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# INVESTIGATING THE VISUAL COGNITION AND DESIGN PREFERENCES FOR ORACLE BONE SCRIPT FROM A COGNITIVE LOAD PERSPECTIVE AMONG THE CHINESE STUDENTS IN MALAYSIA

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## ABSTRACT

Oracle bone script can significantly aid in learning simplified characters. However, the complexity of its design, the learners' cognitive schemas, and the connections between oracle bone script and simplified characters might increase cognitive load, potentially becoming an obstacle to learning. There is currently a lack of research in this area, particularly concerning the Chinese students in Malaysia in a multilingual environment. This study consists of two phases: in the first phase, a quantitative method was used to analyze the Chinese reading and writing ability of 50 students, identifying 12 students needing improvement for the second phase of qualitative interviews. By integrating schema theory and cognitive load theory, the study delved into their visual cognition of oracle bone script and the factors influencing this cognition, further exploring their preferences for oracle bone script design styles and the reasons behind these preferences. The study found that, on the one hand, there are significant differences in the recognition and cognition of oracle bone script among participants, with various factors affecting recognition, which do not align with

learners' cognitive schemas, thus increasing cognitive load. On the other hand, most participants preferred the icon oracle bone scrip design style and provided specific design suggestions. Future research could explore different design and teaching strategies, combining thoughtful design, effective teaching methods, and ongoing research to reduce cognitive load, thereby preserving and promoting the rich cultural heritage of oracle bone script.

**KEYWORDS:** cognitive schema, cognitive load theory, Oracle bone script, Chinese character education, graphic design.

## 1 INTRODUCTION

### 1.1 Background and Problem Statement

The oracle bone script (OBS) is the earliest writing system in China and is characterised by pictograms and ideograms (Gao et al., 2022). This graphic hieroglyphic writing is based on the depiction of real things. It is precisely because of the dual function of graphics and writing. OBS plays a crucial role in the education of simplified characters (SC), a bridge between abstract SC and figurative reality (Xu & Sun, 2020). When learning SC, students are first exposed to these ancient symbols and try to understand their meanings, constructing an initial cognitive schema. "Meaning" not only helps students understand the symbols of the OBS but also connects these symbols to modern SC (Chen, 2023). However, the OBS are thousands of years old. On the one hand, OBS is designed in various styles, even for the same one (Gao & Liang, 2020); on the other hand, Chinese characters have gone through a long iteration, from pictographs to traditional characters to the SC. Chinese characters were constantly abstracted to form the writing system used today. OBS's pictographic and ideographic features differ significantly from how the SC is structured and used (Han et al., 2022). Students need to spend extra cognitive resources to adapt and adjust to understanding and memorising the symbols.

**Figure 1: The form of the oracle bone script.**

Adapted from: Toutiao (2019); Sohu (2023); Xiaoxuetang (2024)

In the learning process based on OBS, students need to deal with the complex transformation process between visual symbols, real meaning, and SC. In this process, students' cognition proceeds based on their current level of knowledge and their perceptions of the OBS, not just the definition of abstract symbols (Chen, 2021). While some OBS designs shorten the learning process to process, this is only the case for some OBS. Cognitive load theory suggests that the more complex the learning material and the less knowledge and experience the learner possesses, the more cognitive resources are required for the individual to process the schema, and the greater the learner's intrinsic cognitive load (Van & Sweller, 2005). That is, when learners encounter an OBS, and they do not have an appropriate or automated schema, they must individually but simultaneously mentally remember all components of the graphic information; or if learners cannot activate an appropriate schema, then the processes used to interpret the meaning of the OBS place a high demand on working memory, thus resulting in a relatively high cognitive load.

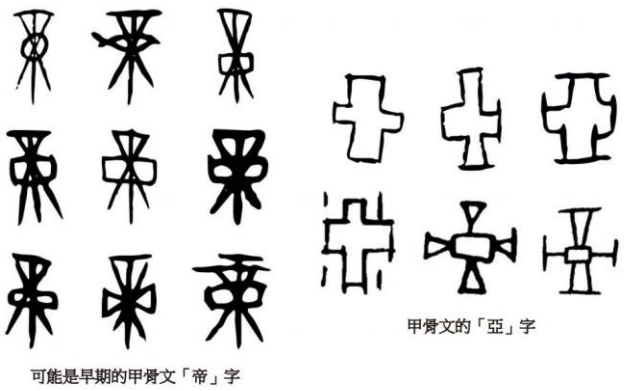


**Figure 2: Different forms of the same oracle bone script.**

Adapted from: Case press (2023)

The complexity of OBS design, learners' cognitive schema, and the connection between OBS and SC may all increase learners' cognitive load. Although OBS has been very effective in guiding the learning of SC, most of the related studies have focused on China. There is no relevant research on the Chinese in Malaysia who also learn and use Chinese language (Wang, 2024). Unlike China, Chinese students in Malaysia live in a multicultural and multilingual environment, which gives them greater flexibility and adaptability in language learning and cultural symbol acceptance. Utilising multiple cognitive schemas already in place to make associations and analogies facilitates comprehension and memorization of OBS (Harun et al., 2021). However, this multilingual background may also lead to an

increased cognitive load as they need to switch and integrate between languages when confronted with OBS (Treffers-Daller et al., 2022).

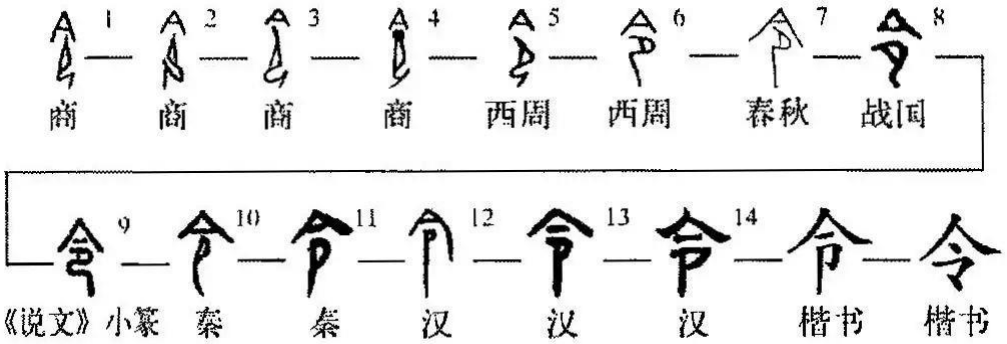


**Figure 3: The Evolution of the Character "令" from Oracle Bone Script to Simplified Character.**

Adapted from: Zuo (2024)

This study aims to explore the visual perception of OBS among Chinese students in Malaysia through schema theory and cognitive load theory, which includes factors affecting the perception and preference of different OBS design styles. This study will collect students' feedback and experiences during the learning process through interviews, providing valuable references for educators and graphic designers.

### 1.2 Relationship Between Oracle Bone Script and Chinese Characters

OBS and SC are two critical stages in the history of Chinese script development, and the cultural inheritance between them reflects the evolution and cultural continuity of Chinese writing (Zhu & Lee, 2015). OBS is China's earliest surviving mature writing system, originating in the Shang Dynasty (ca. 14th century BC to 11th century BC). Ancient soothsayers carved these hieroglyphic and ideographic symbols on animal bones to record life's political, economic, religious, and social aspects (Pennick, 2014). Chinese characters' basic structure and expression were laid down at the origin of Chinese writing. On the other hand, SC is a product of the Chinese script reforms carried out at the beginning of the 20th century to improve literacy and writing efficiency (Luo, 2015). SC was simplified by reducing the number of strokes, merging homographs, and retaining the main building blocks. Despite the simplification, many of SC's essential components and glyphs can still be traced back to the OBS and their subsequent evolution (Gao & Liang, 2020). The relationship

between OBS and SC is described below regarding interpretation, graphic structure, and educational research.

### 1.2.1 Definitions

There are differences between the pictographic and ideographic characteristics of the OBS and the streamlined and ideographic characteristics of the SC. These features are reflected in the interpretations of the OBS and the SC.

On the one hand, the difference between OBS and SC is reflected in the process of interpretation. The interpretation of OBS first unfolds through the glyphs. Since most OBS are pictographs, researchers determined their interpretations by comparing the images (Zhao & Jiao, 2020). By the middle of the 20th century, the study of OBS entered the stage of systematic categorical interpretation, which was further revised and enriched by lexical and grammatical structures (Fu et al., 2022). Nowadays, OBS's digital processing and statistics have improved the accuracy and efficiency of interpretation. Meanwhile, international joint research has injected rich perspectives into the interpretation work (シュ, 2022).

The interpretation of SC is reflected in the effect of the glyphs on their meaning after the simplification of traditional characters. Although the simplification process has preserved the main building blocks of traditional characters to ensure consistency and recognisability, some of the SC may need clarification, posing a challenge to interpretation (Zhao & 2007). However, some of the SC may lead to confusion, posing challenges to interpretation (Zhao & Richard, 2007). On the one hand, researchers have explored the interpretive changes of SC in different contexts through lexical and grammatical analyses (Hoosain, 1992). On the other hand, quantitative analyses of the interpretive changes of SC have been conducted using big data and computer technology to provide data support for the rationality and scientificity of glyphs (Liu & Nakagawa, 2004).

On the other hand, it is reflected in the differences in the methods of interpretation. The interpretation methods of OBS mainly include pictogram interpretation, combined ideogram interpretation and morpho-sound interpretation (Xiong et al., 2015). Firstly, pictogram interpretation is to understand the meaning of a character by observing its shape. For example, the shape of the character "日" in the OBS is similar to the sun, so it is interpreted as "sun." Secondly, the combined ideogram interpretation expresses complex concepts by combining multiple pictograms or symbols. For example, the character "明" is formed by

combining "日" and "月" to represent light. Finally, shape-sound interpretation is a less common method in OBS, in which the pronunciation and meaning of a character are interpreted through the clues provided by the character's shape. The interpretation methods of SC mainly include simplified and standardised interpretation (Zhao & Richard, 2007). Simplified interpretation SC by reducing strokes and combining similar morphological characters while maintaining the basic meaning of the original character. Standardised paraphrasing ensures consistency and normality through unified planning and standardisation by official bodies (Zhao, 2005).

These differences make the OBS and SC differ in meaning.

### 1.2.2 Graphical structure

OBS and SC also differ in terms of graphic structure.

On the one hand, OBS has a pictorial nature. Firstly, the pictographic features of OBS directly reflect the image of things (Anzhu, 2020). For example, the character for "山" depicts the shape of a mountain. This feature not only helps people to make associations but also facilitates people's reading and memorization. And also, the structure of OBS is relatively complex. This complexity is reflected in the number of strokes, the variety of glyph constructions, and the degree of detail (Gao & Liang, 2020). For example, the glyph for "龟" not only depicts the overall shape of the turtle but also includes the texture of the turtle shell. This complexity reflects the high degree of recognisability of the original form. The complex graphic structure provides rich research material and cultural information (Serruys, 1974).

On the other hand, SC demonstrates the simplicity of the font. SC has a simple graphic structure and fewer strokes, reducing writing time and reading and writing difficulty (Liu et al., 2016). For example, the character "马" is simplified from "馬," which retains the basic image but has significantly fewer strokes, making it easier to write. Its simplicity has led to its widespread use as the primary form of writing for everyday communication and official documents.

### 1.2.3 Oracle Bone Script and Education

On the one hand, OBS guides the teaching of SC. The OBS is the source of the development of Chinese characters, and this kind of etymological study can not only help students grasp the historical background of SC but also help them understand the evolution and enhance their understanding of the structure of Chinese characters. Xu and Sun (2020) argued that the

problems of SC learning stem from students' need to understand the origin and development of Chinese characters, and the OBS can be an excellent solution to this problem. Egorov et al. (2022) analysed the possibility of development in teaching practice by comparing the relationship between OBS and SC.

On the other hand, OBS bears the mission of passing on culture in education. Through OBS, learners can experience the history and wisdom of ancient China and enhance their sense of identity with Chinese culture. As Zhang et al. (2021) pointed out in their study, OBS is an important cultural heritage in China, embodying the life and wisdom of ancient Chinese people. Similarly, Chen (2024) and Wang & Shi (2024) stated in their studies that OBS are the carriers of Chinese culture and its mode of transmission and are the core of Chinese culture.

### 1.3 Schema Theory and Cognitive Load Theory

#### 1.3.1 Schema Theory

Schema is a concept in cognitive psychology that refers to the cognitive structures or frameworks in an individual's brain used to organise and interpret information. Schemas help us make sense of the world and provide a reference when confronted with new information (Axelrod, 1973). In the study of schema in oracle scripts, schema refers primarily to the cognitive framework or structure people have for OBS. This cognitive framework helps learners understand and interpret their form and meaning.

Few studies apply schema theory directly to OBS. As a cognitive structure, schema theory provides logical support and an explanatory framework for people to identify and analyse the morphological features of oracle bones. According to schema theory, people form cognitive schemas through "assimilation" and "adaptation" based on the interconnection of old knowledge and new information from previous experiences. "Assimilation" is the incorporation of external information into an existing schema, resulting in an ever-expanding schema (Wachtel, 1980), allowing the researcher to understand the oracle symbols through knowledge and experience. Learners with different knowledge experiences will produce different understandings. This cognitive framework not only helps to categorise the symbols but also helps us to interpret their meaning and expand our knowledge of OBSs. "Conformity" means that when the environment changes, the original schema can no longer assimilate the new information but must be adapted to build a new schema (Wagoner, 2013). By constructing and adapting semantic schemas, researchers can interpret the meaning of

symbols in different contexts. For example, in understanding the symbol "马," we not only consider its form but also its symbolic meaning in Shang Dynasty culture, thus revealing the multiple meanings of the symbol.

Through the application of schema theory, researchers can better interpret OBS and reveal the cognitive factors behind their evolution, providing new perspectives and methods for OBS research.

### 1.3.2 Cognitive load theory

In cognitive load theory, Intrinsic Cognitive Load (ICL) is closely related to the complexity of the learning material itself (Van & Sweller, 2005). The complex symbolic structure and multiple meanings of OBS make the learning and comprehension process challenging, and Intrinsic Cognitive Load is a critical factor in the study. Although there are fewer studies on the relationship between cognitive load theory and OBS, we can still draw the relationship between intrinsic cognitive load and OBS in the characteristics of OBS.

The first aspect concerns the cognitive load of OBS recognition. OBS are complex and diverse, and each symbol contains specific morphological features. Recognizing these symbols requires a lot of visual and cognitive effort on the part of the learner, which can increase the intrinsic cognitive load.

Firstly, about morphological recognition of OBS. OBS is morphologically complex, including various lines, structures, and combinations. Luk and Bialystok (2005) showed that learners must pay attention to the details of each symbol, such as the shape and arrangement of the strokes, when recognizing pictographs. These complex visual features increase the difficulty of symbol recognition. Second, the decomposition and combination of OBS are discussed. Many OBS are made up of combinations of simple symbols; that is, a combined ideogram is made up of several pictographs. Hu (2023) pointed out that learners need to recognize and understand the components of these combinations of symbols and how they are combined. For example, the character "休" consists of two parts, "人" and "木," and learners need to understand the meaning of the combination based on the identification of these parts. This process requires a high level of cognitive processing and, finally, the recognition of OBS. There are many morphologically similar symbols in OBS, which makes it more difficult to identify different symbols, and Chen (2021) found that morphologically similar symbols such as "日" and "目" can be easily confused during the identification process,

which requires more cognitive effort for learners to differentiate these symbols. More cognitive effort is required to distinguish between these symbols.

On the other hand, there is an excellent understanding of the meaning of OBS. Understanding the meaning of OBS involves not only recognizing the forms of the symbols but also linking these forms to the meaning of the symbols. Learners who do not possess high cognitive ability and rich background knowledge will increase their intrinsic cognitive load.

Secondly, about the multiple meanings of the figures. OBS often have many different meanings, and Funk (2019) showed that the word "日" not only represents the sun but also time, light, and other concepts. Learners need to accurately interpret the meaning of these symbols in different contexts when understanding them. Second, about contextual relevance. The meanings of many oracle bone symbols depend on their use in specific contexts. Keightley's (1985) study pointed out that learners need to relate the symbols to specific cultural and historical contexts to understand their meanings accurately. For example, understanding divination symbols in OBS requires learners to understand ancient divination practices, rituals, and reasoning about abstract symbols. Some OBS are abstracted, and it is not easy to understand their meanings directly. Huang et al. (2020) pointed out that learners need to understand the meanings of these abstract symbols through association and reasoning. For example, comprehending ideographs and pictograph characters requires learners to make connections between the form and sound of the symbols, a process requiring a high level of cognitive processing.

The last aspect concerns the load on memory and recall. Learning and remembering many complex OBS highly demands learners' memory skills. Memorising these symbols and their meanings requires many cognitive resources, which increases the intrinsic cognitive load.

Thirdly, about the load of symbol memory. OBS are huge in number and varied in form, and learners need to remember many symbols and their corresponding meanings. Wu (2023) showed that memorising these symbols requires learners to practise and reinforce them repeatedly, and secondly, it is about the difficulty of recall. When required to use OBS, learners must recall these symbols and their meanings accurately from memory. Dress et al. (2023) found that recalling complex OBS was more challenging than recalling simple modern scripts, and finally, regarding creating long-term memory. To store and retrieve OBS effectively in long-term memory, learners need to practise and review a lot. Terry (2017)

pointed out that building long-term memory requires multiple cognitive processing and reinforcement.

To summarise, intrinsic cognitive load is critical to the OBS learning process. The complexity, diversity, abstraction, and multiple meanings of oracle symbols increase learners' cognitive load in recognizing, understanding, and remembering these symbols.

### 1.3.3 The Intersection of Schema Theory, Cognitive Load Theory, and the Oracle Bone Script

There is a significant intersection between schema theory and cognitive load theory in understanding and explaining cognitive processes in OBS learning. By combining these two theories, OBS's instructional design and strategies can be optimised to improve learners' understanding and retention of OBS and enhance learning.

On the one hand, they both emphasise the importance of structuring knowledge. Schema theory suggests that by building and adapting schemas, learners can process and store information more efficiently (Spiro, 2017). For example, when learning OBS, learners can build new knowledge schemas by linking newly learnt OBS to their existing knowledge of SC. On the other hand, cognitive load theory states that by optimising the use of cognitive resources, unnecessary cognitive load can be reduced, and learning efficiency can be improved (Sweller, 2020). For complex symbolic systems like OBS, structured knowledge helps to reduce cognitive load and improve learning.

On the other hand, they both emphasise the importance of simplifying complex information. OBS is complex and diverse, and by creating concise and clear schemas, learners can process this complex information more efficiently (Saleh ALYousef, 2020). Cognitive load theory states that by simplifying learning tasks, learners can focus on the intrinsic cognitive load and reduce the burden of learning (Apostolou & Linardatos, 2023).

## 1.4 Current Status of Oracle Bone Script Graphic Design

The OBS has received a great deal of attention from researchers and designers. This section critically examines the current research on integrating OBS in modern design and its cultural and economic impact. The literature is divided into two main areas of focus: the expression of SC forms and the use of new media in creating economic and cultural value.

The first concerns the expression of SC forms. Previous studies have expressed the formal meaning of SC by combining OBS with modern design. These studies emphasised the importance of incorporating visual and perceptual features of images while maintaining the SC textual information.

Zhou and Li (2021) discuss the dynamic design of SC based on their compositional thinking. They argue that dynamic fonts, as visual tools, should have other characteristics besides the fundamental duality of function and form. Chen (2021) suggests that the SC design should respect the characters' meaning and structure while enhancing the characters' image sensors so that the characters and pictures fit harmoniously. SC should maintain its basic textual information and have an intuitive and emotional sense of images. Yin (2021) designed a visual image of the staff's professional clothing in an SC museum and summarised and analysed the symbolism and typical features of the OBS by analysing the principles of visual symbolism and the forms of artistic composition, which are the unique artistic values of the OBS, and the rules derived through visual thinking.

Li (2021) found through literature review and investigation that the charm of OBS lies in their pictorial nature. In her thesis, she analysed many of the features of OBS and explored functionality and formal aesthetics in her practice by combining text shapes with product structures. Yin (2022) explored modern Chinese character design from the perspective of visual culture and analysed the aesthetic value, cultural connotation and social significance expressed in its socio-cultural attributes. In her study, she discusses SC design in the context of consumption and social value, arguing that the integration of OBS into modern design is a legacy of traditional culture.

Another focus of literature is on using new media to enable the OBS to create new economic and cultural values. Digital economy technologies and the design of cultural tourism products are vital pathways to activating and developing OBS in economic development.

Wu & Xu (2021) explore three forms of application of OBS in modern design: emoticons, toys, and tourism products. They argue that the design of OBS can incorporate images into people's lives to spread culture and reflect the popularity and entertainment of the OBS. Jia (2021) proposes to activate and develop OBS culture through new interdisciplinary perspectives. A systematic marketing strategy was developed to create a visual image of the OBS by integrating modern communication channels and technological means, as well as the

thinking and power of the younger generation. Wang (2021) and others found that the traditional means of communication were boring, but the informational communication channels were under-researched. Therefore, they designed an OBS learning system based on WeChat applets, database technology and MINA framework. The system achieves the functions of Oracle idiom fill-in-the-blank, SC selection, SC query OBS, and primary school through the WeChat applet, which helps revitalise and use the OBS.

Zhang (2021) proposes that OBS is a breakthrough point for influencing foreign cultures with cultural elements that have local SC. He argued that OBS should be integrated with product design and that transforming two-dimensional OBS into three-dimensional product design requires creative design and thinking. Qiu (2021) suggested that integrating OBS culture into cultural tourism could promote local economic development. She believes that OBS's cultural product design should focus on docking with modern life, exploring the central market direction, realising the combination of innovation and practicality, and developing products that meet the needs of different target groups. Wu et al. (2022) analysed the OBS cultural communication dilemma in Anyang City. They concluded that the OBS cultural dilemma lies in limiting the communication conditions caused by communication, design, cultural orientation, and policy support.

In summary, despite designers' efforts to find breakthroughs in OBS design, this section reveals that OBS design behaviours need to be more cohesive due to the need for a systematic theoretical supportive approach. In addition, socially orientated design does not explicitly target specific audiences, limiting in-depth exploration of the meaning of social design.

### 1.5 Research Questions and Objectives

The research questions of this study are as follows:

- What is the visual perception of OBS among the Chinese students in Malaysia?
- What are the factors that influence the visual perception among the Chinese students in Malaysia?
- What are the preferences and reasons for the different OBS design styles among the Chinese students in Malaysia?

**1.6 Significance of the study:** This study is significant in terms of theory, practice, and culture. By exploring The Chinese students' visual perceptions of OBS and their influencing factors in Malaysia, we can deepen our understanding of schema theory and cognitive load

theory, provide guidance for education and design practice, and promote the transmission and dissemination of OBS culture.

### 1.6.1 Significance of the Theory

Firstly, this study combines schema theory and cognitive load theory to provide a novel perspective to understand and explain OBS's learning and cognitive processes. Schema theory emphasises structuring knowledge and integrating new information with pre-existing schemas, which is crucial for understanding the complexity of OBS and how learners process this information. Cognitive load theory, on the other hand, focuses on using and managing cognitive resources and helps us understand the cognitive challenges learners face when processing OBS information. By applying these two theories to the study of OBS, this study not only enriches the scope of application of these two theories but also provides a theoretical foundation for future research on symbol learning and visual cognition.

### 1.6.2 Significance of the Practice

In terms of practice, the results of this study can provide valuable references for educators and designers. By investigating Chinese students' visual perceptions of OBS and the factors influencing them, educators can better understand students' difficulties in learning OBS and, thus, design more effective teaching methods and strategies. In addition, this study explored students' preferences for different OBS styles and their rationale, which provides design references for the modern application and promotion of OBS. Understanding students' preferences for different design styles can help designers use OBS more effectively in modern visual communication to retain their historical and cultural values while meeting modern aesthetic needs.

### 1.6.3 Significance of culture

Finally, this study contributes to promoting the dissemination and preservation of the precious cultural heritage of OBS in the Chinese community in Malaysia. By studying students' perceptions and preferences of OBS, we can better understand the acceptance and dissemination pathways of OBS in the modern Chinese community. Further cultural promotion activities can be based on the findings of this study to design educational and promotional content that better matches the student's interests and cognitive characteristics, thus enhancing the younger generation's identification and interest in OBS culture.

## 2 Research Methodology

### 2.1 Sample

This study is based on Malaysia and was conducted using online tests and telephone interviews. The target population is the Chinese students in Malaysia who are studying at Taylor's University. The study involved both qualitative and quantitative data collection and analysis.

On the one hand, 50 students were randomly surveyed on the status of their SC reading and writing skills through an online questionnaire. This step was only to screen out students who needed to improve their Chinese language skills. Their perceptions and preferences were studied. Exploring from the learner's point of view can better analyse the problem and provide feasible solutions to help them. The researcher quantitatively described the Chinese language proficiency of the surveyed population.

On the other hand, 12 students who met the survey criteria were selected for in-depth telephone interviews. In this step, we likewise used a new online questionnaire to present and explain the interview questions during the telephone interviews. The researcher turned on the recording device to record the interview process with the participants' consent so that the data could be collated and analysed quantitatively and qualitatively later.

In order to maintain the confidentiality of participants, each participant was assigned a unique identifier. Participants are referred to as S1, S2, etc., where 'S' stands for 'Subject' followed by their respective number.

### 2.2 Research Procedures and Research Design

#### 2.2.1 Test of simplified character reading and writing skills

Here is the first part of the survey. The researcher sent the online test questionnaire to the participants by sharing the link. This part contains three aspects: "profiled," "Chinese reading ability," and "Chinese writing ability."

Firstly, the "profiled" section covers nationality and ethnicity. It is intended to filter the background of the test participant to ensure that the participant meets the requirements—namely, a Chinese person who belongs to Malaysia but does not have Chinese nationality. The section does not address the testee's personal privacy or human ethics issues.

Secondly, the "Chinese Reading Ability" section utilised a selective pairing format, matching simplified characters and Pinyin. The ten simplified characters and their Pinyin equivalents were provided, and the tester was asked to match them. The results of the pairings were recorded. These simplified characters are shown in the table below.

**Table 1: Chinese reading ability (SC-Simplified Character; PY-PinYin).**

| No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| SC | 网 | 行 | 日 | 月 | 雨 | 用 | 也 | 要 | 气 | 朋 |
| PY | wǎng | xíng | rì | yuè | yǔ | yòng | yě | yào | qì | péng |

Thirdly, the "Chinese Writing Ability" section employed handwritten Chinese characters to fill in the blanks for the phrases provided. The test taker was presented with a set of fragmented Chinese words, the fragmented parts of which were annotated in Pinyin, and was asked to enter the corresponding Chinese characters by hand according to the prompts. In this section, ten simplified characters were tested.

These simplified characters are shown in the table below.

**Table 2: Chinese writing ability (SC-Simplified Character; P-Phrase).**

| No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| SC | 坐 | 子 | 衣 | 页 | 小 | 文 | 身 | 山 | 肉 | 人 |
| P | 坐下 | 桌子 | 衣服 | 页码 | 小孩 | 文化 | 身体 | 山川 | 牛肉 | 人民 |

### 2.2.2 In-depth Interviews on Oracle Bone Script's Visual Perceptions and Design Preferences

Before the start of the interview, the researcher explained the procedure and purpose of the survey to the participants. After obtaining the participant's consent, the interview and recording began.

In this part, six different OBS were selected for presentation. On the one hand, these six OBS can be divided into two categories according to their strokes, one with fewer strokes and the other with more strokes. The number of strokes in an OBS is an essential factor in cognitive load. On the other hand, the OBS can also be classified according to their types: hieroglyphic and ideograph characters. They are the OBS that are close to the nature of painting (Da, 2021). They are categorised into groups arranged in a chaotic order. These OBS were used throughout the stages of the investigation, but at each stage, the pictograms served different purposes.

**Table 3: Explanatory notes on the oracle bone script.**

| Oracle Bone Script | Interpretations | Categories | Strokes of a Chinese character | Simplified Chinese character |
|---|---|---|---|---|
|  | In the oracle bone script, the shape of the character "回" is like a circle or a box, symbolizing circulation and encirclement. | Ideograms | Less | 回 |
|  | In the oracle bone script, the character "门" is shaped like a door, with two doors and a door frame in the center. It directly represents the image of "door" through graphics. | Pictograms | Less | 门 |
|  | The oracle bone script character for "bird" is shaped like a bird with wings, a tail, and a beak. It directly depicts the image of a bird. | Pictograms | More | 鸟 |
|  | The oracle bone script for autumn resembles a cricket or locust, which was borrowed as "autumn" in the oracle bone script. | Ideograms | More | 秋 |
|  | The oracle bone script character for "stop" is shaped like a foot or a footprint, which means to stop, to cease. It expresses the meaning of "stop" through its shape. | Pictograms | Less | 止 |
|  | The character for "sitting" in the oracle bone script is the shape of a person kneeling on a mat, indicating a form of rest. | Ideograms | More | 坐 |

Firstly, an investigation was conducted into the visual cognitive aspects of OBS. Questions 1 and 2 of the questionnaires were answered. Question 1 investigated the personal experience of the participants, and the researcher asked them, "Do you know about Oracle Bone Script? When did you learn about it? How did you come to know about it? ". This question was designed to investigate the participants' knowledge about OBS. The level of knowledge about OBS may affect the participant's perception. Question 2 investigated the participants' visual perception of the OBS. The participants were required to look at the six OBS images provided, and then they were required to describe the information they got from each of the images, "What do you think each of them represents?" That is, through the images, what did they think and how did they feel. They also tried to guess the SC represented by the images. Through this survey, we can determine whether people know these OBS (determined by the correctness or incorrectness of the guesses). On the other hand, what information can people

perceive from the OBS (summarising the similarities and differences from people's imagination)? This will test the participants' visual recognition of the OBS and see how different participants imagine the OBS.

The second is an exploration of the factors that affect visual cognition. Participants will be presented with the six OBS covered in the previous question, along with their respective corresponding SC, and it also involves questions 3, 4, and 5 in the questionnaire. Question 3 is a free and open-ended question that investigates the participants' feelings about the cognitive load of the OBS. That is, "Based on your previous observations, did you find any of the images difficult to understand? *What do you think are the reasons that make these Oracle Bone Scripts difficult to understand? ". We can get personal opinions about different participants and the factors that make different OBS challenging to understand. Moreover, we can analyse the commonalities and differences. Question 4 is an investigation that addresses the graphic complexity factor, that is, "*Do you think the difficulty in understanding the images is related to the complexity of the lines?" this question aims to explore the relationship between lines and visual perception. Question 5 was an investigation of the factors that combine graphics and text. That is, "When they appear together, do you find it more helpful for understanding, or does it make you more confused? Please share your thoughts. ". This question aims to explore whether there is a visual cognitive relationship between OBS and SC that is easier to understand.

The last is about the preference for visual design. It involves questions 6 and 8 in the questionnaire. The participant will see the six SCs that appeared in the previous question. On the one hand, we continued the SC involved in the above questions and corresponded to the OBS. The SC's design style is consistent with the standard regular OBS.

On the other hand, for selecting design types of OBS, the researcher selected the three most representative design types as a sample over the period. The first was a sample of the original OBS from a copy file of the original BS provided by the XiaoXue Oracle Database as the symbol. These texts were designed and used during the Shang dynasty (1600 BC - 1046 BC), over 3600 years ago, and are the most primitive samples of OBS designs. The second was a sample of the OBS vector picture designed by Richard Sears' team as the index from 2002 to the present. Richard Sears launched his Chinese character website, Chinese Etymology, in 2002. The graphics were redesigned and edited into vector graphics with minimal differences between the new and original OBS graphics. (Richard. S, 2022) the third was a sample of the

icon style of the OBS designed by XiaoXiang HanZi's team from 2017 to 2020. This cultural company, based in Shanghai, China, specialises in Chinese character education. They specialise in the design of Chinese characters and have developed OBS cards, books, and design products that have been well-received in the education market.

**Table 4: Preference of Design (SC-Simplified Character; OBS-Oracle Bone Script).**

| No. | SC | Original OBS | Victor OBS | Icon OBS |
|---|---|---|---|---|
| 1 | 回 |  |  |  |
| 2 | 门 |  |  |  |
| 3 | 鸟 |  |  |  |
| 4 | 秋 |  |  |  |
| 5 | 止 |  |  |  |
| 6 | 坐 |  |  |  |

For question 8, "*which design style of the Oracle Bone Script do you prefer? Please explain why". This is an open-ended question for graphical deterministic information. In this part, the test participants must select their preferences for each set of OBS separately and explain the reasons for their choices. Of course, this is free, and the participant can choose all or none because it involves personal preference. Through this survey, we may see trends in people's preferences. On the other hand, we can precisely know what kind of problems exist in the design of the different OBS from the learner's point of view. Question 9 concerns the timing and stage of graphics: "At which stage of learning do you think it would be more effective to use Oracle Bone Script as an aid? ". This question shows the measurement of the acceptance of OBS at different stages of education. Question 10 was about the perception of OBS design, "If you are a designer creating a new design based on Oracle Bone Script, what kind of design do you think would be most helpful in enhancing learning effectiveness?". This

question aims to see, through the learner's perspective, what the real OBS design needs are. From there, it provides more in-depth suggestions for visual design.

## 3 Data analysis

### 3.1 Reading and Writing Ability

**Table 5: Totally the level of Chinese reading and writing ability.**

| Scale | Score | N | Percent (%) |
|---|---|---|---|
| None | 0 | 2 | 4 |
| Low Ability | 1-7 | 2 | 4 |
| Normal Ability | 8-9 | 10 | 20 |
| High Ability | 10 | 36 | 72 |
| Total | 10 | 50 | 100 |

This step screens the population that fits the scope of the investigation of this study. This study does not involve people with HIGH ability because they do not need to be guided by OBS. It also does not involve people who cannot read and write Chinese NONE because it is impossible to understand the connection between SC and OBS. It only involves people with LOW and NORMAL ABILITY because they need to improve their abilities further.

After counting, 12 participants belonged to low and normal ability, which accounted for 24% of the whole. Further qualitative research will be conducted around these 12 participants.

### 3.2 Visual Cognition

Firstly, the researcher conducted quantitative statistics on the status of the distribution of visual cognition of the OBS; the results are shown in the table below. The results of this part are related to the second question of the survey: "What do you think each of them represents?"

**Table 6: Frequency of positive and incorrect oracle bone script recognition.**

| Oracle bone script | Correct frequency (%) | Wrong frequency (%) | Uncertain frequency (%) |
|---|---|---|---|
|  | 0 | 11 | 1 |
|  | 12 | 0 | 0 |
|  | 11 | 1 | 0 |
|  | 1 | 9 | 2 |

| | | | |
|---|---|---|---|
|  | 0 | 10 | 2 |
|  | 0 | 10 | 2 |

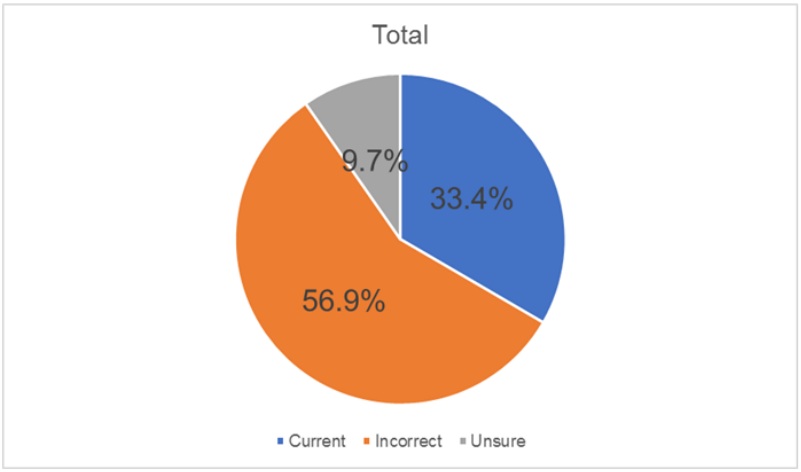


**Chart 1: Overall distribution of participants' perceptions of the OBS.**

Through the above data, we found that:

On the one hand, significant differences exist in recognizing and cognizing OBS. As can be seen in Table 1, there is a significant difference in the difficulty of recognizing different OBS. The number of correctly recognized  and  is high, 12 and 11, respectively. This indicates that the participants correctly guessed the meaning the OBS expressed and accurately stated the SC corresponding to the OBS. On the other hand, the number of incorrect identifications for  (11),  (9),  (10), and  (10) was high, and the number of correct identifications was 0. This indicates that people could not guess the meanings expressed by the OBS. In addition, a few people (7) expressed uncertainty or unrecognised results for these 4 OBS. This indicates that these OBS confused people's perceptions.

On the other hand, the overall error rate of OBS recognition is High. Table 2 shows that the overall recognition error rate is 56.9%, higher than the correct recognition rate (33.4%). This also indicates that OBS is challenging to recognize.

Next, the researcher will delve into the participants' knowledge of OBS. Keyword extraction and statistics were carried out by organising the interview data. Among them, the descriptive

responses of the participants were expressed in English, and the guesses about the Chinese characters were expressed in the form of SC.

**Table 7: Keyword extraction of participants' perceptions about oracle bone script.**

| Oracle bone script | Keywords | Number of frequencies (n≥2) | No answer |
|---|---|---|---|
|  | Container for Water（s1,s2,s9,s10,s11） | N=5 | None |
| | Lights/Fire（s4，s5） | N=2 | |
| | Folding/Cake/Hair Cards (s3)，Self (s6)，Turtle (s7)，Snail's pace (s8)，Walk（s12） | N=5 | |
|  | Door（s1-s12） | N=12 | None |
|  | Bird（s1-s12） | N=12 | None |
| | Chicken（s1） | N=1 | |
|  | Insect（s3,s6,s8,s9,s10,s11） | N=6 | S1, S2 |
| | Dream（s4，s5） | N=2 | |
| | Grasshopper (s7)，Ro/Hammer (s3)，Cup（s12） | N=3 | |
|  | Grassy（s1,s2,s5,s6,s9,s10） | N=6 | S3 |
| | Wood/Tree（s4，s11，s12） | N=3 | |
| | Bird (s8)，Hands/Fingers (s7)，Rakes/Punches（s2） | N=3 | |
|  | Fire/Candle（s1,s5,s7,s8,s10,s11,s12） | N=7 | S4 |
| | Person-related（s2，s9） | N=2 | |
| | Growing plants in pots (s3)，Electronic（s6） | N=2 | |

As we can see from the table above.

The original meaning of the  is "shaped like a circle or box, symbolising the concept of circulation, encirclement." However, the data shows that most participants (n=5) thought it expressed "a vessel for catching water." Two others thought it expressed "灯/火." In addition to this, participants gave other answers: "fold/cake/haircard," "己," "龟," "snail," and "walk."

*S1: "It feels like it's catching water, like it's a container. Because there's a sense of putting it away. A feeling of catching water."*

*S5: "The "dot" in the top right corner looks like a flame, and the curly part looks like a wick. I think it's a lamp or a candle, something related to fire."*

*S3: "The curly shape seems to suggest folding, and it also looks like a cake or a hairpin."*

*S7: "I think it's 龟？It kind of reminds me of a turtle."*

All participants (S1-S12) firmly believed that  means "door." At the same time, they could also see that the corresponding SC was "门."

*S1:"It is like an ancient door. It should be the character for "门." "*

*S7: "I am guessing it's "门" ? Because it looks like a door, the ones that swing open left and right used in the old times."*

*S10: "It is a "door."*

Similarly, all participants (S1-S12) thought that  means "bird" and the corresponding SC is also "鸟." However, only one respondent (S1) thought that it could mean "鸡" in addition to "鸟."

*S1: "It looks like a chicken or a bird. I think it is a chicken because it has a slightly longer tail. So it's the Chinese character for "鸡"."*

*S4: "It is a "bird"."*

*S9: "Bird, because it has a beak, feathered tail and talons."*

The original meaning of  is "a character shaped like a cricket or locust, " borrowed as "秋" in the OBS." Among the participants, only one (S7) recognized it correctly. However, she did not guess what the corresponding SC was. Most participants (n=6) thought it was a bug, but they were unsure what kind of bug it was or what it meant. Two participants (S4, S5) thought it looked like the character "梦," while another participant (S3) thought it looked like the character "萝," as well as the character "锤." Another participant (S12) thought it was a cup. In addition, two participants (S1, S2) thought the graph was too complex to understand.

*S7: "Grasshopper? It looks like it has 2 antennas and two big eyes."*

*S5: "This shape reminds me of the character for "梦" because they look very similar."*

*S3: "This oracle bone script character looks much like "萝" but seems more complex. It also resembles the shape of a hammer."*

*S1: "This one feel so messy that you cannot tell at once. It's impossible to tell what it is from the shape."*

 means "shaped like a foot or footprint. It expresses the meaning of "stop" through its shape, and the SC for it is "止." In the survey, most participants (n=6) thought the expression was "草." Some others (n=3) interpreted it as wood or branches. There were also "birds" (S8), "hands/fingers" (S7), and "rakes/pins" (S2). One person (S3) said he could not understand.

*S2: "It feels like a metal rake used for plowing in the countryside, but it also looks like a hand gesture for giving an injection. It might be related to plowing tools, but it also resembles the character for "草"."*
*S11: "wood or branches "木"."*

 originally means "the shape of a person kneeling on a mat, indicating a form of rest. The SC for this is "坐". Most (n=7) thought it expressed the meaning of fire or candle. Two participants (S2, S9) thought this figure was related to a person; they recognized the upper part as being in the shape of a person but did not guess the meaning. There were also potted plants (S3) and electricity (S6). One other person (S4) could not understand the meaning of the graphic.

*S1: "This is "火". The top part looks like smoke."*
*S7: "Candle? It looks like a candle burning. "*
*S2: "It feels like a person holding onto something while crossing a river. The bottom part looks like a zip line used for crossing rivers, but this probably didn't exist in ancient times……"*

The above analysis shows a clear gap between the participants' recognition and knowledge of the OBS. For  and  , participants can easily guess the answer. However, for the others, we got vibrant responses. This feedback shows us that, on the one hand, the OBS can trigger a rich imagination, while on the other hand, it indeed triggers a cognitive burden for behaviours that cannot be linked to exact meaning.

Next, we explore the specific factors that contribute to this situation.

### 3.3 Influencing Factors

For descriptive statistical analyses, the researcher counted the frequency of each type of feedback in each question to reveal the most common views and trends. An explanation of each theme was also provided.

**Table 8: Extraction of cognitive factors affecting oracle bone script.**

| Questions | Topic | Number of frequencies |
|---|---|---|
| Question 3: Factors that make the OBS difficult to understand | The language of pictograms is not obvious. | 8 |
| | Line complexity. | 3 |
| | Connection with SC. | 3 |
| | Cultural background and historical knowledge. | 2 |
| Question 4: Relationship between OBS comprehension difficulty and line complexity | Irrelevant | 7 |
| | Relevance | 2 |
| Question 5: Impact of the simultaneous appearance of OBS and SC | Help understand | 3 |
| | Increased confusion | 3 |

Next, the researcher critically analyses the specific manifestations of the theme and the relationship with cognitive load theory.

**Question 3: "What factors do you think made these oracle bone script difficult to understand?"**

1. "The language of pictograms is not obvious." Participants who held this view wanted the OBS to convey meaning directly through its graphics. However, many of the OBS are complex in design or too abstract, making it difficult to perceive the meaning at first sight.

*S1: Mentions that "the pictorial language is not very obvious, so that people do not perceive the intended meaning in the first place."*
*S4: Mentioned "Problems with the drawing of graphics make some difficult to recognise."*
*S7: Mentions "the drawings sometimes don't look like the object they are being drawn as."*

According to the cognitive load theory, unclear information representations increase the intrinsic cognitive load, making processing and comprehension difficult. OBS's lack of direct and clear visual cues increases the cognitive load by making it necessary for learners to devote more cognitive resources to inferring the meaning of the graphic.

2. "Line complexity". In general, participants felt that the complexity of the lines of the OBS would make it difficult to determine the focus or understand the graphics, causing problems with identification and interpretation. Some participants said that some OBS have many lines, but the graphic representations are very concrete and conducive to being understood.

*S1 noted that ""秋" has an unusually large number of lines, and it is difficult to know where to look for its focus."*
*S5 Mentions ""秋" autumn, can't guess it's an autumn, it's too complicated."*

Complex and redundant information increases cognitive load. Too much irrelevant information distracts learners from practical schema construction. As a result, complex lines can make it difficult for learners to grasp critical information, thus increasing cognitive load.

3. "Connection with SC". Participants felt that the connection between OBS and SC was weak. Because of the morphological differences with SC, it is difficult to associate the OBS with the corresponding SC, which makes understanding more difficult.

*S2 states, ""秋" is guessed "萝" because it is too similar and the connection to the modern Chinese character is closer."*
*S6: "Ancient people had more abstract ideas, and I think differently from them."*

Cognitive load theory emphasises the importance of the connection between existing and new knowledge for learning. The weaker connection between OBS and SC leads to learners' difficulties using their pre-existing cognitive frameworks to make sense of them, thus increasing the intrinsic cognitive load.

4. "Cultural background and historical knowledge." Understanding OBS requires a certain amount of cultural context and historical knowledge. Many of the concepts and symbols expressed in the OBS are closely related to the cultural and historical context of the time, and those who lack this knowledge will have difficulty understanding them.

*S5: Mentions that "some cultural reserve and cultural differences are needed."*
*S12: Mentions "the lack of dissemination of historical information of the time."*

The lack of cultural background and historical knowledge increases the learners' intrinsic cognitive load. Learners must expend additional cognitive resources to acquire and process this background information, which affects the understanding of the OBS.

**Question 4: Do you think the difficulty of understanding OBS is related to the complexity of the lines?**

1. "Irrelevant". The difficulty of comprehension of graphs is not directly related to the complexity of the lines. Participants believe that the difficulty of comprehending graphs does not depend on the lines but is related to the specificity of the graphs and the accuracy of their presentation.

*S1 states that "there is no necessary relationship to the complexity of the lines."*
*S7: mentions, "Not really. The bird had many lines, but it wasn't hard to see it was a bird."*
*S11: mentioned, "I think it is not highly related because it is more on how accurately the image is drawn."*

This further supports the Cognitive Load Theory that the effective presentation and organisation of information is more important than the complexity of the information. Specific and accurate graphics help to reduce the intrinsic cognitive load and make it easier for learners to understand.

2. "Relevance". On the one hand, the more complex the line, the easier it is to understand. Complex lines will contain more information and allow the graphic to be presented more concretely. On the other hand, lines that are too vague could be more specific, making understanding more difficult. If the information conveyed by a graphic's lines needs clarification, it can make comprehension easier.

*S3 mentions that "there is a relationship, but inversely proportional."*
*S9 states, "Yeah, because if the line is too vague, it may be hard to understand."*

This is consistent with the notion of intrinsic cognitive load, whereby the complexity of the task itself increases the amount of information and thus reduces the vagueness of understanding. Whether complexity contributes to understanding depends on whether the lines provide valuable information.

**Question 5: Do you find it more helpful to understand the OBS and SC when they appear together? Or did it confuse you more?**

1. "help understand". When both OBS and SC appear together, the SC can provide a valid reference to better understand the OBS through the form and meaning of the SC, reducing the intrinsic cognitive load.

*S4: mentions "better understanding, all related except "秋"."*

*S8: "Yes, because I can see the resemblance between the drawing and Chinese characters."*

This feedback suggests that the SC, as pre-existing knowledge, can provide learners with a familiar reference point to enable them to understand the OBS more easily. By linking new information (OBS) with pre-existing knowledge (SC), learners can utilise pre-existing schematic structures to process the new information, reducing difficulties in the comprehension process and lowering the intrinsic cognitive load.

2. "Increased confusion". The appearance of SC can conflict with the morphology of the OBS, making understanding more difficult.

*S7: mentions, "Some of them make perfect sense, but others just make me feel more confused."*

*S10: mentions, "A few are more confusing, like "止", which is more like "草"."*

From the cognitive load theory perspective, complex information presentation adds extra cognitive load. Learners need to compare and correlate between two different textual systems, which can lead to fragmentation and overloading of cognitive resources, thus increasing the difficulty of comprehension and the sense of confusion. In summary, the main obstacles to understanding the oracle bone inscriptions are "The language of pictograms is not obvious," "Line complexity," "Connection with SC," and "cultural background and historical knowledge." The difficulty of graphic comprehension is related to whether the lines carry valuable information. Although there is a morphological conflict between OBS and SC, the presence of SC can provide valid references to aid comprehension. In conjunction with cognitive load theory, these findings emphasise the importance of information presentation and organisation, where explicit information representation and effective knowledge connections can significantly reduce the intrinsic cognitive load, thereby facilitating comprehension (Cook, 2006).

**3.4 Design Preferences:** For question 6, one aspect, we output a statistical table of OBS design preferences.

**Table 9: Frequency of selection of different design styles.**

| Simplified character | Design Style Name | Style Examples | Number of frequencies | No choice |
|---|---|---|---|---|
| 回 | Original OBS |  | 7 | 0 |
| | Victor OBS |  | 0 | |
| | Icon OBS |  | 5 | |
| 门 | Original OBS |  | 0 | 1 |
| | Victor OBS |  | 6 | |
| | Icon OBS |  | 5 | |
| 鸟 | Original OBS |  | 2 | 0 |
| | Victor OBS |  | 3 | |
| | Icon OBS |  | 7 | |
| 秋 | Original OBS |  | 3 | 3 |
| | Victor OBS |  | 1 | |
| | Icon OBS |  | 6 | |
| 止 | Original OBS |  | 0 | 4 |
| | Victor OBS |  | 5 | |
| | Icon OBS |  | 3 | |
| 坐 | Original OBS |  | 3 | 0 |
| | Victor OBS |  | 0 | |
| | Icon OBS |  | 9 | |

**Table 10: Totally of selection of different design styles.**

| Design Style Name | Original OBS | Victor OBS | Icon OBS | No choice |
|---|---|---|---|---|
| Numerical value (N) | 15 | 15 | 35 | 8 |
| Proportions | 21% | 21% | 48% | 10% |

According to the statistics, Icon OBS was selected the most times, 35 times, or 48%,  which was selected the most times (7 times). Original OBS and Victor OBS had the same share of 21%. Of these,  were chosen the most (6 times),  followed by (5 times). Notably, there were still 10% of participants who did not give a choice, with "止" (4 times) and "秋" (3 times) being the most frequent.

On the other hand, by explicitly analyzing the characteristics of the three different styles, the reasons for people's preferences are summarised, as well as the strengths and weaknesses of the designs.

The first is a summary of keywords and frequency of occurrence.

**Table 11: Summary of keywords and frequency of occurrence for preferred reasons.**

| Oracle Bone Script Design Style | Keywords (frequency >3) | Keywords (frequency ≤ 3) |
|---|---|---|
| Original OBS | Simple（6）,Clear（6） | Modern（3） |
| Victor OBS | Strong（5）, Audiovisual（4） | Equilibrium（3） |
| Icon OBS | Clear(11), Modern(6), Pictogram（5） | |
| No choice | Dislike（4） | Don't understand(3) Not similar（2） |

Next, we provide definitions and explanations for the extracted keywords and detailed analyses from four perspectives: Original OBS, Victor OBS, Icon OBS, and no choice.

**Table 12: Keyword definition.**

| Oracle bone script | Keywords | Interpretations |
|---|---|---|
| Original OBS | Simple | The design style is simple and intuitive, with no complex elements or superfluous embellishments. |
| | Clear | The design is well readable, and the graphic structure is clear and easily recognisable. |
| | Modern | The design style is contemporary and close to the form of modern Chinese characters. |
| Victor OBS | Audiovisual | The design visually communicates the meaning of the hieroglyphs accurately and intuitively. |
| | Equilibrium | Maintaining the original hieroglyphic character but with a modern touch. |
| | Strong | It has a beautiful and strong visual effect. |
| Icon OBS | Clear | The design is well readable, and the graphic structure is clear and easily recognisable. |
| | Modern | The design style is contemporary and close to the form of modern Chinese characters. |

| | | |
|---|---|---|
| | Pictogram | A pictorial design is more conducive to recognising the meaning of a graphic. |
| No choice | Dislike | The design was not what was expected, and I was not happy with all the design styles. |
| | Don't understand | No understanding of the meaning or expression of the design. |
| | Not similar | Not similar enough to modern Chinese characters or primitive oracle bones to establish an association. |

Participants preferred the Original OBS because of its simplicity, clarity, and modern design. This result suggests that even though the Original OBS is the original OBS form, its clean lines and structure still have some of the appeal of modern design. Participants mentioned the simplicity and clarity of this option, suggesting that they valued legibility and directness because simple designs are easier to understand and accept in everyday use.

*S5: "Option 1, cleaner and clearer, the lines have a tendency to swing back."*
*S11: "Pick 1, because it looks more like the modern version."*
*S9: "Pick 1, the lines are more aesthetically pleasing and closer to the current word."*

Victor OBS's design attempts to incorporate modern elements while retaining tradition, a compromise that has been well received. The graphic expression is strong and aesthetically pleasing when presenting the message visually. However, some participants felt that although it was more robust in terms of visual expression, it compromised on conveying the purity of the original culture.

*S1: "Choice 2, the graphic expression has a stronger sense of "/`丁"."*
*S11: "Option 2, the overall lines are linked to the simplified Chinese characters and also to the swirling state."*

The modernised design style of Icon OBS appeals to the contemporary audience's need for intuition and clarity that is easier to understand and recognise. Whilst this style can simplify the learning process, this simplified design may deprive some cultural and historical elements of their intended depth and complexity. Although highly actionable in practice, the Icon OBS may dilute the oracle's historical value and cultural context.

*S12: "Pick 3, it is the most obvious and closest to modern because it has an eye."*
*S7: "Pick 3 because it looks more like the modern version."*

Those who did not make a choice mainly disliked or needed help understanding the designs, finding them inconsistent with their expectations or challenging to associate with. This subset of participants expressed dissatisfaction with all three designs, suggesting they may have a higher demand for modern adaptations of the OBS or a stronger preference for the traditional form.

*S3: "Don't like any of them, can't associate either one with "秋"."*
*S8: "Don't like any of them, they all tend to mislead me into thinking it's a different word."*

Overall When modernising and adapting OBS designs, we need to consider the diverse needs of different audiences, retaining the depth and complexity of the culture while meeting the requirements of modern society for simple and intuitive designs. This will help to balance passing on and disseminating traditional culture.

### 3.5 The design suggestions of oracle bone script form Participants

Based on the participants' feedback, we can summarise several essential design elements for improving the effectiveness of OBS learning.
The first is a keyword distillation of each respondent's ideas.

**Table 13: Keyword distillation of participants' views on design**.

| Participants | Keyword refinement |
|---|---|
| 1 | Understanding Chinese characters, optimizing design, and aiding comprehension |
| 2 | Existing text, memory, use design |
| 3 | Color, motion, art lettering |
| 4 | Simple, abstract |
| 5 | Streamlined, modern living, visualization |
| 6 | Refined and streamlined |
| 7 | Hieroglyphics, Plain Pictures, Storytelling |
| 8 | Clear, informative, detailed |
| 9 | Connection, beauty, color |
| 10 | Color, Image, Understanding |
| 11 | Accurate strokes, lines |
| 12 | The logic of modern thinking |

By further summarising the keywords, we identified the following keywords as the focus of our discussion.

**Table 14: Further summary of keywords.**

| Keywords | Distributions |
|---|---|
| Simplified Design | Simple, Refined, Intuitive |
| Fusion of Ancient and Modern | Modern, Existing Characters, Modern Logical Thinking |
| Visual Effects Design | Color, Dynamic, Aesthetic |
| Image Association | Pictograms, Image, Connection, Aid Understanding |
| Precise and Detailed | Accurate Strokes, Clear, Information, Detail |

The following is a comprehensive discussion.

**"1. Simplified Design**

Simplified Design was a commonly recognised strategy, with keywords including "Simple" (S4, S6), "Intuitive" (S5) and "Refined" (S6). This view emphasised that designs should avoid over-complexity to make it easier for learners to understand and remember. For example, Interviewee 4 stated, "It should be simpler, not too complicated, it can be abstract, like cursive, because actually SC comes from cursive." This suggests that the pictographic features of OBS should be retained in the design while being appropriately simplified. According to schema theory, simplifying the design helps reduce learners' cognitive load so that they can more easily integrate new information into existing cognitive structures (Van & Sweller, 2005). A simple design helps to form new schemas quickly, thus improving learning. However, oversimplification may limit learners' understanding and memory of more complex structures (Ausubel, 2012). Therefore, designers should balance simplicity and complexity to ensure that learners can construct and apply new cognitive schemas effectively.

**2. Fusion of Ancient and Modern**

The keywords "Modern" (S1, S3, S12), "Existing Characters" (S2), and "Modern Logical Thinking" (S12) reflect the participants' need for modernity. The design's modern feel helps learners relate the oracle bones to existing SC, thus enhancing learning. S2 noted, "It is good that the design is closer to the existing characters, which is more conducive to memorisation." From the perspective of cognitive load theory, a design with a modern feel may reduce the external cognitive load, making it easier for learners to understand and remember new information within the framework of existing knowledge (Wouters et al., 2008). However, a design that is too modern may increase the intrinsic cognitive load as learners need additional cognitive resources to process elements that are not historically accurate. Therefore, the design should preserve the historical aspects of the OBS while introducing modern elements as appropriate to enhance ease of use and effectiveness of learning.

### 3. Visual Effects Design

Visuals are an essential factor in enhancing learning, with keywords including "Colour" (S3, S9, S10), "Dynamic" (S3) and "Aesthetic" (S5, S9). Colour and dynamic elements can increase the attractiveness and interest of the design, thus stimulating learners' interest. S10 noted, "With colour, it's a bit more graphic while retaining the original look as much as possible." However, adding too many visual elements may distract learners from focusing on the text. Schema theory states that visuals can promote memory and comprehension by enhancing sensory input. However, too many visual elements may increase the external cognitive load and make it difficult for learners to focus on the core content (Albus et al., 2021). Therefore, visuals should be used primarily to aid learning, with moderate use of colour and dynamic elements to maintain the simplicity and functionality of the design.

### 4. Image Association

Image association is the key to improving learning outcomes. By retaining the visual features of hieroglyphics, learners can understand the meaning of the text through image association. As S7 put it, "hieroglyphics, or text that uses pure pictures. Because it's easier to tell stories through pictures, like comics." According to schema theory, image association design can help learners construct new schemas quickly, thus improving learning (Hurtienne, 2011). However, cognitive load theory suggests that overly complex image designs may increase cognitive load. Therefore, the design should ensure the simplicity of strokes and structures while preserving pictorial features so learners can understand and memorise the text with a low cognitive load.

In addition, image associations should connect existing things and words to better aid comprehension (Barnard et al., 2003). S9 emphasised that "the most important point is to act as an intermediate link between existing things and words." This suggests that image association design should consider the characteristics of SC and OBS to promote understanding and memory. However, connections that are too tight may increase learners' cognitive load, making it difficult to distinguish and master different text structures. Therefore, the design should balance connectivity and independence to ensure learners can effectively integrate and apply new knowledge.

### 5. Precise and Detailed

In OBS design, precision and detail are central to improving learning outcomes. Designs should have clear and precise lines to avoid ambiguity. S11 noted that "more precise strokes

and lines are more helpful than drawings that are always changing." From the cognitive load theory perspective, precision reduces intrinsic cognitive load and makes it easier for learners to grasp the correct form of words (Plass et al., 2010). However, more relaxed designs may increase extrinsic cognitive load as learners need more time and energy to process complex details. Therefore, the design should focus on simplicity and flexibility while maintaining accuracy to increase the effectiveness and efficiency of learning.

In addition, the design should be rich in information and details to provide more learning content and enhance learning outcomes. S8 stated, "There should be clear drawing with more information and detail." Rich detail reduces the intrinsic cognitive load, and the right amount of information can help learners focus and learn effectively (Van & Ayres, 2005). Therefore, the design should provide the necessary information while maintaining simplicity and legibility to reduce the cognitive load on learners and improve learning outcomes.

In summary, OBS design should balance simplification and complexity, modernity and tradition, visual effect, and practical understanding. Combining schema theory and cognitive load theory makes it possible to design an OBS that is easier to understand and remember, thus improving the learning effect. During the actual design process, adjustments and optimisations must be made to ensure that the design is both culturally valuable and easy to learn and disseminate. These design strategies are not only applicable to OBS. However, they can also be extended to the learning and dissemination of other ancient scripts and hieroglyphics to achieve broader education and cultural transmission goals.

## 4. DISCUSSION

### Visual Cognition

There is significant variation in the recognition and cognition of OBS. Only a few OBS were accurately recognised for their meaning, while many more were challenging to perceive. These difficulties lead to a high overall OBS recognition error rate (56.9%). Multiple factors make OBS significantly different from modern language systems, thus increasing the cognitive burden. Despite the richness of the imagery that OBS can provoke, the factors that influence behaviours that cannot be connected to precise meanings deserve to be explored in depth.

**Influencing factors:** The factors affecting the recognition of OBS are diverse. Descriptive statistical analyses showed that factors such as "The language of pictograms is not obvious",

"Line complexity", "Connection with SC", and "cultural background and historical knowledge" all affect the participants' perception of OBS. The mismatch between the complexity of the information carried by the OBS themselves and the internal schema of the participants resulted in a higher cognitive load during the recognition process. This finding validates the conclusions of previous studies.

Some participants believed that the complexity of the lines was separate from the difficulty of graphical comprehension and that the overall design and form of the OBS were the key to recognition. Other participants believed that the two were "related" and that the difficulty of graphic comprehension was related to whether the lines carried valuable information. According to the cognitive load theory, the complexity of the lines needs to be interpreted in a way that helps the learner to connect the schemas better. Otherwise, complexity can increase cognitive load and reduce learning (Van & Sweller, 2005). Therefore, designers should balance information complexity and cognitive load when designing instructional materials.

Although SC can be used as a practical reference for understanding OBS, presenting too much information at the same time may increase learners' cognitive load, leading to fragmentation and overloading of cognitive resources. The way and amount of information presented must be carefully considered to avoid unnecessary cognitive load (Sweller, 2011). For example, SC and OBS can be introduced gradually in stages, or external cognitive load can be reduced through visual and content simplification. The comprehension effect depends on the morphological connection between OBS and SC. When morphology creates conflict or too much information, it is not conducive to comprehension. Educators should pay attention to this and help learners construct new cognitive frameworks based on their existing knowledge by designing learning materials that are coherent and relevant. However, the effectiveness of this approach depends on learners' mastery of prior knowledge. If learners do not have a firm grasp of simplified characters, the effectiveness of this approach may be undermined.

**Design preferences**

On the one hand, the Icon OBS is favoured by the majority (48%) as it is easier to understand and recognise due to its prominent, modern, and figurative design. This design may be very effective in the educational field, but it may dilute the historical value of OBS. Original OBS (21%) and Victor OBS (21%) appealed to those who preferred the original OBS style of

expression. Participants who did not select designs (10%) found them inconsistent with their expectations or challenging to associate with. Designers need to consider the diverse needs of different audiences when modernising and adapting OBS, retaining the depth and complexity of the culture while meeting the demands of modern society for simple and intuitive designs to find a balance in passing on and disseminating traditional culture.

On the other hand, participants' expectations of OBS designs include the following: the design should be simple, straightforward, and modern; it should have more colours and dynamic elements while retaining hieroglyphic features; the design should have accurate strokes and lines connecting SC and OBS; and the design should contain more information and details and be intuitively easy to understand. These strategies need to be considered critically in practical application. OBS design should balance simplicity, complexity, modernity, tradition, visual effect, and practical understanding.

In conclusion, by combining schema theory and cognitive load theory, the graphic design of OBS should focus on improving the comprehension and memorisation of OBS and reducing learners' cognitive load. The actual design process needs to be continuously adjusted and optimised to ensure that the design has cultural value and is easy to learn and disseminate. These design strategies are not only applicable to OBS. However, they can also be extended to learning and disseminating other ancient scripts and hieroglyphics to realise a broader range of educational and cultural transmission goals.

## 5. Recommendation and future research

Given the significant cognitive challenges associated with recognizing and understanding Oracle Bone Script (OBS) among the Chinese students in Malaysia, it is imperative to critically address both the design and instructional methodologies employed. The study's findings underscore several areas for improvement and future research to enhance OBS education from a cognitive load perspective.

### On the one hand, for design recommendations

Balancing Complexity and Simplicity: one of the primary issues identified is the mismatch between the complexity of OBS and students' cognitive schemas. Future designs should aim to reduce unnecessary cognitive load by simplifying line complexity and making pictograms more intuitive. This can be achieved by incrementally introducing elements of OBS, gradually increasing complexity only as learners become more familiar with basic structures.

Additionally, integrating modern, figurative designs that resonate with contemporary visual literacy while retaining key traditional elements can facilitate better recognition and comprehension.

Cultural and Historical Integration: understanding the cultural and historical context of OBS is crucial for meaningful learning. Therefore, design efforts should include contextual information that connects OBS with students' heritage. This can help bridge the gap between abstract symbols and their meanings, making learning more relevant and engaging.

Visual and Content Simplification: incorporating principles from cognitive load theory, designers should prioritize visual clarity and content simplification. Using color coding, dynamic elements, and clear hieroglyphic features can enhance visual appeal and aid memory retention. However, care must be taken to avoid overwhelming learners with too much information simultaneously, which can lead to cognitive overload.

**On the other hand, for the instructional methodologies**

Gradual Introduction and Scaffolding: educators should adopt a scaffolded approach to teaching OBS, introducing new characters and concepts in a phased manner. This allows students to build on their existing knowledge without being overwhelmed. Providing ample opportunities for practice and reinforcement can help solidify understanding and facilitate schema construction.

Interactive and Engaging Learning Materials: developing interactive learning materials that actively engage students can significantly enhance the learning experience. For instance, incorporating digital tools and platforms that allow for interactive exploration of OBS can make learning more dynamic and engaging. Gamification elements, such as quizzes and challenges, can also motivate students and provide immediate feedback.

Contextual Learning: embedding OBS learning within broader cultural and historical narratives can enhance students' appreciation and understanding of the script. This contextual approach not only makes learning more meaningful but also helps students see the relevance of OBS in their cultural heritage.

**Lastly, for the future research directions**

Longitudinal Studies on Cognitive Load: future research should conduct longitudinal studies to examine the long-term effects of different design and instructional strategies on cognitive

load and OBS comprehension. Such studies can provide insights into how cognitive frameworks develop over time and identify the most effective methods for reducing cognitive load.

Innovative Design Techniques: exploring innovative design techniques, such as augmented reality (AR) and virtual reality (VR), could offer new ways to engage students and reduce cognitive load. These technologies can provide immersive learning experiences that make abstract concepts more tangible and easier to understand.

Cross-Cultural Comparisons: conducting comparative studies with students from different cultural backgrounds can provide a broader perspective on the effectiveness of OBS design and instructional strategies. Such comparisons can reveal universal principles of cognitive load management and highlight culturally specific factors that influence learning.

In conclusion, enhancing the recognition and understanding of OBS among the Chinese students in Malaysia requires a multifaceted approach that combines thoughtful design, effective instructional methodologies, and ongoing research. By addressing these areas, educators and designers can create more accessible and meaningful learning experiences that preserve and promote the rich cultural heritage of Oracle Bone Script.

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