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The Cognition of Time Shaped by Linguistic Elements: Alphabetic Language and Ideographic Language

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Abstract: This study investigated the impact of language script on spatial cognition by comparing reaction times of native speakers of alphabetic languages and Chinese in response to horizontally and vertically arranged button groups. It is postulated that the linear, one-dimensional nature of alphabetic scripts may shape cognitive processing differently than the complex, two-dimensional Chinese characters. In the experiment, participants from both linguistic backgrounds were tasked with quickly responding to buttons arranged in both horizontal and vertical configurations. Results indicated that speakers of alphabetic languages exhibited significantly shorter reaction times for the horizontally oriented buttons compared to the Chinese speakers. Conversely, Chinese speakers demonstrated faster reaction times for vertically arranged buttons relative to the alphabetic language speakers. These results suggest that language script structure can influence spatial cognition. The linear, sequential arrangement inherent to alphabetic languages may predispose speakers to be more efficient in processing horizontally sequenced stimuli, while the two-dimensional structure of Chinese characters may confer an advantage in processing vertically presented information. Additionally, cultural factors, such as the traditional vertical writing and reading direction of Chinese script, may contribute to these differences. The findings provide preliminary support for the notion that language script can shape cognitive strategies for processing spatial information, with speakers of alphabetic languages and Chinese employing different strategies for horizontal and vertical spatial processing. Further research is needed to explore the underlying mechanisms, as well as the impact of early exposure to a specific script on spatial cognition.

Keywords: metaphors, time representations, orthography, cognitive linguistics

1. Introduction

Time, an intangible concept, is often expressed through spatial representations across different languages. However, linguistic factors, including semantics, can influence the use of spatial metaphors in diverse languages. For instance, Chinese speakers are inclined to use vertical metaphors to represent time, while Americans typically employ transverse metaphors. Previous research suggests two possible mechanisms for these differences. Firstly, Chinese often incorporates vertical spatial metaphors in language (e.g., 上周 “last week”, 下周 “next week”; 上个月 “last month”, 下个

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月 "next month"), whereas English commonly represents time transversely. Secondly, the writing system itself may impact temporal expression strategies. Chinese characters are more complex morphologically compared to the Latin alphabet, being essentially one dimension higher. The present paper aims to further explore these theories, focusing on orthographical perspectives. It is important to note that due to the unique nature of orthography across languages, few studies have compared the effects of alphabetic and ideographic writing systems on time cognition. Instead, the author seeks to acknowledge the potential influences of different writing systems, rather than excluding them.

Understanding the role of language in shaping time cognition has practical and academic significance. The difference between ideogram and alphabet affects our language competency, including how we read, reasoning, input and perceive the texts and sounds. Furthermore, by delving into the history and origins of Chinese characters and Latin alphabet, we can gain insights into the evolution of language and its impact on cognition like our temporal metaphors expression. Chinese, with its rich history and ideographic script, is used by more than a billion people, while the Latin alphabet is employed by multiple languages, making it a dominant writing system worldwide. The exploration of how these scripts influence time cognition offers a glimpse into the intertwined relationship between language, culture, and thought. So, this paper is aimed to enlarge the research field by exploring the universality of the ideographic languages and alphabetic languages, rather than just focus on two specific languages.

2. Literature Review

2.1. Time Represented by Metaphors

The cognition of time, an inherently abstract concept, is intriguingly intertwined with the linguistic mechanisms employed by different cultures. Our understanding of time is often facilitated by metaphorical expressions rooted in spatial experiences. Different languages construct varying metaphors for time by virtue of their distinct linguistic and orthographic structures. Time, being abstract, is challenging for humans to directly comprehend. To navigate this challenge, many languages resort to spatial metaphors, grounding the abstract in the more concrete [1]. Expressions like "moving forward" or "looking back" in English are classic examples of this phenomenon. Not only English, but also other language has their own strategy to represent time. But according to further exploration, different languages perceive and represent time differently.

2.2. Chinese Vertical vs. American Transverse Metaphors

A growing body of research highlights significant variations in spatial representations of time across languages. An intriguing observation centers on the linguistic elements of Chinese and American English. For instance, Chinese speakers often employ vertical metaphors for time, such as "上周" (last week) and "下周" (next week), which translate to "up week" and "down week" respectively. In contrast, American English speakers typically use transverse metaphors, such as "the previous week" and "the following week", suggesting a horizontal timeline [2].

2.3. Proposed Mechanisms

Based on the results, the theory that language can shape thoughts from linguistic relativity can somehow be verified [3]. Fuhrman, O, in their groundbreaking work, proposed two potential mechanisms for these variations. Firstly, the presence of vertical spatial metaphors in Chinese contrasts with the transverse orientation in English, suggesting a deep-seated linguistic influence on time perception [4]. Secondly, the writing system itself might play a role. Chinese characters are morphologically complex, arguably one dimension higher than the Latin alphabet, which might

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influence cognitive strategies for temporal expression [5]. For example, the horizontal writing progression in English, from left to right, might embed a transverse temporal cognition, while the vertical nature of traditional Chinese writing may reinforce an up-down perception of time. There is also a linkage between the two mechanisms. The pattern of the writing system itself may influence the spatial metaphors to a large extend. For instance, the spatial representations time is most likely unidirectional with the writing direction. The speakers of left to right writing direction (Like English speakers) are more likely to use left to right metaphors to represent time, while the speakers of right to left writing direction (Like Hebrew speakers) prefer right to leave representations [6]. So, owing to the pattern of writing system, the semantic metaphors in one language may manifest a similar pattern with the writing system. There should be more exploration on the writing system, rather than ignore it.

2.4. Writing Systems and Time Perception

2.4.1. Alphabetic Languages (Such as English)

The writing systems of these languages are typically considered one-dimensional and linear. They use a finite set of letters (usually 26) to represent phonemes. The letters are combined in a linear order to form words, representing different sounds. This writing system focuses on the correspondence between phonemes and letters [7].

2.4.2. Ideographic Languages (Such as Chinese)

The writing systems of these languages are typically considered two-dimensional. Chinese characters are ideographic, with each character representing a concept or vocabulary item. The structure of Chinese characters is more complex than that of letters, usually composed of multiple parts (strokes, radicals, etc.). Due to this complexity, Chinese characters can store more information [8].

2.4.3. Significance

Furthering the discussion on orthographic influences, few studies have embarked on a comprehensive exploration of the differences between alphabetic and ideographic writing systems in shaping time cognition. Undoubtedly the writing system can't be hailed as a part of language in the narrow sense, after all the language ability that can be acquired in the critical period is mainly the sounds and grammar. Orthographic knowledge is the result of learning and reading experience, rather than being subject to the constraints of a critical period like phonological and grammatical acquisition [9]. Despite this, orthography can still significantly shape people's cognition. For instance, Tan, L. H., Laird, A. R., Li, K., & Fox, P. T. found evidence of the impact of orthography on brain activity patterns. Their research demonstrated that Chinese and English speakers use different brain regions when processing language, due to the distinct orthographic systems in these languages [10]. Such findings highlight the profound influence of orthography on cognitive processes. Further studies, such as those by Perfetti and Tan [11], indicate that the logographic nature of Chinese characters requires a more holistic approach to reading, whereas the alphabetic nature of English relies more on phonological processing. These divergent cognitive demands posed by different writing systems underscore the importance of considering orthography when examining language cognition. However, there's a growing consensus that writing systems, with their inherent spatial orientations, play a vital role in shaping cognitive processes, including time perception [12]. Moreover, the potential effect of orthography on time cognition remains under-researched. If our cognition of time is so deeply influenced by spatial metaphors, it is conceivable that the very system we use to inscribe our thoughts—the writing system—would leave an indelible mark on our temporal perception.

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2.5. Research Question

Based on the two mechanisms raised above, the author wants to be fixed on the second one, because there are lots of research about the semantic metaphors in different languages, but the effect of writing system is more likely to be ignored. And there is enough research about the difference between two very languages like Chinese, as to the general language categories like ideographic language and alphabetic languages, there is little discussion. The author wants to enlarge the research field by raise a new research question: Is there any difference and conceivable pattern in the spatial representation's usage for time between native speakers of ideographic language and native speakers of alphabetic language?

3. Experiment

In this experiment, the author transfers the Chinese and alphabetic language speakers' space-time association into their reaction time through a non-linguistics implicit association task. The methodology is based on the pattern designed by Fuhrman and Boroditsky (2010). This task has several benefits. Firstly, it is non-verbal in nature, as it uses photographs for stimuli and requires participants to respond with button presses, eliminating the need for language production or comprehension. Secondly, it measures reaction time, which is an implicit indicator of cognitive processing that participants are less likely to consciously alter to appease the researcher. Lastly, the task assesses temporal reasoning across a broad spectrum of temporal sequences and time spans. Based on this experiment, the empirical question can be: will the native speakers of alphabetic language react more quickly when they use transverse arranged buttons? And the Chinese native speakers react more quickly when they use vertical arranged buttons?

3.1. Participant

26 Chinese and 26 native speakers of alphabetic language participated the experiment in exchange of remuneration. The author didn't set strict limits for the demographic information (including gender, nationality, age, etc.) of the participants in that it can be considered as an irrelevant variable. Participants were trained on the experiment. Additionally, according to the data from questionnaire, all the participants are right-handed, and all of them have English as their second language. Some alphabetic language participants have Chinese as their L3, while all the remaining participants haven't accepted the education of L3. With a view to excluding the possible effect of their L2 and L3, all participants completed a second language proficiency test before the experiment. The test was designed to evaluate the participants' ability to judge the degree of liveliness and deadness of metaphors in their second languages with 20 questions. Participants were asked to translate the provided phrases into their native language, and after all the data were collected, the correctness would be calculated. The questions are attached in this Appendix A behind this paper. Here come the results:

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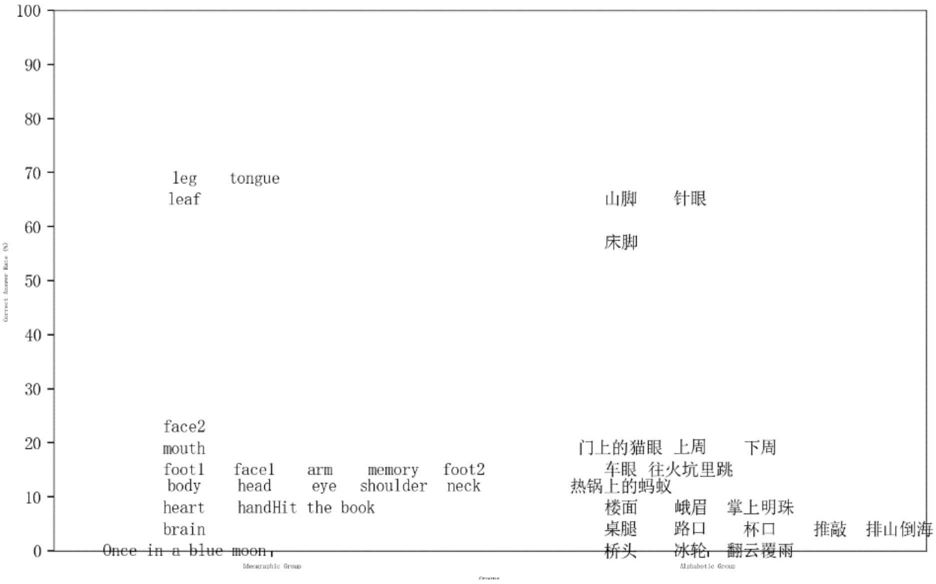

Figure 1: Language Ability Test.

The result manifested that all the Chinese participants still failed to recognize the majority metaphors in the test, which somehow means they haven't formed an English thinking pattern, and vice versa, all the alphabetic language native participants haven't formed a Chinese thinking pattern neither. So, all the participants were qualified with this experiment.

3.2. Material

The experiment was equipped with 16 groups of pictures. Each group has two pictures. And the two picture in the same group represent two different processes of one same event respectively with a logically temporal order. For instance, the first group has two pictures: one picture describes a complete banana, while another picture describes a peeled banana. All the 16 groups of pictures will be attached to this paper in the Appendix B.

3.3. Method

The test was held online. All of the participants learnt about the research methods by reading the experiment leaflets before the research start. Every participant was asked to join the test through Microsoft browser, for which the Microsoft browser can promise stability and measure accuracy in the maximum way. The participants were divided into two groups: Group 1 and Group 2. Each group had 26 Chinese and 26 Native speakers of alphabetic language. Two groups carried out the test simultaneously. The participants entered the program through their usernames. Before the test start, a crosshair would emerge for 10 seconds in the center of the screen to focus participants' attention. In the center of the screen, an image that presented one process of an event would be demonstrated (e.g., a bitten apple) for 5s. Then, the first image disappeared, the participants would be provided with another image that presented one process of the same event as Step5 (e.g., an apple core), and at the same time the participants would be asked: This process is ____ than the previous one. The participants needed to answer the question through buttons on the screen: For Group 1, there are two buttons arranged transversely: one white button in the left and one black button in the right, while for Group 2, there are two buttons arranged vertically: one white button up and one black down. The white button represented the answer: earlier, while the black one referred later, of which the participants had been informed in the guidance through leaflet before the test. The program would

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calculate the react time: i.e., from the second image's emerging to the moment that the participants pressed the button. The process of judgement repeated for 16 times. Then collected the data and addressed them for the results.

3.4. Result

In this experiment, the reaction times of participants were measured when they responded to horizontally and vertically arranged button groups. We observed two distinct patterns based on the participants' linguistic backgrounds.

In the horizontally oriented buttons, participants who were speakers of alphabetic languages demonstrated significantly faster reaction times compared to the Chinese-speaking participants. However, within the vertically aligned buttons, Chinese-speaking participants had a shorter reaction time compared to the participants from alphabetic language backgrounds.

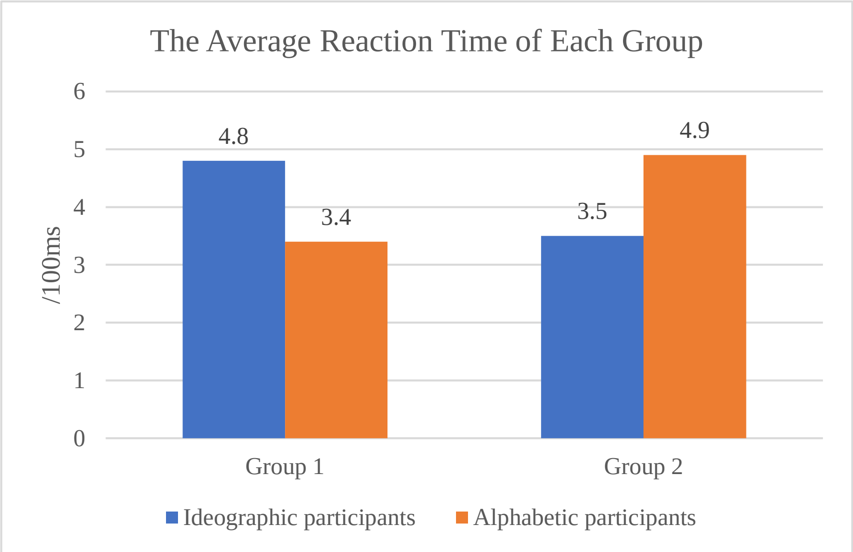

Figure 2: The Average Reaction Time of Each Group.

4. Discussion

Our results align with the literature that has posited the influence of script on various cognitive processes, ranging from basic perception to more complex tasks like reading. In particular, our findings seem to support the notion that script can shape the cognitive strategies and preferences that individuals employ when processing spatial information.

Moreover, it's essential to consider the role of cultural practices in influencing cognitive processes. For instance, traditional Chinese script is often written and read in a vertical direction. This practice might have conditioned Chinese participants to be more efficient at processing information presented in a vertical orientation.

Additionally, the inherent complexity of Chinese characters could have contributed to the Chinese-speaking participants' enhanced ability to process detailed or tightly-packed visual information, such as the vertically arranged buttons. Conversely, the linear sequencing of alphabetic scripts might have predisposed speakers of these languages to be more efficient at processing horizontally sequenced stimuli.

Furthermore, our results highlight the impact of early linguistic experience on cognitive processes. The data suggest that exposure to a particular script during the critical period of language acquisition could shape spatial cognition and processing preferences in adulthood.

However, it is essential to note some limitations of our study. The sample size was relatively small, and the task was limited to measuring reaction times in button pressing. Future studies could expand the sample size and employ a diverse range of tasks to explore the generalizability of these findings. The further exploration of the effect of orthography on cognition must be built based on the development of neuroscience and related technologies like MEG, so that the result can be more convincible.

5. Conclusions

The differences in reaction times between the two different button arrangement groups could be indicative of the potential cognitive impacts of language structure and script.

Different language will cause different effect on people's cognition of time. Obviously, the ideographic language speakers prefer using vertical direction to represent time, while the strategy of horizontal processing has ingrained in the minds of alphabetic language speakers. Except for the time representations, this experiment is also a good exemplary for the possible influence that caused by orthography. Alphabetic languages, such as English, typically use a linear, one-dimensional script. This linear structure may have influenced the cognitive strategies of the participants who speak these languages, making them more adept at processing information presented in a horizontal orientation. On the other hand, Chinese script, characterized by its complex and arguably two-dimensional structure, might make speakers more efficient at processing vertically presented information.

In conclusion, our findings provide preliminary evidence that language script may influence spatial cognition. The results suggest that speakers of alphabetic languages and Chinese may employ different cognitive strategies when processing horizontally and vertically arranged stimuli. However, further research is needed to examine the underlying mechanisms, the role of cultural practices, and the potential impact of early exposure to a specific script on spatial cognition.

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Appendix A

The language test used in screening participants.

Question: Translate the underlined word.	Key
Foot of the hill	底部
The body of the document	主要部分
The head of the company	领导
The face of the clock	表盘
The leg of the table	支柱
The heart of the problem	核心部分
The arm of the chair	扶手
Eye of the needle	孔
Hand of the clock	把
The mouth of the river	入口
Once in a blue moon	非常偶尔
Hit the book	熬夜复习
The tongue of a shoe	鞋舌
The shoulder of the road	路缘石
The brain of the computer	中央处理器
The memory of the computer	存储能力
The neck of the bottle	细长部分
The leaf of a book	页
The face of a building	外表面
The foot of the bed	底部

桌腿	The pillar of a table
楼面	The surface of a building
床脚	The back part of a bed
山脚	The bottom of a mountain
车眼	The light of a car
路口	Crossroad
桥头	The part of a bridge which is close to the bank
杯口	The rim of a cup
门上的猫眼	Peephole
针眼	Hole
推敲	Infer
上周	Last week
下周	Next week
热锅上的蚂蚁	A person in critical situation (be in hot water)
往火坑里跳	To risk oneself on purpose
冰轮	The moon
峨眉	A mountain
掌上明珠	Adorable thing
排山倒海	Of spectacular significance
翻云覆雨	Birds and bees

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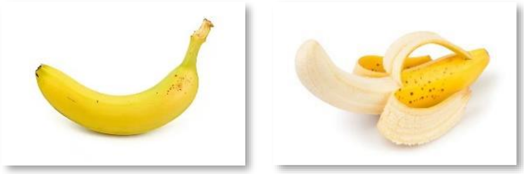
Appendix B

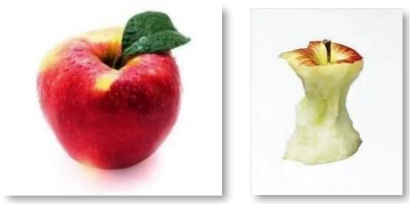
The pictures used in the experiment.



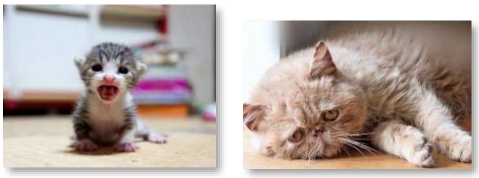
Group1

Group2

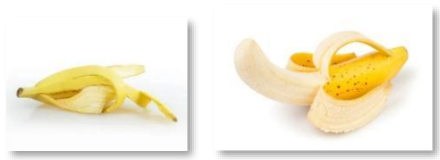
Group3



Group4



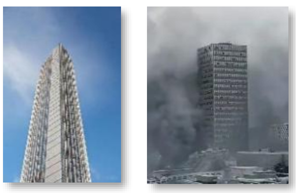
Group5



Group6

Group7

Group8

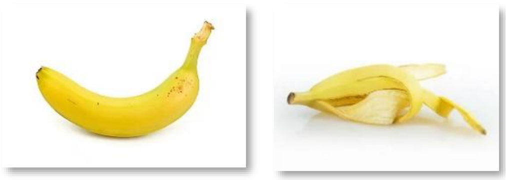


Group9

Group10

Group11

Group12



Group13

Group14

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Group15

Group16