The Influence of Visualization in Book Content on Language Processing and Memory

Dian Prasetyo Adi[1], Quinta Avenida[2], Tati Sugiarti[3], Ulfah Yanuar Lianisyah[4], Rudiansyah[5]
[1,2,3,4,5]Universitas Sebelas Maret, Surakarta, Indonesia
Email: dianprasetyoadi@staff.uns.ac.id

Abstract

This study explored the effects of visualization and phonetic processing on comprehension and memory retention in learning Mandarin as a second language. Through an experiment involving three conditions: pinyin, black-and-white pictures, and colored pictures, the study evaluated participants' accuracy and reaction time in completing visual and phonetic-based tasks. The results showed that visual cues, especially colored pictures, increased response accuracy and decreased reaction time compared to pinyin and black-and-white pictures. These findings suggest that visualization not only aids vocabulary recall but also facilitates faster cognitive processing, potentially reducing students' cognitive load. Implications for Mandarin teaching include the importance of using appropriate visual teaching materials to support learning and memory retention at the beginner level. These results contribute to the growing body of evidence supporting the effectiveness of multimodal learning and the importance of tailoring teaching methods to learners' cognitive characteristics.

Keywords: *Visualization, Phonetic Processing, Mandarin, Memory Retention, Second Language Learning.*

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A. INTRODUCTION

In recent years, the role of visualization in language learning has received special attention as an effective means to improve vocabulary acquisition, comprehension, and overall language proficiency. Visualization, including the use of images, videos, and diagrams, engages multiple cognitive pathways, making learning materials easier to learn and remember. Dual Coding Theory states that information that is processed both visually and verbally is more likely to be remembered (Boers et al., 2017). In line with this theory, visual aids not only help vocabulary acquisition (Peters, 2019) but also improve reading comprehension by providing contextual clues that aid in semantic processing (Fitriani et al., 2019). In addition, visualizations can trigger emotional responses that increase engagement and motivation, making the learning experience more memorable (Kawahara, 2021). With these benefits, visual aids are considered invaluable in learning complex languages, such as Mandarin, where character recognition and writing skills are aided by visual strategies (Lam & Arwood, 2017).

Language processing and cognition in a second language (L2) are complex processes, involving a variety of cognitive strategies and often influenced by the learner's first language (L1). For L2 learners, the use of metacognitive strategies and having a strong "language ego" contribute significantly to successful language learning (Mahalingam & Yunus, 2016; Zahra et al., 2023). When learning new

linguistic structures, the cognitive load can be quite large, as the L1 often influences the interpretation of grammatical forms in the L2, introducing complexity into language processing (Ionian & Montrul, 2010). Processibility Theory (Pienemann, 2015) and Task-Based Language Teaching (TBLT) emphasize the importance of cognitive engagement, asserting that learners acquire language more effectively when instruction is tailored to their developmental stage and cognitive abilities. These findings emphasize the importance of meeting learners' cognitive processing needs, especially when learning a new language such as Mandarin, which has a distinctive linguistic structure that requires specific strategies for language processing.

Memory also plays a central role in language learning, influencing how learners acquire, store, and retrieve linguistic information. The Declarative/Procedural (DP) model suggests that language production relies on declarative memory for facts and vocabulary and procedural memory for grammar and language usage (Ullman & Lovelett, 2016). In addition, phonological working memory has been shown to be important for vocabulary acquisition (Archibald & Joanisse, 2012), with a strong phonological memory capacity contributing to more effective language retention and retrieval. Memory strategies, especially those that promote deep cognitive processing, are important for transitioning vocabulary from short-term to long-term memory (Farjami, 2013). Understanding the role of memory processes, especially in learning complex syntactic structures (Hamrick, 2014), emphasizes the need to integrate memory-enhancing strategies into language learning.

Building on these insights, the current study explores how the visualizations and content in the 'Easy Steps to Chinese' textbook affect learners' language processing and memory. While visualizations aid comprehension and retention, it is important to examine their impact specifically in the context of Mandarin learning, where unique visual and phonetic elements play a significant role. This study aims to determine whether the use of visual aids combined with structured textbook content can improve language processing and memory retention in L2 Mandarin learners. Through this study, it is hoped that it will provide educators with evidence-based insights into the use of visualizations to create more effective learning environments for Mandarin learners.

B. LITERATURE REVIEW

1. Visualization in Language Learning

Visualization in language learning is an effective strategy to improve vocabulary acquisition, comprehension, and language proficiency. The use of visual aids, such as images, videos, and diagrams, has been shown to facilitate the learning process by engaging multiple cognitive pathways. One of the main benefits of visual aids in language learning is their impact on vocabulary acquisition. Peters (2019) revealed that the combination of images and text on the screen can significantly improve vocabulary learning from audiovisual input. This finding is in line with the research of Winke et al. (2013), which showed that learners often utilize captions effectively, indicating that visual elements can help learners manage cognitive load

and improve retention. Dual Coding Theory supports this idea, stating that information processed through visual and verbal channels is more likely to be remembered (Boers et al., 2017). Furthermore, the effectiveness of visual aids is not only limited to vocabulary acquisition, but also includes reading comprehension. Fitriani et al. (2019) showed that visual representations can help understand complex language structures by providing contextual clues that facilitate semantic processing. This is also supported by the findings of Muraki et al. (2022), which shows that visualization helps learners understand the meaning of text, especially in reading comprehension tasks. The use of images not only helps comprehension, but also increases learner engagement and motivation (Chung, 2023).

In addition to vocabulary and comprehension, the role of mental imagery in language learning has also been widely explored. Lam and Arwood (2017) stated that imagery can help encode linguistic forms into conceptual networks, thereby improving long-term memory retention. This is especially relevant in the context of learning a language with a complex script, such as Mandarin, where visual strategies can facilitate character recognition and writing skills.

The emotional aspect of learning through visualization is also worth considering. Kawahara (2021) suggests that images can trigger emotional responses that enrich the learning experience, making it more memorable. This emotional engagement can be especially beneficial in language learning, where motivation plays a key role in success.

In addition, the effectiveness of visual aids is not always the same for all learners. Individual differences, such as cognitive style and prior knowledge, can influence how learners interact with visual materials. Kibar & Akkoyunlu (2016) found that students' visual cognitive styles varied significantly based on their academic majors, suggesting that tailoring visual strategies to individual learning preferences may enhance their effectiveness. In conclusion, visualization serves as a tool that should be used in language learning, facilitating vocabulary acquisition, comprehension, and emotional engagement. By utilizing visual aids and understanding the cognitive processes involved, educators can create more effective and engaging language learning environments.

2. Language Processing and Cognition in Second Language (L2)

Language processing and cognition in second language (L2) acquisition involve complex interactions between cognitive strategies, affective factors, and first language (L1) influences. Understanding these dynamics is essential to optimize teaching methods and improve learning outcomes.

One important aspect of L2 acquisition is the role of metacognitive strategies. Mahalingam and Yunus (2016) emphasize that successful language learners often use essential social and cognitive strategies to navigate the complexities of language learning. These strategies not only facilitate comprehension but also enhance learners' ability to regulate their own learning process. Similarly, Zahra et al. (2023) highlight the concept of "language ego," which refers to learners' self-perception in relation to

the language they are learning. A strong language ego can lead to greater success in speaking and overall language acquisition, as learners are more willing to engage with the language and imitate native speakers.

The influence of L1 on L2 acquisition is another critical area of study. Ionian and Montrul (2010) discuss how L1 transfer can affect the interpretation of grammatical structures in the L2, illustrating the complexities involved in language processing. This transfer can take many forms, such as disruptions in pronunciation or syntax, which can hinder the learning process if not properly addressed. In addition, the concept of interlanguage, as described by Song (2012), provides a framework for understanding the transitional linguistic system that learners develop as they acquire a second language. This system is characterized by variability and is influenced by both the L1 and the target language.

Cognitive theory also plays an important role in understanding L2 acquisition. Processibility theory, as described by Pienemann (2015), suggests that language acquisition follows predictable developmental stages, which are influenced by the learner's cognitive processing abilities. This theory suggests that learners can only acquire certain grammatical structures once they have developed the cognitive skills necessary to process them. The implications of processibility theory for teaching are profound, as it encourages educators to tailor instruction to the developmental stage of the learner.

Task-based language teaching is another approach that emphasizes cognitive processes in language learning. Robinson (2011) argues that task complexity is critical to effective language acquisition, as it requires learners to engage in meaningful communication and problem solving. This approach not only improves fluency but also encourages deeper cognitive processing of the language.

In addition, technology integration in language learning has been shown to facilitate cognitive engagement. Yin (2017) discusses how multimedia tools can enhance the learning experience by providing a variety of inputs that suit different learning styles. This is in line with the findings of Wang (2016), who emphasized the importance of understanding learners' cognitive processing strategies in developing effective teaching materials. Language processing and cognition in L2 acquisition involve multifaceted interactions between cognitive strategies, affective factors, and L1 influences. By understanding these dynamics, educators can develop more effective teaching methods that meet the needs of diverse language learners, thereby enhancing their L2 acquisition.

3. Memory in Language Learning

Memory plays a critical role in language learning, influencing how learners acquire, store, and retrieve linguistic information. Understanding the memory mechanisms involved in language acquisition can improve teaching strategies and learning outcomes.

One of the fundamental concepts in understanding memory in language learning is the distinction between declarative and procedural memory. The

Declarative/Procedural Model states that language learning relies on both of these memory systems: declarative memory for facts and vocabulary, and procedural memory for grammar and language usage (Ullman & Lovelett, 2016). This model suggests that effective language learning strategies should engage both types of memory. Ullman & Lovelett (2016) argue that techniques that enhance memory can improve second language learning outcomes by facilitating the encoding and retrieval processes associated with these memory systems.

Working memory, particularly phonological working memory, is also an important factor in language learning. Research by Archibald & Joanisse (2012) suggests that short-term phonological memory is strongly associated with new word learning, suggesting that learners with stronger phonological memory abilities may have an advantage in acquiring new vocabulary. These findings are supported by Pierce et al. (2017), who highlighted that variations in early language experience can impact phonological working memory, which in turn impacts language learning outcomes.

Furthermore, the role of memory strategies in vocabulary acquisition cannot be underestimated. Farjami (2013) emphasized the importance of "deep" semantic processing strategies rather than conventional methods such as flashcards, which often result in shallow learning and short-term retention. By encouraging learners to engage in deeper cognitive processing, educators can help facilitate the transition of vocabulary from short-term to long-term memory.

The interaction between memory and language processing is also evident in the bilingual context. Cunnings (2016) discussed how working memory processes and cognitive control influence sentence processing in bilingual speakers. This highlights the importance of understanding individual differences in memory abilities, as these differences can have a major impact on language comprehension and production.

Furthermore, the relationship between memory and language skills has been explored in children with language disorders. Baird et al. (2010) found that children with language disorders showed deficits in verbal memory, which impacted their overall language learning abilities. This highlights the importance of addressing memory challenges in language teaching, particularly for learners with specific language disorders.

The recognition of syntactic structures has also been linked to memory processes. Hamrick (2014) provides evidence that memory plays a role in the learning of syntactic structures, with research suggesting that memory mechanisms are critical to understanding and producing complex language forms.

Memory is a fundamental component of language learning, influencing vocabulary acquisition, grammatical comprehension, and overall language proficiency. By leveraging insights from memory research, educators can develop more effective instructional strategies that meet the cognitive needs of language learners, thereby enhancing their learning experience.

4. Hypothesis

Based on the formulation of the problem proposed, this study tests three main hypotheses related to phonetic processing and visual aids in learning Mandarin:
H1: Phonetic processing through pinyin will result in lower memory retention compared to visual aids in supporting vocabulary mastery.
H2: Visual aids are more effective than phonetic processing in remembering and pronouncing Mandarin phrases verbally.
H3: Visualization has a more significant role in improving accuracy compared to phonetic-based processing, without any significant difference in response speed.

This hypothesis is formulated to evaluate the effect of visual aids on the ability of retention, accuracy, and speed of Mandarin processing, which is directly compared to phonetic processing through pinyin.

C. METHOD

The number of participants in this study was 19 seventh and eighth grade students from SMP Kristen Shining Star Sragen, but because 2 students were sick and could not participate in the experiment, the number of participants became 17 students. All participants had previous experience in learning Mandarin through the Easy Steps to Chinese 1 textbook, published by Beijing Language and Culture University. Of all the participants, there were 8 male students and 9 female students. All students were right-handed, and there were no problems with pronunciation, vision or hearing. The average age of the participants was 13 years, with a standard deviation of 0.87. This study used several main materials to measure language processing and memory. Visual stimuli consisted of pictures taken from “Easy Steps to Chinese 1” (Chapters 1-4), which corresponded to vocabulary or phrases relevant to the students' lessons. Although grade 8 had studied Chapters 5 to 9, because grade 7 had only studied Chapters 1-4, so that grade 7 could work on the experiment, only Chapters 1-4 were selected. Words and phrases in pinyin form, without additional characters or context, were also presented as phonetic stimuli. The number of words or phrases cited in the book for stimuli was 10 for each condition, and repeated twice for each condition. The words used included greetings, goodbyes, numbers and dates. The study involved three main stages: completing a background survey and informed consent, administering a digit span memory test, and performing the main language processing task in the experiment. The first stage began with students completing a consent form (Appendix 1) signed by them, confirming their willingness to participate in the study. After that, a background survey (Appendix 2) was administered to collect data on each student's Mandarin learning history, including the length of study, frequency of study routines, and previous experience with pinyin or visual aids in language learning. In the Digit Span Test (Appendix 3), students were presented with a series of digits, starting with three digits and increasing progressively up to nine digits. Each sequence was read aloud with a one-second interval between each digit. Students were asked to repeat the sequence exactly as they heard it, orally. The longest sequence that students correctly recalled was recorded as their digit span score.

The Pinyin and Visual Recall Task consisted of three separate conditions designed to measure the effects of phonetic processing (pinyin) and visual aids (pictures) in both black and white and in color on language retention and verbal production. In the first condition, known as the Pinyin Translation Task, participants were shown a series of words or phrases in pinyin and hanzi on a computer screen using PsychoPy software for 5000 ms. During the 5000 ms the images were displayed, participants were also given the same amount of time to answer questions based on the stimuli that appeared. The distance between the stimulus and the blank layer was 500 ms, before the layer was displayed with pinyin stimuli or images. Before the first condition began, participants were asked to practice answering questions with 3 stimuli, with the images showing three words, namely the numbers one, two and three written in pinyin and hanzi in Mandarin. After understanding the experimental instructions, participants were asked to press the space key to start the first condition. Participants were instructed to read each pinyin stimulus silently and provide an Indonesian translation for each word or phrase that appeared.

In the second condition, participants were given a black and white picture and asked to verbalize the word or phrase in Mandarin that corresponded to the picture. They were expected to remember and pronounce the Mandarin word or phrase represented by the picture, with reaction time (from the time the picture was displayed to the start of the verbal response) and accuracy recorded. In the third condition, the same as the second condition, but using colored pictures. The accuracy and speed of translation were recorded automatically on the pavlovia. Although it can be done at home, to measure the accuracy of the respondent's method of answering, the respondent worked on the experiment in a quiet room, and under supervision so that they worked seriously and focused.

After completing the series of experiments, participants were asked to fill out a survey on understanding the pictures (appendix 4), to ensure that the respondents understood the meaning of the pictures presented when participating in the experiment.

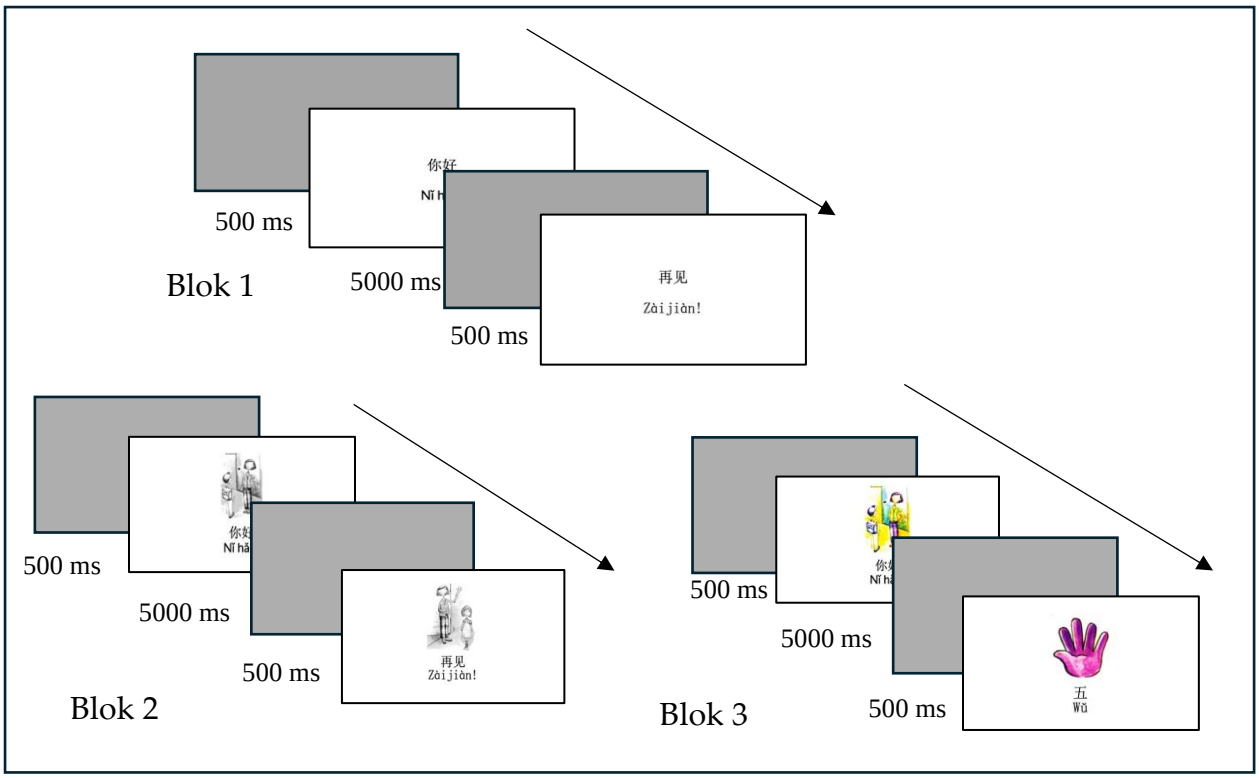

Figure 1 Pinyin and Visual Recall Task Process Sequence

Data from both conditions, including accuracy and reaction time, were collected and analyzed using JASP software. Descriptive statistics (mean, standard deviation) are presented for each task (pinyin and black-and-white and colored pictures) to evaluate accuracy and reaction time scores. Audio from participants was downloaded from Pavlovia and analyzed using Praat software (Figure 2), focusing on the analysis of their reaction time (RT) and correct responses. To compare performance between the pinyin task and the picture task, paired-sample t-tests were conducted to assess differences in memory retention based on accuracy scores across the two conditions, as well as to determine whether one condition (pinyin vs. black-and-white vs. colored pictures) resulted in faster recall or production based on reaction time. In addition, correlation analyses between digit span scores and task performance were conducted to explore potential relationships between short-term memory capacity and language processing performance.

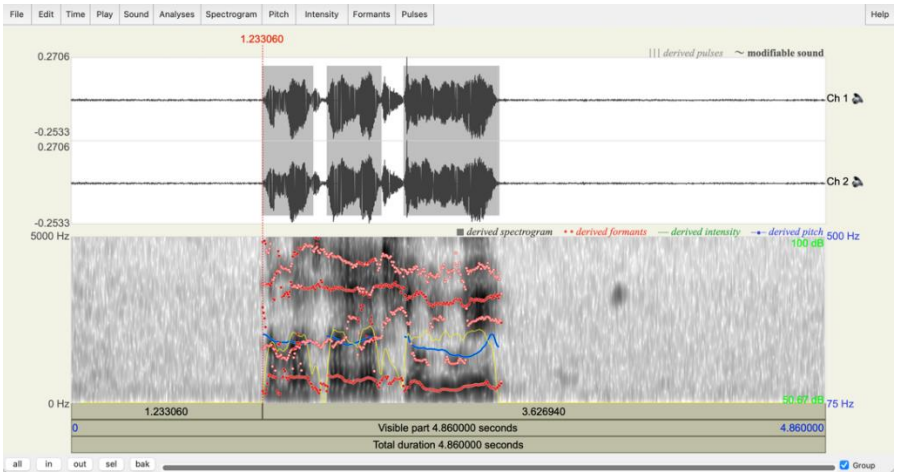

Figure 2 Audio Analysis Using Praat

D. RESULTS AND DISCUSSION

1. Participant Background

To find out the participants' background, participants were asked to fill out a background questionnaire. This questionnaire aims to explore information about the history of learning Mandarin from each participant, including the duration of learning, the frequency of regular learning, and their experience in using pinyin or visual aids in the language learning process. The results of filling out this questionnaire are presented briefly in Table 1, which provides a comprehensive picture of the variations in participants' backgrounds that can later affect their learning outcomes.

Table 1 Participant Background

	Mean (M)	Standard Deviation (SD)	Range	Skewness	Kurtosis)
Age	13	.87	4	1.59	4.23
Language Background					
Time of starting Mandarin	2.11	1.05	3	.82	-.25
Frequency of using Mandarin outside of class	1.88	.78	2	.21	-1.24
Learning experience outside of school	1.76	.43	1	-1.37	-.149
Learning location outside of school	1.25	.5	1	2	4
Mandarin Language Proficiency					
Pinyin reading ability	2.35	.70	2	-.63	-.57
Confidence in translating Pinyin	2.35	.78	3	.11	-.01
Difficulty reading Mandarin vocabulary	2.05	0.65	2	-.05	-.31
Motivation and Attitude Towards Mandarin					
Interest in learning Mandarin	2.94	.65	3	-1.43	4.80

Frequency of learning Mandarin outside of class	1.64	.70	2	.63	-.57
Confidence in daily conversation	2.05	.65	2	-.05	-.31
Effect of visualization on comprehension	3.58	.79	3	-2.43	6.75
Learning Style Preference					
Learning method preference	1.88	.92	2	.25	-1.90
Ease of remembering words/phrases with pictures	3	.35	2	0	8
Cognitive and Memory					
Difficulty remembering new vocabulary	2.17	.72	2	-.29	-.89
Vocabulary memorization method	1.70	.84	2	.64	-1.29
Ease of pictorial tasks compared to text only	2.94	.65	2	.05	-.31

Table 1 provides an overview of the participants' backgrounds including age, language background, Mandarin proficiency, motivation and attitude towards Mandarin, learning style preferences, and cognitive and memory aspects. The average age of the participants was 13 years with relatively low variation (SB = 0.87), indicating a fairly uniform age group. The age distribution showed a positive skew, meaning that most participants tended to be younger, with a few participants being older.

In terms of language background, the average time to start learning Mandarin was 2.11 years, indicating a generally short learning experience, only in grades 7 and 8. The frequency of using Mandarin outside of class tended to be low with an average of 1.88, while out-of-school learning experiences were also limited, with most participants having little or no additional experience outside of formal school. The location of learning outside of school showed a highly skewed distribution, with few participants studying in more than one place.

In terms of language proficiency, the ability to read pinyin was at an average of 2.35, reflecting fairly good ability among the participants. Confidence in translating pinyin into Indonesian also has the same average value, with a symmetrical distribution. Difficulty in reading Mandarin vocabulary is at an average of 2.05, indicating the difficulty felt by most participants in understanding new vocabulary. Motivation and attitudes of participants towards Mandarin were also measured, where the average interest in learning Mandarin was 2.94, indicating a lack of interest among participants. Most participants rarely study Mandarin outside of class, with an average frequency of 1.64. Confidence in using Mandarin in daily conversation shows an average of 2.05, reflecting a low level of confidence. Learning style preferences show that most participants find visualization helpful (average 3.58), which appears significant with high negative and sharp skewness. This indicates that pictures and

illustrations play an important role in helping them understand Mandarin. In addition, the ease of remembering words or phrases accompanied by pictures has a very concentrated distribution, indicating that visualization is very helpful for most participants in remembering vocabulary. In terms of cognitive and memory, most participants experienced similar difficulties in remembering new vocabulary (mean 2.17). Preferences in vocabulary recall methods also varied, with some participants finding certain methods more helpful. In addition, participants generally found it easier to complete tasks involving images compared to text-only tasks (mean 2.94), highlighting the important role of visualization in their learning.

Digit Span Task

Participants before the experiment began working on a digit span task, in which they were asked to repeat a sequence of numbers mentioned with a range of digit lengths between 3 and 9 digits. This task was designed to measure participants' short-term memory capacity in remembering increasingly long sequences of numbers.

The results of the task showed that the average digit span successfully repeated by participants was 5.4 digits, with a standard deviation of 0.79. This average figure provides an overview of participants' short-term memory capacity in the task, while the relatively low standard deviation indicates consistency among participants' abilities in the repeated digit span. These results can be used as a reference in assessing the level of memory and short-term memory capacity in the group of research participants.

Pinyin and Visual Recall Task

This study used the Pinyin and Visual Recall Task to evaluate the differential effects of phonetic and visual cues on Chinese language processing. The task consisted of three main blocks: pinyin, black-and-white pictures, and colored pictures, which were designed to assess students' accuracy and reaction time in recalling and processing linguistic information.

In each block, data were collected on students' reaction time and response accuracy. The mean reaction time and standard deviation for each condition were analyzed to see the variation in processing speed between the three types of cues. In addition, the accuracy in completing the task in each block was also calculated along with its standard deviation, to understand the extent to which each type of cue (pinyin, black-and-white pictures, and colored pictures) affected students' accuracy in recalling information.

The results of this analysis are presented in Table 2, which shows a comparison between the three blocks in terms of accuracy and reaction time.

Table 2 Accuracy and Reaction Time

	Accuracy (%)	Reaction Time (ms)
Block 1 (Pinyin)	34.44 (0.33)	1.88 (0.37)
Block 2 (Black and White)	38.58 (0.35)	1.87 (0.46)
Block 3 (Color)	45.66 (0.33)	1.67 (0.43)

Table 2 shows the average results of Accuracy (%) and Reaction Time (ms) for each experimental condition: Block 1 (Pinyin), Block 2 (Black-and-White Images), and Block 3 (Colored Images). Based on the data in the table, it can be seen that the condition of Block 3 (Colored Images) has the highest average accuracy, which is 45.66% (SD = 0.33). This condition is followed by Block 2 with an accuracy of 38.58% (SD = 0.35) and Block 1 with the lowest accuracy, which is 34.44% (SD = 0.33).

Meanwhile, in Reaction Time (RT), there is an interesting trend where the average reaction time in Block 3 (Colored Images) is faster compared to Block 2 (Black-and-White Images) and Block 1 (Pinyin). The mean reaction time for the colored picture condition was 1.67 ms (SD = 0.43), slightly faster than Block 2 (Black-and-White Pictures) with 1.87 ms (SD = 0.46), and Block 1 (Pinyin) with 1.88 ms (SD = 0.37).

To test whether there were significant differences in Accuracy and Reaction Time among the three experimental conditions, a Repeated Measures ANOVA analysis was conducted. The results of this ANOVA are presented in Tables 3 and 4.

Table 3 Results of ANOVA Analysis for Accuracy

Condition	Sum of Squares (SQ)	df	Mean Square (MS)	F	p
Repeated Measurement Factor 1	1136.359[a]	2[a]	568.179[a]	3.494[a]	0.047[a]
Remainder	3902.308	24	162.596		

Note: The analysis used Type III Sum of Squares.
[a]Mauchly's sphericity test showed that the sphericity assumption was violated ($p < 0.05$).

The results of the Repeated Measures ANOVA analysis for Accuracy in Table 3 show that there are significant differences between the three experimental conditions: Pinyin, Black and White Pictures, and Color Pictures. Based on the table, the Sum of Squares (SQ) for the repeated measures factor is 1136.359, with the degrees of freedom (df) adjusted to 2, resulting in a Mean of Square (RK) of 568.179. The F value obtained is 3.494 with a significance level of $p = 0.047$, indicating that the three conditions have significant differences in student accuracy. The residual components in the ANOVA model have a Sum of Squares of 3902.308 with a df of 24 and a Mean of Square of 162.596. Since the Mauchly test shows that the sphericity assumption is violated ($p < 0.05$), the Greenhouse-Geisser correction is used to adjust the df in this analysis, so that the ANOVA results are more valid and reliable.

Table 4 ANOVA Analysis Results for Time Speed

Condition	Sum of Squares (SQ)	df	Mean Square (MS)	F	p
Repeated Measurement Factor 1	0.514[a]	2[a]	0.257[a]	1.010[a]	0.379[a]
Remainder	6.101	24	0.254		

Note: Mauchly's test indicates that the sphericity assumption is violated ($p < 0.05$). Therefore, the Greenhouse-Geisser correction (or other corrections used) is used to adjust the degrees of freedom in the ANOVA analysis.

Meanwhile, Table 4 shows the results of Repeated Measures ANOVA for Reaction Time Speed in the same three conditions. In this analysis, the Sum of Squares (SQ) for the repeated measures factor is 0.514 with df adjusted to 2 and Mean Square of 0.257. The ANOVA results produce an F value of 1.010 with a significance level of $p = 0.379$, indicating that there is no significant difference in reaction time between the three conditions. The residual component in this model has a Sum of Squares of 6.101

with a df of 24 and Mean Square of 0.254. Similar to the analysis for precision, the violation of the sphericity assumption indicated by the Mauchly test ($p < 0.05$) led to the application of the Greenhouse-Geisser correction on the df to ensure the validity of the results.

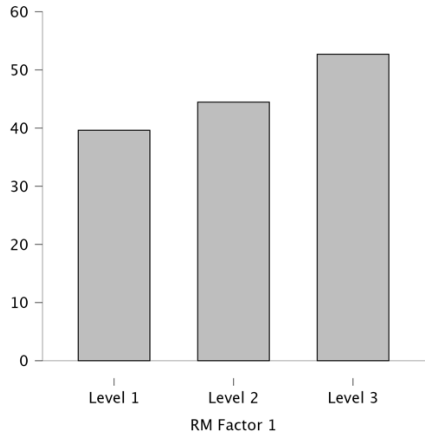

Figure 3 Average Accuracy (%) in Each Experimental Condition (Block 1: Pinyin, Block 2: Black and White Pictures, Block 3: Color Pictures)

2. Participants' Understanding of the Images

To evaluate the extent to which respondents understood the images used in the experiment, they were asked to complete a picture comprehension survey with a score range of 1 to 7. This survey aims to measure participants' visual perception and interpretation of each image, which is an important element in understanding the effects of visual aids on the retention and processing of linguistic information.

The survey results showed the average comprehension scores for the 10 images presented as follows: 5.35 (SB = 2.37), 4.94 (SB = 2.28), 5.94 (SB = 1.92), 4.59 (SB = 2.06), 4.41 (SB = 2.43), 4.82 (SB = 2.10), 4.76 (SB = 1.99), 4.94 (SB = 2.11), 4.59 (SB = 1.77), and 4.59 (2.09). These average values indicate that picture comprehension varies across different images, with images tending to be easier to understand. The standard deviation for each image score ranged from 1.77 to 2.43, indicating some variation in perception among respondents in assessing the comprehension of each image. The relatively high standard deviation values for some images suggest that visual perception of these images was more diverse, possibly due to differences in participants' backgrounds or visual experiences.

Overall, these data provide insight into image comprehension in an experimental context, and suggest variations in visual comprehension that may impact efficiency and accuracy in tasks involving visualization.

3. Correlation with Memory Capacity

To explore the relationship between memory capacity and task performance, correlation analysis was conducted between students' digit span scores and their accuracy and reaction time on each task. The regression test showed a significant relationship between digit span scores and accuracy in the colored picture condition

(p = 0.049), indicating that students with higher memory capacity may perform better in tasks requiring visual processing. In terms of reaction time, the analysis showed no significant relationship between digit span scores and reaction time in the pinyin, black-and-white, and colored picture conditions, indicating that memory capacity does not affect language processing speed.

Table 5 Regression of Digit Span Task Score with Task Accuracy

Model		Unstandardized	Standard Error	Standar-dized	t	p
M_0	(Intercept)	5.538	0.243		22.768	< .001
M_1	(Intercept)	5.079	0.434		11.710	< .001
	Pinyin Acc	0.011	0.037		0.283	0.783
	Hitam-Putih Acc	-0.032	0.038	0.333	-0.841	0.422
	Warna Acc	0.028	0.012	-1.129	2.270	0.049

This study focused on the effects of visualization and phonetic processing on language retention and processing in Mandarin learners, by comparing pinyin translation and picture naming tasks. The results showed that visualization, especially with colored pictures, had a positive impact on participants' accuracy and reaction time compared to pinyin and black-and-white pictures. This suggests that visual cues play an important role in strengthening language retention and memory.

Visualization has been shown to be an effective strategy in language learning, facilitating vocabulary acquisition, comprehension, and better cognitive engagement. As stated by Peters (2019), the combination of images and text enhances vocabulary acquisition through audiovisual input. The results of this study support Peters' findings by showing that the image condition, especially the colored images, resulted in higher accuracy and faster reaction times compared to the pinyin and black-and-white image conditions. Winke et al. (2013) also found that visual elements can reduce cognitive load, increasing retention, which is in accordance with the results of this study which showed higher accuracy in the visual condition compared to pinyin. This is in line with the Dual Coding theory (Boers et al., 2017) which states that information processed through visual and verbal pathways is easier to remember. This study used the Pinyin and Visual Recall Task to evaluate the differences in the effects of phonetic and visual cues on Mandarin processing. In this task, participants completed three different blocks: pinyin, black-and-white images, and colored images. The highest average accuracy was found in the colored image condition (Block 3), followed by the black-and-white image (Block 2), and the pinyin condition (Block 1) with the lowest accuracy. Meanwhile, the average reaction time in Block 3 was also faster compared to Block 1 and Block 2.

This study is in line with the findings of Fitriani et al. (2019) and Muraki et al. (2022), which showed that visualization helps understand complex language structures and facilitates semantic understanding. This can be seen from the increase in accuracy in the visual condition (especially colored images) in this study, indicating that contextual images can support better language comprehension. In addition, Lam and Arwood (2017) stated that mental imagination helps encode linguistic forms in deep conceptual networks, supporting long-term memory retention. These findings

are supported by the results of the current study, which showed that visualization, especially in the form of colored images, improved accuracy and reaction time better than the pinyin condition, indicating that visual cues can facilitate memory processing and retrieval.

This finding is also relevant to Kawahara's (2021) research which revealed that images can trigger emotional responses and increase learning motivation, adding an emotional dimension to the language learning experience. The combination of visualization and reduced cognitive load seems to play an important role in encouraging deeper engagement and improved learner performance in language tasks.

In the context of language processing and cognition, this study supports Mahalingam and Yunus' (2016) view that cognitive strategies, such as the use of visual cues, can enhance comprehension. In this study, visualization was shown to increase accuracy and speed up reaction time, indicating that visual cues can reduce cognitive load and improve language processing efficiency. These results support the findings of Robinson (2011), who emphasized the importance of task complexity in developing deeper cognitive language processing. Visual cues presented in the form of colored images provide complex yet supportive stimuli, allowing learners to better assimilate linguistic information.

In addition, this study resonates with the concept of interlanguage described by Song (2012), where second language learners develop a transitional linguistic system when processing a new language. In this study, visual processing appears to help learners overcome phonetic difficulties associated with pinyin, which often poses a barrier to vocabulary learning. This suggests the important role of visual cues in supporting the language learning process and enabling learners to develop a more robust language comprehension system.

This study shows that visualization can improve accuracy and reduce reaction time, supporting the Declarative/Procedural model by Ullman and Lovelett (2016) which emphasizes the importance of both types of memory in language learning. Visualization plays a role in helping the encoding process in declarative memory, especially in vocabulary learning, as seen in the colored picture condition in this study, where students showed a higher level of accuracy compared to other conditions.

The results of this study are also in line with the findings of Archibald and Joanisse (2012) and Pierce et al. (2017) which state that phonological memory plays an important role in language learning. In this study, students experienced a significant increase in accuracy in the visual condition compared to the pinyin condition. This indicates that reducing phonetic load through visualization helps learners retain language information more effectively.

In addition, these results are also consistent with Farjami's (2013) research, which emphasizes the importance of deep cognitive processing to support long-term retention. The colored picture condition in this study appeared to allow students to process information more deeply compared to the pinyin condition, which resulted in increased accuracy and speed in their language information recall and recall tasks.

The correlation between memory capacity, as measured by the Digit Span Test, and task performance offers additional insight into individual differences in language learning. Students with higher memory scores tended to demonstrate greater accuracy, particularly on the colored picture naming task. This suggests that students with stronger short-term memory capacity may benefit from visual cues, as their higher memory capacity allows them to process and recall images more efficiently. These findings support the role of working memory in language learning, particularly on tasks involving vocabulary recall and sentence production (Archibald & Joanisse, 2012).

The results of this study have important implications for language teaching, particularly for Mandarin as a second language. The findings regarding the benefits of visual aids highlight the importance of integrating pictures and other visual materials into the Mandarin curriculum, especially at the beginner level. Visual aids can reduce cognitive load and support faster language retrieval, which is particularly beneficial in classrooms where students are still developing basic character recognition and vocabulary skills.

In addition, the results of this study suggest that teaching strategies should take into account individual differences in memory capacity when implementing visual aids. Students with lower memory capacity may need additional support or activities that reinforce vocabulary acquisition through a multimodal approach, such as combining pinyin with pictures or introducing mnemonic techniques to support recall.

For the development of textbooks, it is advisable to add pictures that support understanding of the material. If using textbooks in teaching, it is advisable to use original colored books to maintain visual quality. Avoid using black and white photocopies, as this can reduce the effectiveness of visual aids and potentially hinder students' learning process.

While this study provides insight into the role of visualization and phonetic processing in Mandarin language learning, there are several limitations that need to be acknowledged. First, the sample size was relatively small and confined to a single school, which may affect the generalizability of the results. Future research with larger and more diverse samples would help validate these findings. Additionally, this study focused only on short-term memory and immediate recall. Longitudinal research exploring the effects of visualization on long-term retention could provide a more comprehensive understanding of how visual aids impact language acquisition over time.

Future research could also investigate other forms of visual aids, such as videos or animated illustrations, and their impact on different aspects of language learning, such as grammar comprehension and speaking fluency. Additionally, exploring the role of visualization in languages with different writing systems, such as Arabic or Japanese, could provide insight into the broader application of visual aids across language learning contexts.

E. CONCLUSION

This study demonstrates the positive effects of visualization on language processing and memory retention among Mandarin learners. Visual cues have been shown to facilitate faster and more accurate recall, which is particularly beneficial for a language like Mandarin with its complex characters and unique learning challenges. Integrating visual aids into language teaching practices can create a more effective, engaging, and accessible learning environment, thereby supporting students' success in learning Mandarin as a second language. These findings strengthen the evidence supporting multimodal learning and highlight the importance of tailoring instructional materials to suit the cognitive needs of language learners.

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Appendix 1

UNS UNIVERSITAS SEBELAS MARET

FORMULIR PERSETUJUAN

Kepada peserta,
Selamat datang di proyek penelitian kami. Sebelum Anda memutuskan untuk berpartisipasi dalam proyek ini, kami akan meminta Anda untuk membaca dengan cermat formulir persetujuan informasi berikut. Dokumen ini dirancang untuk memberikan informasi tentang tujuan, prosedur, risiko, dan manfaat yang terkait dengan proyek penelitian ini. Harap membaca dengan cermat dan mempertimbangkan apakah partisipasi Anda sesuai dengan kehendak Anda sendiri. Jika Anda memiliki pertanyaan atau kekhawatiran, silakan hubungi kami sebelum memutuskan untuk berpartisipasi.
Tujuan Penelitian:
Proyek penelitian ini bertujuan untuk mengeksplorasi bidang pengetahuan tertentu dengan tujuan meningkatkan kondisi sosial. Kami akan mengumpulkan data dari Anda untuk mencapai tujuan ini.
Prosedur Penelitian:
Jika Anda setuju untuk berpartisipasi dalam proyek penelitian ini, Anda akan diminta untuk menyelesaikan serangkaian tugas dan survei. Tugas dan survei ini akan melibatkan beberapa informasi pribadi Anda, seperti usia, jenis kelamin, dan latar belakang pendidikan.
Risiko dan Manfaat:
Risiko dalam proyek penelitian ini sangat kecil. Semua data akan diperlakukan secara rahasia, dan hanya anggota tim peneliti yang dapat mengakses data tersebut. Kami akan melindungi privasi dan informasi pribadi Anda saat merilis hasil penelitian.
Dengan berpartisipasi dalam proyek penelitian ini, Anda akan berkesempatan untuk memberikan kontribusi bagi masyarakat, membantu mendorong kemajuan dan perkembangan ilmu pengetahuan. Selain itu, kami akan berbagi informasi tentang hasil penelitian setelah proyek penelitian selesai.
Membatalkan keikutsertaan dari Penelitian:
Anda dapat membatalkan ikut serta dari proyek penelitian ini kapan saja, dan keputusan Anda untuk tidak ikut tidak akan mempengaruhi hubungan Anda dengan kami saat ini atau di masa depan.
Persetujuan Partisipasi:
Saya telah membaca dengan cermat dan memahami informasi di atas. Saya memahami bahwa saya dapat keluar dari proyek penelitian ini kapan saja, dan saya bersedia berpartisipasi dalam proyek ini secara sukarela. Saya setuju bahwa data saya akan digunakan dengan menjaga kerahasiaan.

Tanda tangan peserta: _____

Tanggal:_____

Appendix 2

KUESIONER LATAR BELAKANG RESPONDEN

Petunjuk:
Mohon jawab pertanyaan di bawah ini dengan jujur. Jawaban Anda akan digunakan untuk tujuan penelitian dan akan dijaga kerahasiaannya.

A. Data Pribadi

1. Nama: ……
2. Usia: ……..
3. Jenis kelamin:
   ☐ Laki-laki ☐ Perempuan
4. Kelas:
   ☐ Kelas 7 ☐ Kelas 8
5. Nomor Partisipan: ……

B. Latar Belakang Bahasa

5. Apa bahasa ibu Anda?

☐ Indonesia
☐ Lainnya: …….

6. Sejak kapan Anda mulai belajar bahasa Mandarin?

☐ Kurang dari 1 tahun
☐ 1-2 tahun
☐ 2-3 tahun
☐ Lebih dari 3 tahun

7. Seberapa sering Anda menggunakan bahasa Mandarin di luar kelas?

☐ Tidak pernah
☐ Jarang (sekali dalam seminggu)
☐ Kadang-kadang (2-3 kali seminggu)
☐ Sering (lebih dari 3 kali seminggu)

8. Apakah Anda pernah belajar bahasa Mandarin di tempat lain selain sekolah?

☐ Ya ☐ Tidak

9. Jika ya, di mana Anda belajar bahasa Mandarin selain di sekolah? (boleh lebih dari satu)

☐ Kursus bahasa
☐ Aplikasi pembelajaran (misal: Duolingo, HelloChinese)
☐ Pelajaran pribadi (guru privat)
☐ Lainnya: ……

C. Penguasaan Bahasa Mandarin

10. Bagaimana tingkat kemampuan Anda dalam membaca *pinyin*?

☐ Sangat sulit
☐ Cukup sulit

☐ Cukup mudah
☐ Sangat mudah

11. Seberapa percaya diri Anda dalam menerjemahkan *pinyin* ke dalam bahasa Indonesia?

☐ Tidak percaya diri
☐ Cukup tidak percaya diri
☐ Cukup percaya diri
☐ Sangat percaya diri

12. Apakah Anda kesulitan memahami kosakata Mandarin yang diajarkan dalam buku *Easy Steps to Chinese*?

☐ Sering kesulitan
☐ Kadang-kadang kesulitan
☐ Jarang kesulitan
☐ Tidak pernah kesulitan

D. Motivasi dan Sikap Terhadap Bahasa Mandarin

13. Seberapa tertarik Anda dalam belajar bahasa Mandarin?

☐ Sangat tidak tertarik
☐ Tidak tertarik
☐ Tertarik
☐ Sangat tertarik

14. Seberapa sering Anda belajar bahasa Mandarin di luar kelas?

☐ Tidak pernah
☐ Sekali seminggu
☐ 2-3 kali seminggu
☐ Setiap hari

15. Seberapa percaya diri Anda dalam menggunakan bahasa Mandarin dalam percakapan sehari-hari?

☐ Tidak percaya diri sama sekali
☐ Kurang percaya diri
☐ Cukup percaya diri
☐ Sangat percaya diri

16. Menurut Anda, apakah visualisasi (gambar, ilustrasi) membantu Anda memahami bahasa Mandarin lebih baik?

☐ Sangat tidak membantu
☐ Tidak membantu
☐ Membantu
☐ Sangat membantu

E. Preferensi Gaya Belajar

17. Bagaimana Anda lebih suka belajar bahasa Mandarin?

☐ Dengan membaca teks
☐ Dengan mendengarkan percakapan atau rekaman audio
☐ Dengan melihat gambar dan ilustrasi
☐ Dengan berbicara dan berlatih dengan teman

18. Apakah Anda lebih mudah mengingat kata atau frasa jika disertai dengan gambar?

☐ Sangat tidak setuju
☐ Tidak setuju
☐ Setuju
☐ Sangat setuju

F. Kognitif dan Memori

19. Seberapa sering Anda merasa kesulitan mengingat kosakata baru?

☐ Sangat sering
☐ Cukup sering
☐ Jarang
☐ Tidak pernah

20. Ketika Anda belajar kosakata baru, metode mana yang paling membantu Anda mengingat?

☐ Mengulang kata-kata secara lisan
☐ Menulis kosakata di buku catatan
☐ Menggunakan gambar atau visualisasi
☐ Membuat kalimat dengan kata tersebut

21. Apakah Anda merasa tugas yang melibatkan gambar lebih mudah diselesaikan dibandingkan tugas yang hanya melibatkan teks?

☐ Sangat tidak setuju
☐ Tidak setuju
☐ Setuju
☐ Sangat setuju

Penutup

Terima kasih telah meluangkan waktu untuk mengisi kuesioner ini. Jawaban Anda sangat berarti bagi penelitian ini dan akan membantu meningkatkan pembelajaran bahasa Mandarin.

Appendix 3

Digit Span Task

Nama :

Kelas :

Nomor Partisipan:

3 angka: 3 - 5 - 9

4 angka: 2 - 8 - 4 - 7

5 angka: 6 - 1 - 9 - 3 - 8

6 angka: 5 - 2 - 7 - 1 - 4 - 9

7 angka: 4 - 6 - 8 - 3 - 7 - 1 - 2

8 angka: 9 - 3 - 5 - 2 - 8 - 6 - 4 - 7

9 angka: 1 - 5 - 8 - 9 - 3 - 6 - 7 - 4 – 2

Appendix 4

Survei Pemahaman Terhadap Gambar

Nama: _____

Kelas: _____

Nilailah seberapa baik Anda memahami gambar berikut ini. Nilai 1 menunjukkan bahwa gambar tersebut membingungkan, sedangkan nilai 7 menunjukkan bahwa Anda sangat memahami maksud dari gambar tersebut.

1	2	3	4	5	6	7

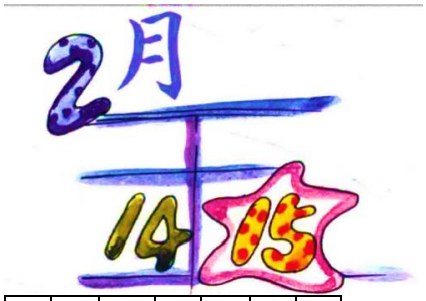
1	2	3	4	5	6	7

1	2	3	4	5	6	7

1	2	3	4	5	6	7

1	2	3	4	5	6	7

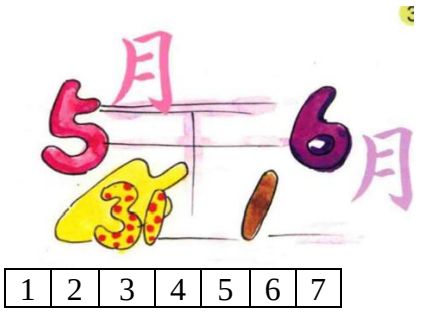
1	2	3	4	5	6	7



1	2	3	4	5	6	7

1	2	3	4	5	6	7

1	2	3	4	5	6	7



1	2	3	4	5	6	7