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Effects of Homophone Priming on the Decision-Making in Perceptual Color Recognition of Mandarin Speakers

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Abstract: This study delves into the nuanced interactions between language, cognition, and perception by examining the impact of homophones on decision-making and perceptual color recognition among native Mandarin speakers. Drawing on theories of linguistic relativity and cognitive processing, this research hypothesized that homophonic primes would subtly influence both decision-making processes and color recognition tasks. Participants were assigned at random to surveys where they were unknowingly exposed to stimuli with and without homophonic primes before engaging in color recognition tasks involving subtle shade differentiations. Contrary to initial expectations, statistical analysis revealed no significant differences in decision-making accuracy between conditions, suggesting that homophones may not overtly affect conscious decision-making processes in our bilingual cohort. However, intriguing variations emerged in the perceptual color recognition task, where participants exposed to homophonic primes showed tendencies to perceive color shades more similarly compared to those in the control condition. This finding implies a potential cognitive load effect or subtle priming influence on perceptual categorization tied to linguistic structures. The implications of these findings challenge traditional views on language's role in shaping cognitive processes, highlighting the complexity of how linguistic structures such as homophones may operate at subconscious levels. The study contributes to ongoing debates in cognitive science and linguistics by underscoring the need for nuanced approaches to understanding cross-linguistic cognitive mechanisms. Future research should further explore the Whorfian hypothesis within bilingual contexts, considering additional variables such as language proficiency and cultural influences to elucidate the intricate relationship between language and cognition.

Keywords: Homophones, decision-making, color recognition, Mandarin speakers.

1. Introduction

Language, as a fundamental tool of human communication, not only conveys meaning but also shapes cognition and perception. Psycholinguistic theories, like the Whorfian hypothesis, suggest that a language's structure and vocabulary can impact how speakers perceive and interact with their environment. This hypothesis posits that linguistic categories and structures subtly guide thought processes, influencing everything from basic sensory perception to complex decision-making [1].

In the context of bilingualism and cognitive processing, this study explores the intriguing phenomenon of homophones—words are pronounced similarly but have different meanings—in

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Mandarin and English. Specifically, it investigates how these homophones may prime certain concepts and influence decision-making processes among native Mandarin-speaking people.

Davis and Herr proposed that homophones can subtly influence subconscious decisions, suggesting a direct link between linguistic structures and cognitive responses, and conducted experiments to investigate the influence of homophones on subconscious decision-making [2]. Participants were exposed to brief presentations of homophonic primes such as "bye" and "buy" before engaging in decision tasks involving financial choices. These primes were designed to activate subconscious associations related to either departure ("bye") or purchasing ("buy"). Participants were then asked to make financial decisions, such as choosing between spending or saving money.

The results demonstrated a subtle but significant effect: participants exposed to the homophonic prime "buy" were more inclined to make decisions favoring spending compared to those exposed to unrelated primes or no primes. This effect suggests that homophones can activate associated concepts subconsciously, influencing decision-making processes even when participants are unaware of the priming. Davis and Herr argued that linguistic structures, through their phonetic similarity and semantic associations, can shape automatic cognitive responses and behavioral tendencies. Their research contributes to understanding how language influences cognitive processes and decision-making, highlighting the subtle yet impactful role of homophones in shaping human behavior.

However, recent research may have challenged these findings, particularly in the context of Mandarin Chinese, a logographic language with a complex character-based system. Unlike alphabetical languages such as English, Mandarin's structure often requires multiple characters to convey a single concept, potentially altering how homophones are processed and perceived [3].

The present study builds upon this foundation by examining whether homophones embedded in Mandarin sentences influence color identification—a task that requires quick decision-making and visual perception. By comparing participants who were exposed to sentences containing homophones with those who were not, the study aims to elucidate how cognitive load and linguistic structures interact to shape decision-making processes.

Psycholinguistic theories emphasize that language not only reflects but also shapes cognitive processes [4]. Understanding how homophones impact decision-making in bilingual contexts contributes to broader insights into language processing and its implications for cognitive psychology. By integrating findings from prior research and theoretical frameworks, this study aims to enhance our understanding of how language shapes perception and decision-making across diverse linguistic systems.

2. Homophones

The comprehension of natural speech involves the analysis of a variety of linguistic information, including the lexical, phonetic, pragmatic, semantic, and syntactic aspects of a spoken sentence [5]. In this assembly, word recognition significantly influences the perception of spoken language because words provide separate pieces of information that contribute to the representation of the meaning and the conceptual interpretation of the sentence to be understood. The presence of homophones, however, complicates such cognitive procedures. For instance, the words “there” and “their” respectively indicate a reference to a specific place and a sense of belonging to a group of people yet are all pronounced very similarly in the English language. Homophones are the subject of extensive psycholinguistic debates, where they are argued to be words that share a one-word form but represent multiple meanings or should be regarded as two different words that share no dictionary connections [6]. In the context of this study, homophones are defined to be words that are pronounced similarly but retain different meanings [7]. For such potentially ambiguous words, the listener must use contextual information to determine the correct denotation. Please remember that all the papers must be in English and without orthographic errors.

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Dominance, the inference of the meaning of a word based on the frequency of its usage, is one factor discovered to be important in the interpretation of individual ambivalent sentences [8]. It is generally believed that a lexically ambiguous word can be understood based on the specific context provided. However, studies contend that both the subordinate meaning (activation by context) and the dominant meaning (activation by frequency) of a homophone compete to be determined as part of the intended message of the sentence. The more frequent, dominant meaning of a homophone in a neutral sentence is activated faster and persists longer than subordinate meanings, and thus sentence contexts that support subordinate meanings take more time to interpret [9-11].

2.1. Homophone Suppression

When encountering homophones, readers initially activate multiple meanings automatically but then intentionally suppress subordinate meanings in favor of the dominant interpretation—a process known as homophone suppression. Studies show that such cognitive processes determine and then exclude the meaning that does not suit the context [11-14]. To initiate homophone suppression, however, one must dedicate cognitive resources to actively exert control over the competition for selection between the dominant and subordinate homophone denotations. Therefore, this cognitive process relies on available mental resources, which can sometimes limit the efficiency of homophone suppression. As a result, contextually inappropriate meanings may persist in memory [2, 15].

Automatic processes, such as retrieving the dominant word meaning from memory while reading, inherently require fewer cognitive resources compared to controlled processes [2]. The strength of connections among phonological nodes, as proposed in Node Structure Theory, where "priming serves as a subthreshold excitation preparing a node for activation or retrieval," determines the speed and magnitude of priming that facilitates the activation of the phonology associated with the target word [16]. In this study's context, priming refers to the phenomenon where recent exposure to a stimulus enhances the processing of a similar stimulus later on [17]. Such cognitive resources are a significant factor contributing to the attainability of information in memory. Therefore, if someone experiencing weak connections among phonological nodes reads a homophone, the dominant and subordinate meanings should be simultaneously activated, but the incorrect meaning may not be effectively suppressed.

2.2. Homophone Priming

Research suggests that homophones in English may cause people to link one to another subconsciously. Davis and Herr found a statistically significant effect of homophones on subconscious decision-making, though the effect size was moderate [2]. Participants exposed to the homophonic prime "buy" were more likely to make decisions favoring spending compared to those exposed to unrelated primes or no primes. While the effect was notable, it was not overwhelmingly large, indicating that homophones influenced decision-making tendencies to a discernible extent but did not completely determine participants' choices. The study's findings suggest that homophones can subtly prime associated concepts and influence behavior, highlighting the nuanced ways in which linguistic structures can affect cognitive processes and decision-making outcomes. More specifically, homophone priming occurs when phonologically similar words coactivate regardless of being contextually irrelevant [18]. Once activated, such contextually unsuitable meanings may remain in memory, thereby subliminally biasing behavior and evaluations [15]. Findings that support homophone priming include cohort theory, which proposes that “a cohort of all the words beginning with a particular sound sequence will be activated during the initial stage of the word recognition process” [19]. However, it may be important to note that individual cognition and task difficulty fluctuate in homophone priming, the effect of which is still undetermined on bilinguals [18].

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Bilinguals could experience stronger priming because processing the second language depletes cognitive resources that homophone suppression relies upon or weaker priming because of less efficient lexical processing.

2.3. Hypothesis

I propose that when homophone suppression fails to deactivate contextually unsuitable dominant homophone meanings, homophone priming may occur. According to previous studies regarding the priming of homophones, a cognitive load reduces the capability of suppressing the alternate meaning of the homophone [2]. In other words, when homophone suppression fails, the unsuitable meaning remains in memory and influences subsequent behaviors, which include personality traits or goals, choices, and evaluations in the same way the intended meaning of the homophone would [15, 20]. This hypothesis was already verified when Davis and Herr demonstrated how homophone priming could cause reading “bye” to activate meanings associated with irrelevant meanings, such as “buy,” and thereby cause an increased likelihood of purchasing, the copy of Davis and Herr's (see figure 1) [2].

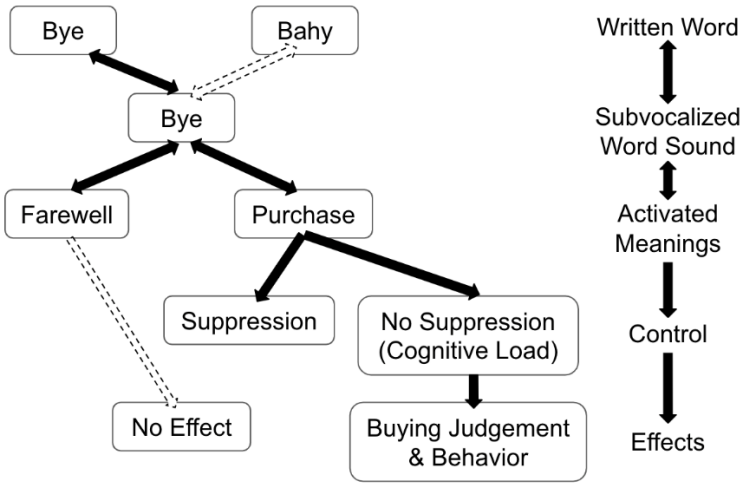

Figure 1: Process Diagram of How Reading "bye" May Influence Buying Behavior

Interestingly, the priming of homophones to behavior is still an ongoing debate. A study attempting to verify models of the lexicon predicting that recognition of words stimulates the activation of phonologically related words has resulted in failure. The results indicate that either the lexicon is not organized such that phonological similarity does not stimulate priming, or that the cognitive processing of phonologically similar words is not impactful in regard to visual lexical decisions [21]. Another study investigating the effects of phonological priming on tip-of-the-tongue (TOT) experiences corroborated Davis and Herr's findings. The study concluded that its results support the transmission deficit model, indicating that phonologically similar words strengthen connections among phonological representations, thereby contributing to TOT phenomena [16].

As a bilingual and one tormented by frequent instances of TOTs, whether this phenomenon should be much more common in Mandarin compared to English, and which has significantly fewer homophones will be explored in this research.

3. An Introduction to Chinese

Numerous papers have emerged recently suggesting the non-arbitrariness between the phonological expressions and meaning of English, offering evidence in favor of an adaptive cognitive heuristic that

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enables listeners to utilize non-arbitrary mappings between word form and meaning [22-24]. Such assumptions are also reasonable in the context of Mandarin, and perhaps even more justified.

While English characters represent a phoneme individually or by combination, Chinese is a logographic language in which each written character represents one morpheme [25]. The majority of Chinese characters are compound characters, typically incorporating a semantic radical that gives a picturesque implication of the word's meaning [26]. Radicals can stand independently as a character of their own, within another character, or only within another character. For example, the semantic radical 马 (horse) is an independent character that can also be incorporated in the character 骑 (ride), whereas the radical 灬 (of or relating to fire) in the character 燕 (swallow) is not an independent character [27].

As Chinese is a monosyllabic, tonal language, any small change in tonal pronunciations of a syllable alters the meaning of a character. A useful illustration can be presented using 'pinyin', Mandarin's standard Romanisation system. The system utilizes 21 onsets and 39 rimes (part of a syllable that contains a word's vowel and the following consonants) consisting of 26 letters (a-z) in four distinct tones to simulate Mandarin's complex pronunciation [28]. For example, the syllable /ji/ has a plethora of individual meanings in the four tones. 鸡 jī, with a flat tone, means chicken; 吉 jí, with a rising tone, means fortune; 挤 jǐ, with an inflected tone, is the verb "to squeeze", and 记 jì, with a falling tone, is the verb "to record". Not mentioned are characters of the exact same pronunciation for each tone but with another different meaning and written structure. Having so many characters results in the pervasiveness of homophones in Mandarin, leading to most Mandarin morphemes having up to five homophones [29].

Mandarin homophony is also sporadic. An examination of the distribution of homophony demonstrates arbitrary homophone clustering, with some words having much more homophones than others [30]. In common language, words such as 谬 miu 'preposterous', used in the phrase 荒谬 huang miu, an adjective describing preposterousness, have no homophones and no words associated with miū, miú, and miǔ, the other three differences in tone. In contrast, the word 鸡 ji 'chicken' not only represents a specific meaning for each tonal variation but retains 13.5 homophones for every tonally specified syllable [29]. In consideration of homophone dominance, this raises the issue regarding which homophone to prime, and how one meaning's frequency can impact the participant's answer.

4. Methods

4.1. Participants

Participants were all native Mandarin speakers in China. A total of 612 people participated in the survey involving sentence priming, while 509 people participated in the control group with no sentence priming.

4.2. Materials

The study used a set of slides designed to present sentences in Mandarin followed by a color, in which participants had two choices as to how to define it. The sentences were crafted to include a homophone that could be related to the color presented. Measures were taken to ensure that the homophone and the color did not have an associative meaning outside of their phonetic similarity. For instance, homophones with radicals indicating color were excluded.

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4.3. Procedure

There were two different surveys to choose from: the survey with a sentence that primes to a color and a survey with no sentence, which only asked participants to define the color presented. Participants could choose to take either study, but could not take both. The sentence group read two Mandarin sentences before identifying the color displayed on the next slide, while the no-sentence group directly identified the color. The slides for the sentence group displayed sentences with homophones strategically embedded as various parts of speech (nouns, verbs, adjectives, etc.). The sentences were concise and clear, designed to ensure easy comprehension for the participants. Participants were instructed to take their time reading the sentences but to choose the color as quickly as possible. Each color was designed to be ambiguous and challenging to differentiate from another similar color, covering the entire screen to prevent any other visual color references. This setup aimed to test if the cognitive load from processing the sentences would influence their color perception.

4.4. Data Collection

The primary data collected were the choices of colors by the participants. The survey results showed the percentage of participants who identified each color correctly or incorrectly, both with and without sentence priming. This comparison helped determine if the sentence containing a homophone influenced their color choice.

5. Analysis

The data were analyzed by comparing the color identification accuracy between the sentence and no-sentence groups. The hypothesis was that the cognitive load from processing the sentences would lead to different color perceptions, potentially causing errors due to homophone priming.

By isolating the impact of homophone presence in sentences and controlling for associative meanings, the study aimed to investigate the influence of homophone priming on decision-making in a bilingual context. The results were analyzed to see if the hypothesis held true, considering the distinct cognitive processes involved in reading and understanding Mandarin characters compared to phonetic languages like English.

5.1. Homophone Priming Effect

The data revealed that in the presence of a Mandarin sentence containing a homophone, participants' color identification was notably influenced. For instance, when primed with "黄" (huáng), which means "emperor" but is also pronounced the same as "yellow," participants were more inclined to identify the color as yellow.

As shown in Table 1, the results indicated a higher percentage of participants selecting colors that were homophones of the words in the sentences, in comparison to the control group. For example, with sentences containing the homophone for "orange" (橙, chéng), 43.46% identified the color as orange compared to 22.4% in the control group.

Table 1: Survey results with priming(top) compared to survey results with no priming(bottom) Order from left to right

	Sentence(612 participants)	No sentence(509 participants)	

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Table 1: (continued).

	Orange	Yellow	Orange	Yellow	Adj, prime orange
	43.46 %	56.54 %	22.4%	77.6%	
	Red	Pink	Red	Pink	Noun, prime red
	93.3%	6.7%	95.07 %	4.93%	
	Green	Yellow	Green	Yellow	Noun, prime green
	48.2%	51.8%	40.08 %	59.92 %	
	Blue	Purple	Blue	Purple	Verb, prime blue
	37.25 %	62.75 %	43.42 %	56.58 %	
	Yellow	Orange	Yellow	Orange	No priming
	46.24 %	53.76 %	20.83 %	79.17 %	

5.2. Cognitive Load and Response

Participants in the no-sentence group clearly distinguished between two types of yellow oranges, the first being lighter than the second. However, the group that had the sentence collectively agreed that they were the same color. This likely indicates that the participants thought they were given the same color twice. This not only suggests they experienced cognitive load and relied on instinctual responses but also may invalidate the orange columns.

The data implies that when under cognitive load, participants might not process the homophones as distinct stimuli, leading to less differentiation between similar colors. This observation aligns with the theory that cognitive resources are taxed when processing complex information, resulting in less precise responses.

5.3. Discrepancies with Existing Research

According to Davis and Herr's logic, a survey with priming should always yield a higher identification rate of the primed color compared to a no-sentence survey. However, this was not consistently observed in the study, as seen with the colors red and blue. The percentage for "red" (红, hóng) was

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93.3% with priming compared to 95.07% in the control group, indicating minimal influence from priming. This inconsistency suggests that the survey results are more complex and do not fully support Davis and Herr's research on homophone priming effects on subconscious decisions. Their theory posits that homophones can subtly influence human decision-making, but the current study provides evidence that this might not apply to Mandarin Chinese.

The discrepancy between the results of this study and those proposed by Davis and Herr can be attributed to the structural differences between English and Mandarin, which are central to the Whorfian hypothesis of linguistic relativity. This hypothesis proposes that the structure and vocabulary of a language influence how its speakers interpret the world.

English, as an alphabetical language, typically features a direct correspondence between words and their meanings. Each word generally carries a single meaning, allowing for straightforward associations and potentially stronger priming effects from homophones.

In contrast, Mandarin Chinese is a logographic language where characters often represent whole words or morphemes rather than individual sounds. Characters in Mandarin can have multiple meanings and pronunciations based on context, necessitating compound words to convey specific meanings. For example, the character "行" (xíng) can mean "to walk," "okay," or "line," depending on its usage and accompanying characters. In addition, Mandarin characters often have multiple meanings and pronunciations based on context. While English words typically convey one meaning per word, Mandarin speakers sometimes require compound words to communicate a single meaning. For example, 荒谬 (huāng miù) is not contextually meaningful if separated and only means "preposterous" when used together. This complexity in Mandarin might reduce the effectiveness of homophone priming observed in English.

This structural complexity in Mandarin may diminish the effectiveness of homophone priming observed in English. Mandarin speakers may rely more on contextual clues and additional characters to disambiguate meanings, reducing the direct influence of a single homophone on decision-making processes. Consequently, in the study conducted with Mandarin-speaking participants, the expected priming effects on color identification may have been mitigated due to the language's inherent structure requiring deeper semantic processing.

By exploring these structural differences and their implications for cognitive processes, this study contributes to our understanding of how language shapes perception and decision-making. It highlights the nuanced ways in which linguistic structures influence cognitive operations, supporting the Whorfian hypothesis within the specific context of homophone priming and bilingual cognition.

5.4. Expansion on the Whorfian Hypothesis

The theory of linguistic relativity proposes that the way language is structured influences how its speakers perceive and think about the world. Based on this hypothesis, individuals who speak varying languages perceive the world differently due to the particular linguistic categories and structures they employ. In the context of homophone priming, this theory can help explain why English speakers might be more susceptible to such priming effects compared to Mandarin speakers.

In English, the alphabetical and relatively linear nature of the language more often allows for direct one-to-one correspondence between words and their meanings compared to Mandarin. The direct correlation implies that homophones can readily trigger associated ideas in the minds of English speakers. In different contexts, the word "bank" can evoke thoughts of either an institution of finance or a riverfront. This kind of priming can subtly influence decision-making and perception, as suggested by Davis and Herr's research.

Mandarin, on the other hand, is a logographic language, meaning that its characters often represent whole words or morphemes rather than individual sounds. Additionally, Mandarin characters can

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have multiple meanings and pronunciations, depending on the context. This complexity can make homophone priming less straightforward and less effective. For instance, the character "行" (xíng) can mean "to walk," "okay," or "line," among other things, depending on its usage [3]. The need for compound words to convey specific meanings further complicates the potential for homophone priming in Mandarin.

Moreover, Mandarin speakers might rely more on context and additional characters to disambiguate meanings, reducing the impact of a single homophone. This context-dependent nature of Mandarin could result in weaker priming effects compared to English, where homophones can more directly activate related concepts without additional contextual information.

In summary, the Whorfian hypothesis suggests that language structure influences cognitive processes, including susceptibility to homophone priming. The more direct word-meaning relationships in English make its speakers more prone to such priming effects, whereas the complex and context-dependent nature of Mandarin mitigates these effects. This insight underscores the significance of considering linguistic and cultural contexts in cognitive research and supports the idea that language can subtly shape our perception and behavior.

5.5. Methodologies Differences

Davis and Herr utilized paragraphs ending in "bye" to prime "buy," a method aimed at activating semantic networks related to purchasing decisions. This approach introduces a subjective element, as participants' interpretations of the paragraph's content and its influence on subsequent decisions can vary widely [2]. In contrast, this study employed color perception as the priming stimulus, focusing on a more perceptually objective factor. Participants were asked to distinguish between subtle shades of colors, aiming to assess how perceptual priming might influence decision-making in a non-verbal context. Furthermore, while Davis and Herr restricted their sample to students from a single university, this study included participants of all ages from various regions of Guangdong, China. This broader demographic diversity introduces cultural and experiential variability, potentially affecting how participants interpret and respond to experimental stimuli. Such methodological differences highlight the importance of considering both subjective and objective priming mechanisms across diverse participant groups to comprehensively understand cognitive processes influenced by linguistic and non-linguistic stimuli.

5.6. Questioning the Whorfian Hypothesis

In exploring the discrepancies between this study and Davis and Herr's findings, it becomes pertinent to question the underlying assumptions of the Whorfian hypothesis. Davis and Herr suggest that language, through homophonic priming, can significantly influence decision-making processes by activating specific linguistic associations. However, insights from John McWhorter's "The Language Hoax" challenge the extent of linguistic relativity's impact on cognitive processes. McWhorter argues that while experimental studies may reveal subtle linguistic effects in controlled settings, their practical significance in everyday decision-making remains minimal [31]. McWhorter's critique suggests that the observed discrepancies between studies could stem from the limited practical impact of linguistic relativity on real-world decision-making contexts [31]. By questioning the presumed influence of language on cognitive processes, this study encourages a critical reevaluation of how linguistic and non-linguistic factors interact to shape human cognition and behavior.

6. Conclusion

The findings suggest that homophone priming can influence word recognition and color identification in bilinguals, but this effect may be contingent on the language's structural characteristics. The lack

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of strong support for Davis and Herr's theory in Mandarin highlights the need to consider language-specific factors when studying cognitive processes. This study refutes Davis and Herr's proposal that homophones can subtly influence subconscious decisions, at least within the context of Mandarin Chinese. While there isn't enough evidence to completely dismiss their theory, the results suggest it might not apply universally across different languages. This highlights the importance of linguistic context in cognitive research. This study also offers multiple explanations for its discrepancies with Davis and Herr. Firstly, differences in language structure, as posited by the Whorfian hypothesis, suggest that linguistic differences could shape how individuals perceive and respond to priming stimuli. This theoretical perspective implies that varying linguistic frameworks may underlie the observed differences between studies.

Secondly, methodological disparities play a significant role. Davis and Herr used paragraphs ending in "bye" to prime "buy," activating semantic networks associated with purchasing decisions. In contrast, this study employed color perception as a priming stimulus, focusing on perceptual rather than semantic activation. These methodological choices can profoundly influence participant responses and study outcomes.

Lastly, insights from John McWhorter's "The Language Hoax" challenge the notion that language significantly shapes thought. McWhorter argues that while linguistic relativity may have minimal effects in controlled settings, its practical impact on everyday decision-making is minimal. Therefore, Davis and Herr's argument that linguistic priming influences decision-making may be overstated, given language's limited cognitive effects.

This study offers insights into how homophone priming influences word recognition and color identification among Mandarin speakers. The presence of homophones in sentences can influence subsequent behavior, such as color identification, by activating dominant meanings. The impact of cognitive load on the homophone suppression process results in varying efficiency levels. This research refute the idea proposed by Davis and Herr that homophones can subtly influence subconscious decisions in all linguistic contexts. The primary reason for this discrepancy appears to be the structural differences between alphabetical English and logographic Mandarin. English's straightforward word-meaning correspondence contrasts with Mandarin's need for compound words to convey specific meanings, affecting the effectiveness of homophone priming.

Future research should continue to explore this topic, especially by conducting similar studies with different linguistic contexts. It is crucial to consider the cognitive load and language structure when designing experiments to understand the broader implications of homophone priming. Additionally, more studies on the effects of homophones in English and other languages could provide further insights into the universality of these cognitive processes. This expanded explanation underscores the importance of considering language-specific factors when studying cognitive phenomena like homophone priming. It emphasizes that differences in linguistic structure between English and Mandarin can lead to varying effects on decision-making processes, aligning with the theoretical framework of linguistic relativity proposed by Whorf. Future research should continue to investigate these dynamics across different languages and cultural contexts to further illuminate the intricate relationship between language and cognition.

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