer}(\text{accuracy} \sim 1 + \text{jlpt} + \text{stroke.z} + \text{lnfreq} + \text{lex.z} + \text{lnfreq}:\text{lex.z} + \text{stroke.z}:\text{lex.z} + (1 | \text{participant}) + (1 | \text{item}), \text{data} = \text{mydata}, \text{family} = \text{binomial})$.

lexical knowledge and either kanji frequency or visual complexity, suggesting that these factors independently influenced learners' writing performance.

3.2 Result of kanji writing latencies (initiation time)

Kanji writing latency refers to the time from the auditory presentation of a single kanji word to the initiation of writing, specifically, the moment when the pen first touches the tablet to begin writing the kanji. The best-fitting LME model was identified using Akaike's Information Criterion (AIC) (Harville, 1977) and specified as: $\text{lmer}(\text{RT} \sim \text{trial.z} + \text{lex.z} * \text{stroke.z} * \text{lnfreq} + \text{jlpt} + (0 + \text{lex.z} | \text{participant}) + (1 | \text{item}), \text{data} = \text{mydata})$. After selecting the best-fit model, responses with standardized residuals exceeding 3.0 standard deviation units were excluded as outliers, resulting in the removal of 13 out of 874 responses. The final analysis included 861 kanji writing latencies. The results are presented in Table 2.

The LME model analysis revealed two significant main effects for kanji writing latency: lexical knowledge and kanji frequency. As illustrated in Figure 3, participants with higher lexical knowledge scores initiated writing significantly faster, as reflected by a negative estimate [$t(436.620) = -2.865, p < 0.01$]. This indicates that greater familiarity with Japanese vocabulary facilitates quicker retrieval and access to orthographic forms during handwriting tasks. Kanji with higher frequency were associated with shorter writing initiation times [$t(34.480) = -2.249, p < 0.05$], suggesting that commonly encountered kanji are more readily accessible for production.

Additionally, three interaction effects were found. A significant interaction of lexical knowledge and visual complexity [$t(791.530) = -2.251, p < 0.05$] indicated that participants with higher lexical knowledge initiated writing faster even for kanji with greater visual complexity (i.e., more strokes), whereas those with lower

lexical knowledge exhibited longer latencies for complex kanji. Another significant interaction between lexical knowledge and kanji frequency [$t(794.310) = 2.913, p < 0.01$] suggested that frequent exposure to kanji could help learners compensate for difficulty in retrieval, particularly among those with lower lexical knowledge. A significant three-way interaction of lexical knowledge, visual complexity and kanji frequency [$t(791.380) = 2.095, p < 0.05$] indicated a complex interplay among lexical knowledge, visual complexity, and kanji frequency in determining the ease of initiating kanji writing. In particular, high-frequency and visually simpler kanji appear to be accessed more quickly, especially by learners with greater lexical knowledge.

3.3 Result of kanji writing durations

Kanji writing duration refers to the time from the initiation of writing to the completion of writing the kanji. The best-fitting linear mixed-effects model was identified using Akaike's Information Criterion (AIC) for model comparisons. The final model was specified as: $\text{lmer}(\text{RT} \sim 1 + \text{trial.z} + \text{lex.z} * \text{stroke.z} * \text{lnfreq} + \text{jlpt} + (1 | \text{participant}) + (1 | \text{item}), \text{data} = \text{mydata})$. After model selection, potentially influential outliers were removed, and the final analysis included 860 kanji writing duration observations. The results of the LME model analysis are summarized in Table 3.

As shown in Table 3, visual complexity emerged as the strongest significant predictor of kanji writing duration [$t(33.950) = 14.265, p < 0.001$]. As illustrated in Figure 4, kanji with a greater number of strokes required significantly longer times to complete, reflecting the greater motor demands needed to accurately produce visually complex characters. This finding was expected, as the physical act of handwriting inherently requires more time as the number of strokes increases. In addition, a significant interaction between lexical knowledge and visual complexity was observed [$t(807.700) = -3.295, p < 0.01$]. Participants with higher lexical knowledge demonstrated slightly greater efficiency in writing visually complex kanji, suggesting that stronger familiarity with kanji structures may help streamline motor execution, even when kanji are more visually demanding. No significant effects were found for kanji frequency or kanji difficulty (as measured by JLPT levels), indicating that once kanji writing is initiated, the process primarily reflects motor execution demands rather than cognitive retrieval difficulties. Overall, these findings suggest that while cognitive factors such as lexical knowledge can assist in managing visually complex characters, kanji writing duration is largely governed by the physical and motoric complexity of the character itself.

4 General discussion

This study investigated the handwriting behavior of Vietnamese JFL learners when writing single-kanji words with Kun-readings, focusing on three key aspects: kanji writing initiation, writing duration, and accuracy. The findings highlighted significant influences of lexical knowledge, kanji frequency, visual complexity, and kanji difficulty (JLPT level) on the kanji writing process.

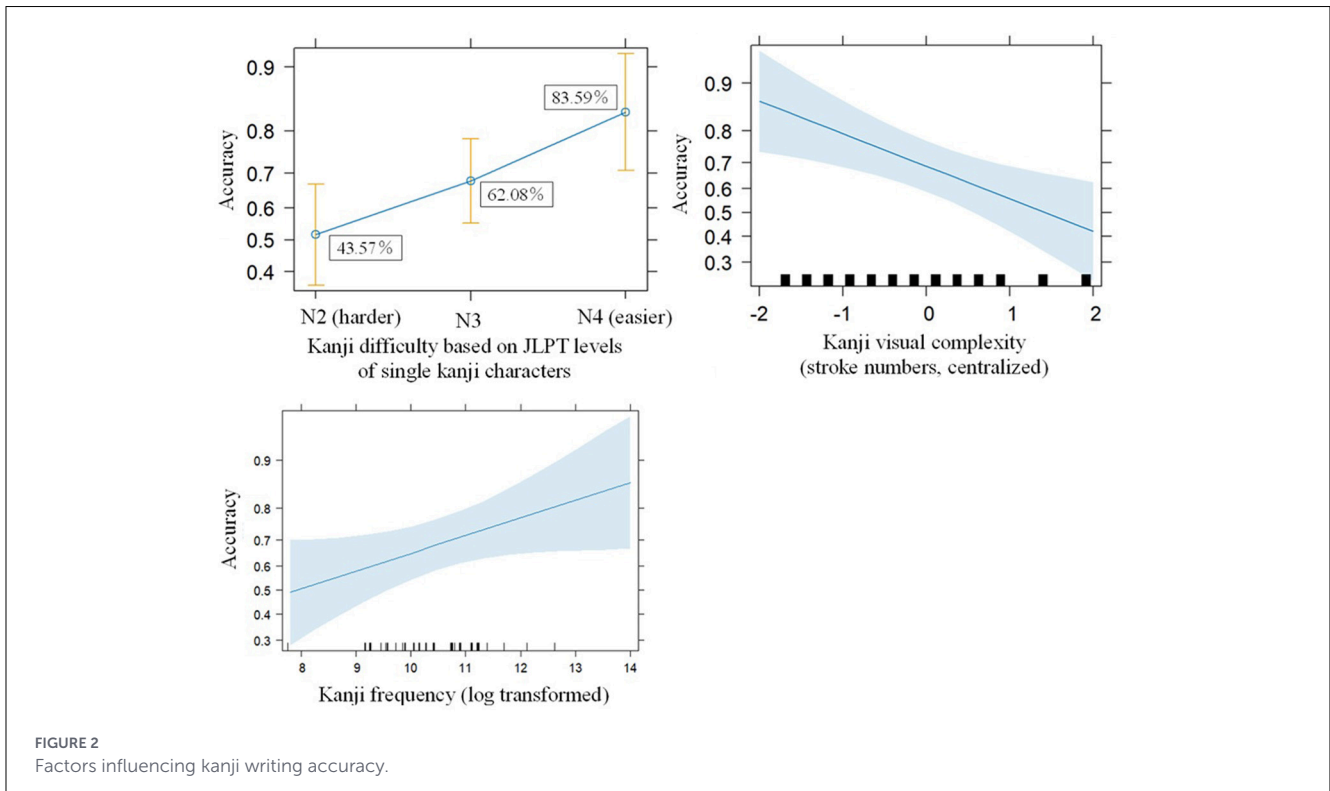


FIGURE 2 Factors influencing kanji writing accuracy.

TABLE 2 Results of the LME model analysis for kanji writing latencies.

Variables	Estimate	SE	df	t value	Pr(> t)	p
(Intercept)	7,508.050	1,137.870	35.180	6.598	0.000	***
Trial order (trial.z)	51.610	60.190	809.080	0.857	0.392	
Lexical knowledge (lex.z)	2,006.980	700.500	436.620	-2.865	0.004	**
Visual complexity (stroke.z)	-942.190	1,070.950	34.390	-0.88	0.385	
Kanji frequency (lnfreq)	-251.230	111.700	34.480	-2.249	0.031	*
Kanji difficulty (JLPT)	-195.200	185.710	34.830	-1.051	0.300	
Lex.z × Stroke.z	1,292.100	573.890	791.530	-2.251	0.025	*
Lex.z × Lnfreq	174.340	59.840	794.310	2.913	0.004	**
Stroke.z × Lnfreq	100.100	98.750	34.010	1.014	0.318	
Lex.z × Stroke.z × Lnfreq	110.150	52.580	791.380	2.095	0.036	*

Participants = 35. Items = 40. Observations = 861 (only correct items with outlier editing). $lmer(RT \sim trial.z + lex.z * stroke.z * lnfreq + jlpt + (0 + lex.z | participant) + (1 | item), data = mydata)$. * $p < 0.05$. ** $p < 0.01$, *** $p < 0.001$.

Figure 5 provides a conceptual framework to illustrate the key factors influencing kanji writing behavior.

The results indicated that lexical knowledge and kanji frequency significantly affected kanji writing latency. Learners with higher lexical knowledge initiated writing more quickly, suggesting that greater familiarity with kanji facilitates faster retrieval of orthographic representations. This aligns with previous studies on native Japanese speakers, which found that word familiarity and frequency enhance the accessibility of stored kanji representations, reducing retrieval time (Hatta et al., 2002; Tamaoka and Kiyama, 2013). Additionally, high-frequency kanji were associated with shorter writing latencies, supporting the notion that repeated exposure reinforces retrieval efficiency. While visual complexity did not exert a main effect on initiation latency, an interaction

revealed that learners with higher lexical knowledge initiated writing faster even for more complex kanji. This interaction suggests a compensatory effect in which higher lexical knowledge may help learners manage the processing demands associated with visually complex kanji (Van Galen, 1991; Bonin et al., 2012). Learners with larger vocabularies are likely to possess stronger lexical and orthographic representations of kanji, which may facilitate faster retrieval of structural information during writing preparation. In particular, such learners may rely on stored orthographic patterns or familiar radicals to organize the internal structure of complex characters. This could allow them to initiate writing more efficiently even when the visual complexity of the kanji increases. In contrast, learners with lower lexical knowledge may rely more heavily on slower, bottom-up processing of individual strokes and components,

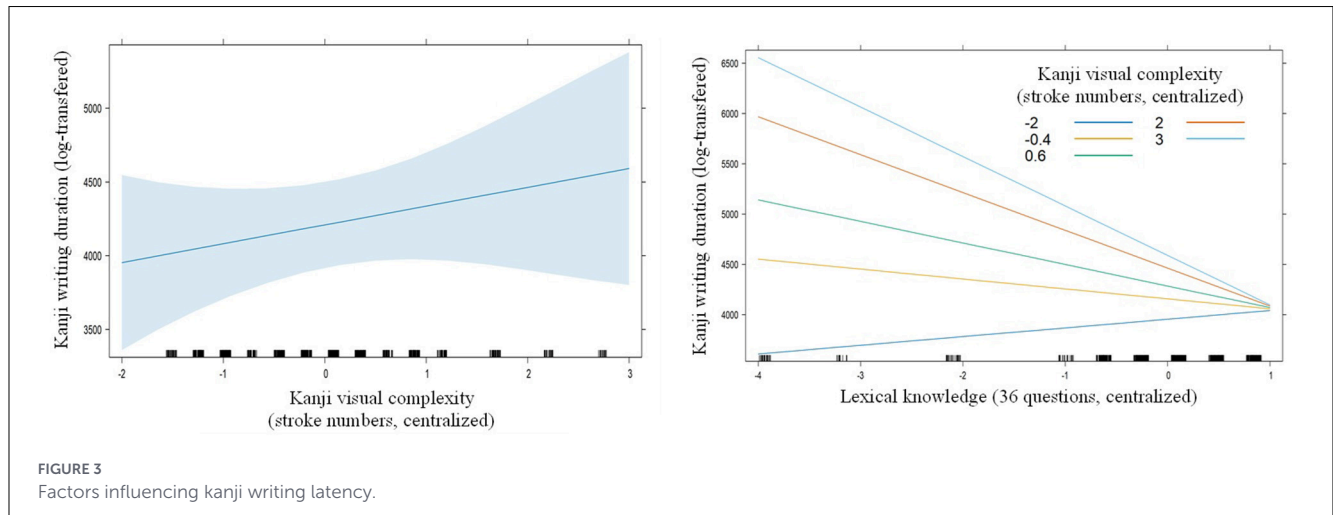


FIGURE 3 Factors influencing kanji writing latency.

TABLE 3 Results of the LME model analysis for kanji writing durations.

Variables	Estimate	SE	df	t value	Pr(> t)	p
(Intercept)	3,826.000	444.700	58.460	8.602	0.000	***
Trial order (trial.z)	-195.100	45.620	823.400	-4.276	0.000	**
Lexical knowledge (lex.z)	-340.900	231.000	35.850	-1.476	0.149	
Kanji frequency (freq)	0.002	0.001	28.920	1.202	0.239	
Visual complexity (stroke.z)	1,481.000	103.800	33.950	14.265	0.000	***
Kanji difficulty (JLPT)	74.350	122.400	33.610	0.608	0.548	
lex.z × freq	-0.001	0.001	805.400	-0.747	0.455	
lex.z × strokes	-174.900	53.080	807.700	-3.295	0.001	**
freq × strokes	0.001	0.001	28.720	1.504	0.143	
lex.z × freq × strokes	0.000	0.000	804.800	-0.744	0.457	

Participants = 35. Items = 40. Observations = 874 (only correct items with editing). $lmer(RT \sim 1 + trial.z + lex.z * stroke.z * lnfreq + jlpt + (1 | participant) + (1 | item), data = mydata)$. ** $p < 0.01$, *** $p < 0.001$.

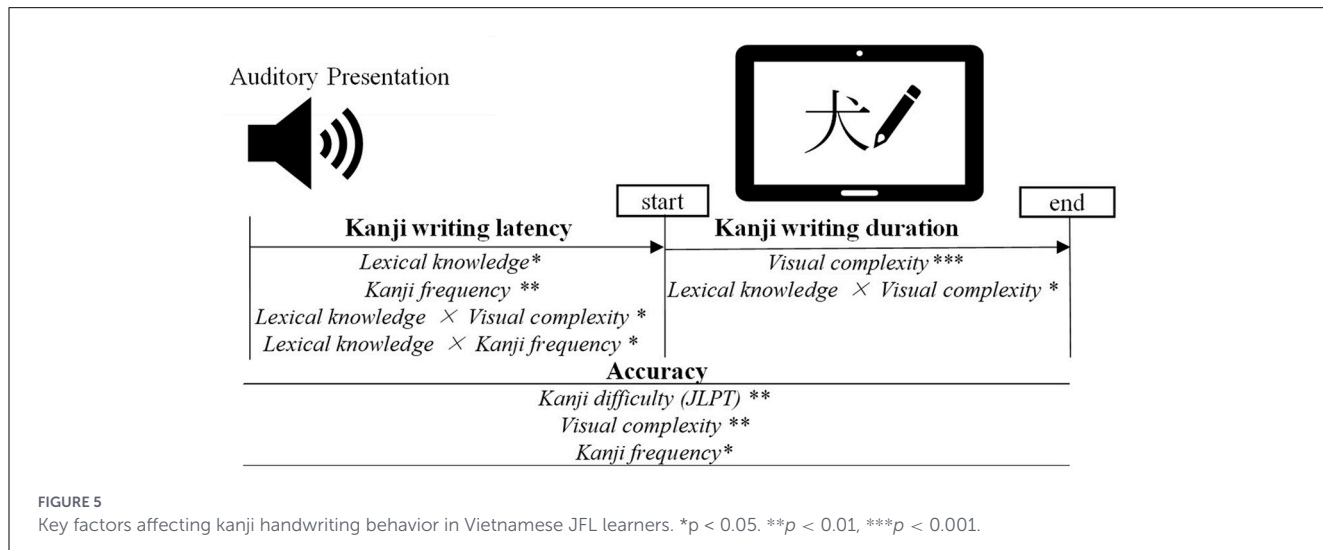
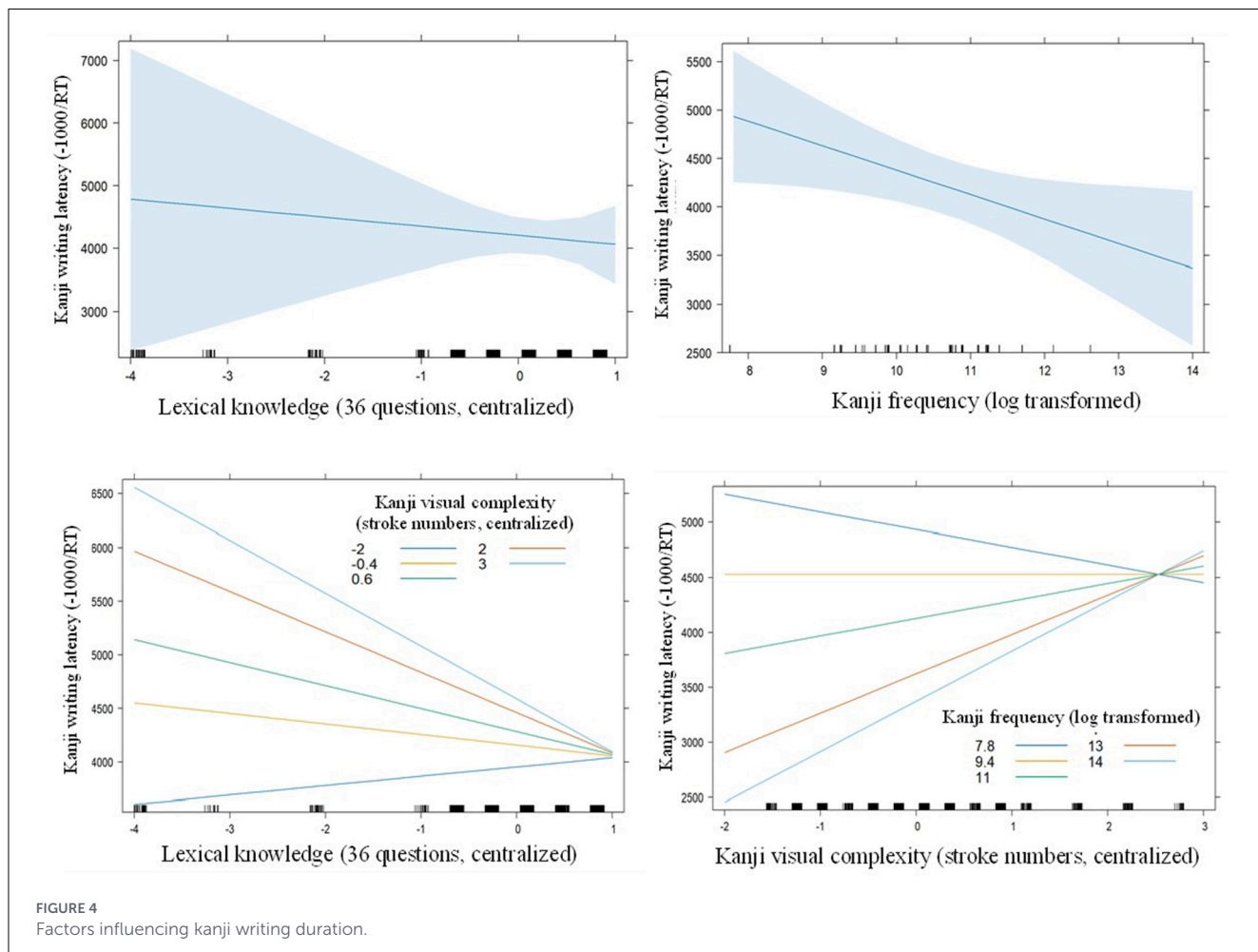
making them more susceptible to delays when encountering visually complex kanji.

Unlike initiation latency, kanji writing duration was primarily determined by visual complexity (number of strokes). More complex kanji took longer to complete, indicating that the physical demands of writing kanji play a central role once the handwriting process begins. This result is consistent with findings from Tamaoka and Takahashi (1999), who noted that low-frequency kanji with higher stroke counts required more time to be written for native speakers. Although there was no interaction between frequency and visual complexity [as in Tamaoka and Takahashi (1999)] the same idea might still hold particularly for JFL learners who are still developing fluency in handwriting. Lexical knowledge did not exert a main effect on writing duration, but it interacted significantly with visual complexity. Learners with higher lexical knowledge completed visually complex kanji more efficiently. This effect may reflect greater experience with kanji writing rather than differences in motor ability *per se*. Learners with larger vocabularies might have encountered and practiced a greater number of kanji, which can strengthen orthographic representations and facilitate the development of more automatized motor programs for producing stroke sequences (Van Galen, 1991; Bonin et al.,

2012). Consequently, when writing visually complex characters, these learners may execute the required motor patterns more efficiently than learners with less experience.

Kanji writing accuracy was primarily influenced by kanji difficulty and visual complexity, independently of lexical knowledge and frequency. Accuracy rates improved progressively from JLPT level N2 (43.57%) to N3 (62.08%) and N4 (83.59%), suggesting that learners struggle more with kanji categorized as more difficult. Additionally, kanji with more strokes were associated with lower accuracy, indicating that the structural complexity of kanji poses challenges for learners in maintaining correct stroke order and balance. These findings align with Hatta et al. (2002), who observed that Japanese school children and Australian JFL learners frequently made orthographic errors in kanji writing, particularly with visually complex characters. Rose (2019) also states that there is a disconnect between how fast a JSL student is building up spoken Japanese vs. their written knowledge.

Vocabulary knowledge did not significantly affect the accuracy of kanji writing, but it did influence the temporal dynamics of the writing process. Participants with greater vocabulary knowledge initiated writing more quickly and, in the case of visually complex characters, completed the writing process faster than



those with lower vocabulary knowledge. One possible explanation is that learners with larger vocabularies have stronger lexical representations and more efficient access to the orthographic forms associated with those words. According to psycholinguistic models of handwriting production, writing involves several stages, including lexical access, orthographic retrieval, and motor execution

(Van Galen, 1991; Bonin et al., 2012). Vocabulary knowledge may facilitate faster retrieval of lexical and orthographic representations, thereby reducing writing latency. However, the accuracy of the final written form may depend more strongly on detailed orthographic knowledge of stroke composition and structure, which may develop independently of general vocabulary knowledge. Consequently,

vocabulary knowledge may primarily influence the efficiency of accessing and producing kanji, rather than the accuracy of the final written product.

The findings suggest that kanji learning strategies should balance both cognitive and motor aspects. Since lexical knowledge and frequency improve writing initiation, frequent exposure to high-frequency kanji through reading and vocabulary exercises could help learners retrieve kanji representations more efficiently. However, since writing duration and accuracy are seemingly primarily influenced by visual complexity, structured handwriting practice focusing on stroke order, spatial balance, and fluency development is crucial. Additionally, instructional approaches should adapt to learners' proficiency levels, as accuracy rates varied across JLPT difficulty levels, indicating that progressive kanji learning with gradual exposure to complex kanji is essential for effective acquisition.

We would like to point out that our study would benefit from chronometric cross-linguistic comparisons (we thank an anonymous reviewer for suggesting this) with target groups which have differential experiences with writing and exposure to Chinese characters (e.g., Mandarin Chinese and English). Currently, virtually no chronometric studies have been published on kanji writing, and we aim to ameliorate this gap and corroborate the current findings in future research with cross-linguistic comparisons.

This study provides valuable insights into the cognitive and motor processes involved in kanji handwriting among Vietnamese JFL learners. The results demonstrate that lexical knowledge and kanji frequency facilitate faster initiation of kanji writing, visual complexity significantly prolongs writing duration, and both visual complexity and kanji difficulty negatively affect writing accuracy. These findings highlight the importance of integrating both retrieval-based and handwriting-focused exercises in kanji instruction, ensuring that learners develop both efficient cognitive access to kanji and accurate motor execution. These distinctions underscore the need for kanji instruction to target both cognitive access (to improve speed) and motoric fluency (to improve accuracy and efficiency).

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: <https://www.osf.io/2az9s>.

Ethics statement

The studies involving humans were approved by Research Ethics Committee of Nagoya University (approval number: NUHM-22-015). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

KT: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. HP: Data curation, Investigation, Writing – original draft, Writing – review & editing. JZ: Writing – original draft, Writing – review & editing, Formal analysis, Methodology, Data curation, Investigation. JK: Writing – original draft, Writing – review & editing, Methodology, Software. RV: Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing, Investigation, Methodology.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/flang.2026.1705688/full#supplementary-material>

References

- Anderson, D. R., Burnham, K. P., and Thompson, W. L. (2000). Null hypothesis testing: problems, prevalence, and an alternative. *J. Wildlife Manage.* 64, 912–923. doi: 10.2307/3803199
- Baayen, R. H., Davidson, D. J., and Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *J. Mem. Lang.* 59, 390–412. doi: 10.1016/j.jml.2007.12.005
- Bates, D., Mächler, M., Bolker, B., and Walker, S. (2015). Fitting linear mixed-effects models using lme4. *J. Stat. Softw.* 67, 1–48. doi: 10.18637/jss.v067.i01
- Besner, D., and Smith, M. C. (1992). “Basic processes in reading: is the orthographic depth hypothesis sinking?” in *Advances in Psychology, Vol. 94* (Amsterdam: North-Holland), 45–66. doi: 10.1016/S0166-4115(08)62788-0
- Bonin, P., Peereman, R., and Fayol, M. (2001). Do phonological codes constrain the selection of orthographic codes in written picture naming? *J. Mem. Lang.* 45, 688–720. doi: 10.1006/jmla.2000.2786
- Bonin, P., Roux, S., Barry, C., and Canell, L. (2012). Evidence for a limited-cascading account of written word naming. *J. Exp. Psychol. Learn. Mem. Cogn.* 38:1741. doi: 10.1037/a0028471
- Chang, L. Y., Stafura, J. Z., Rickles, B., Chen, H. C., and Perfetti, C. A. (2015). Incremental learning of Chinese orthography: ERP indicators of animated and static stroke displays on character form and meaning acquisition. *J. Neurolinguist.* 33, 78–95. doi: 10.1016/j.jneuroling.2014.09.001
- De Francis, J. (2019). *Colonialism and Language Policy in Viet Nam*. Walter de Gruyter GmbH and Co KG.
- Giovanni, F. B. (1994). Order of strokes writing as a cue for retrieval in reading Chinese characters. *Eur. J. Cogn. Psychol.* 6, 337–355. doi: 10.1080/09541449408406519
- Han, Z., Song, L., and Bi, Y. (2012). Cognitive mechanism of writing to dictation of logographic characters. *Appl. Psycholinguist.* 33, 517–537. doi: 10.1017/S0142716411000464
- Harville, D. A. (1977). Maximum likelihood approaches to variance component estimation and to related problems. *J. Am. Stat. Assoc.* 72, 320–338. doi: 10.1080/01621459.1977.10480998
- Hatta, T., Kawakami, A., and Tamaoka, K. (2002). Errors in writing Japanese kanji: a comparison of Japanese schoolchildren, college students and second-language learners of Japanese. *Asia Pac. J. Speech Lang. Hear.* 7, 157–166. doi: 10.1179/136132802805576427
- Hirose, H. (1998). Identifying the On-and Kun-readings of Chinese characters: identification of On versus Kun as a strategy-based judgment. *Read. Writ.* 10, 375–394. doi: 10.1023/A:1008005302732
- Jackson, F. H., and Malone, M. E. (2009). *Building the Foreign Language Capacity We Need: Toward a Comprehensive Strategy for a National Language Framework*. Washington, DC: Centre for Applied Linguistics. Available online at: <https://www.cal.org/wp-content/uploads/2022/06/building-foreign-language-capacity.pdf> (Accessed February 24, 2026)
- James, K. H., and Engelhardt, L. (2012). The effects of handwriting experience on functional brain development in pre-literate children. *Trends Neurosci. Educ.* 1, 32–42. doi: 10.1016/j.tine.2012.08.001
- Katz, L., and Frost, R. (1992). “The reading process is different for different orthographies: the orthographic depth hypothesis,” in *Advances in Psychology, Vol. 94* (Amsterdam: North-Holland), 67–84. doi: 10.1016/S0166-4115(08)62789-2
- Kess, J. F., and Miyamoto, T. (2000). *The Japanese Mental Lexicon*. Philadelphia: John Benjamins Publishing Company. doi: 10.1075/z.95
- Kuznetsova, A., Brockhoff, P. B., and Christensen, R. H. (2017). lmerTest package: tests in linear mixed effects models. *J. Stat. Softw.* 82, 1–26. doi: 10.18637/jss.v082.i13
- Law, N., Ki, W. W., Chung, A. L., Ko, P. Y., and Lam, H. C. (1998). Children’s stroke sequence errors in writing Chinese characters. *Read. Writ.* 10, 267–292. doi: 10.1023/A:1008091730338
- Leong, C. K., and Tamaoka, K. (1995). Use of phonological information in processing kanji and katakana by skilled and less skilled Japanese readers. *Read. Writ.* 7, 377–393. doi: 10.1007/BF01027725
- Ose Askvik, E., Van der Weel, F. R. and van der Meer, A. L. (2020). The importance of cursive handwriting over typewriting for learning in the classroom: a high-density EEG study of 12-year-old children and young adults. *Front. Psychol.* 11:550116. doi: 10.3389/fpsyg.2020.01810
- Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., et al. (2019). PsychoPy2: experiments in behavior made easy. *Behav. Res. Methods.* 51, 195–203. doi: 10.3758/s13428-018-01193-y
- Rose, H. (2019). “Unique challenges of learning to write in the Japanese writing system,” in *L2 Writing Beyond English, Vol. 66*, eds. N. Yigitoglu, and M. Reichelt (Bristol: Multilingual Matters), 78–94. doi: 10.21832/9781788923132-008
- Tamaoka, K. (2007). Rebounding activation caused by lexical homophony in the processing of Japanese two-kanji compound words. *Read. Writ.* 20, 413–439. doi: 10.1007/s11145-006-9036-8
- Tamaoka, K., and Kiyama, S. (2013). The effects of visual complexity for Japanese kanji processing with high and low frequencies. *Read. Writ.* 26, 205–223. doi: 10.1007/s11145-012-9363-x
- Tamaoka, K., Kiyama, S., and Chu, X. J. (2012). How do native Chinese speakers learning Japanese as a second language understand Japanese kanji homophones? *Writ. Syst. Res.* 4, 30–46. doi: 10.1080/17586801.2012.690008
- Tamaoka, K., Makioka, S., Sanders, S., and Verdonschot, R. G. (2017). <https://www.kanjidatabase.com>: a new interactive online database for psychological and linguistic research on Japanese kanji and their compound words. *Psychol. Res.* 81, 696–708. doi: 10.1007/s00426-016-0764-3
- Tamaoka, K., and Taft, M. (2010). The sensitivity of native Japanese speakers to On and Kun kanji readings. *Read. Writ.* 23, 957–968. doi: 10.1007/s11145-009-9184-8
- Tamaoka, K., and Takahashi, N. (1999). The effects of word frequency and orthographic complexity on the writing process of Japanese two-morpheme compound words. *Jpn. J. Psychol.* 70, 45–50. doi: 10.4992/jjpsy.70.45
- Van Galen, G. P. (1991). Handwriting: issues for a psychomotor theory. *Hum. Mov. Sci.* 10, 165–191. doi: 10.1016/0167-9457(91)90003-G
- Vinci-Booher, S., James, T. W., and James, K. H. (2016). Visual-motor functional connectivity in preschool children emerges after handwriting experience. *Trends Neurosci. Educ.* 5, 107–120. doi: 10.1016/j.tine.2016.07.006
- Wang, C., and Zhang, Q. (2015). Phonological codes constrain output of orthographic codes via sublexical and lexical routes in Chinese written production. *PLoS ONE* 10:e0124470. doi: 10.1371/journal.pone.0124470
- Wang, C., and Zhang, Q. (2022). The time course of lexical and sublexical phonological activation in Chinese written production. *Biol. Psychol.* 175:108450. doi: 10.1016/j.biopsycho.2022.108450
- Yamato, Y., Tamaoka, K., and Kayamoto, Y. (2016). Developing and evaluating a lexical knowledge test for Japanese learners with non-kanji backgrounds using Filipinos learning Japanese as a foreign language. *Stud. Linguist.* 30, 39–58. doi: 10.18999/stul.30.39
- Zhang, Q., and Wang, C. (2016). The temporal courses of phonological and orthographic encoding in handwritten production in Chinese: an ERP study. *Front. Hum. Neurosci.* 10:417. doi: 10.3389/fnhum.2016.00417