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The Influence of Grammatical Number on Cognition of Bilinguals: A Test of the Linguistic Relativity Hypothesis

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ABSTRACT

The linguistic relativity hypothesis has focused on the influence of grammar in language on speakers' cognition. Previous studies show that speakers of languages with grammatical number (e.g., English) are more aware of the number of objects. Additionally, recent studies reveal that bilinguals who speak languages with different grammatical structures may alter their cognitive preferences based on their level of language proficiency. This research builds on these findings, following Lucy's approach (1992a), to compare the cognition of monolingual speakers among members of a group consisting of thirty native Thai speakers and thirty native English speakers, with that of bilinguals (Thai-English) with varying proficiency levels in a group consisting of thirty basic-level Thai-English bilinguals, thirty intermediate-level Thai-English bilinguals and thirty advanced-level Thai-English bilinguals. Attention tests and memory tests were implemented to test the level of cognition of each participant, the results being analyzed using ANOVA and Scheffe's test. The results showed that the

English-speaking subjects paid more attention to the number of objects and memorized a greater number of them than the Thai-speaking subjects, suggesting that the presence of grammatical number in English and its absence in Thai played a significant role. The advanced-level Thai-English bilinguals paid more attention to the number of objects and memorized a greater number of them than the intermediate-level Thai-English bilinguals, the basic-level Thai-English bilinguals, and the monolingual Thai speakers, respectively, but paid less attention than the monolingual English speakers. However, there was no significant difference between the basic-level Thai-English bilinguals and the monolingual Thai speakers. This finding may lead us to conclude that: 1) grammatical representation affects speakers' cognition, supporting the linguistic relativity hypothesis; and that 2) bilingualism affects cognition at different levels. This finding suggests the possibility that acquisition of a second language affects bilinguals' cognition, and highlights the importance of promoting bilingualism in Thailand in order to enhance English proficiency and global competitiveness. By highlighting how grammatical differences affect attention and memory, the study suggests language education policies should focus on bilingualism and address cognitive impacts, helping Thai learners overcome linguistic challenges and enhance cognitive and language skills.

Keywords: linguistic relativity hypothesis, grammatical number, bilinguals

Introduction

The main focus of the linguistic relativity hypothesis has been the correlation between thought and language. The main idea is that the cognition of speakers is influenced by the language that they use. Edward Sapir and Benjamin Lee Whorf first proposed the notion (Sapir, 1957; Whorf, 1956). This hypothesis is also known as the "Whorfian Hypothesis" and the "Sapir-Whorf hypothesis." At the core of this hypothesis is the claim that language affects speakers' cognition, suggesting that the greater the differences between two languages, the greater the differences in the cognition of their respective speakers.

The linguistic relativity hypothesis has sparked considerable scientific debate due to its lack of empirical support and insufficient empirical evidence, the hypothesis's position being determined by the subjective interpretations

of individuals (Carroll, 1994, as cited in Birjandi & Sabah, 2012; Reines & Prinz, 2009). Criticism has been primarily directed at the methodology employed to assess languages' impact on speakers' cognition. It is impossible to directly assess cognition as it is an abstract entity. Alongside this debate, a new study on language universals and linguistic typology appeared to undermine the Whorfian hypothesis in the late 1950s (Athanasopoulos, 2006). Lucy (1992a), however, proposed an appropriate methodological framework for applying the linguistic relativity hypothesis in research in a way that could be empirically tested. Lucy claimed that cognition could be assessed through cognitive behavior, arguing that observable testable behaviors that reflected cognitive processes—such as attention and memory—could be empirically studied in speakers' daily lives.

Lucy's framework led to a resurgence in interest in the linguistic relativity hypothesis. Numerous academics have endeavored to investigate the linguistic relativity hypothesis in order to examine the correlation between thought and language in response to Lucy's work, focusing on different grammatical aspects, such as nominal grammatical category (e.g., Charunrochana, 2000; Lucy, 1992b), grammatical number (e.g., Kirjavainen et al., 2020), number system (e.g., Gordon, 2004), grammatical gender (e.g., Boroditsky, 2003), as well as semantic terms (e.g., Chanyeam, 2017). For example, speakers of languages with gendered grammatical categories, such as Spanish and German, tend to attribute male or female qualities to inanimate objects based on their grammatical gender (Boroditsky, 2003). Likewise, speakers of languages with obligatory grammatical number (e.g., English) tend to track and remember the number of objects better than speakers of languages with optional grammatical number (e.g., Thai, Japanese, Yucatec Maya) (Charunrochana, 2000; Kirjavainen et al., 2020; Lucy, 1992b). Most research has been conducted on monolinguals, findings indicating that a language's grammar influences the cognition of its monolingual speakers, and demonstrating that differences in cognition among monolinguals are influenced by the grammar of the language they use, thereby providing support for the linguistic relativity hypothesis.

However, findings regarding language and cognition among monolinguals appear inadequate for comprehending speakers' cognition, particularly for those able to speak two or more languages (Pavlenko, 2014). Preliminary attempts were thus made to apply the principle of linguistic relativity to the context of bilingualism (e.g., Green, 1998; Pavlenko, 2005), considering the following question: If the grammar of any language affected monolinguals' cognitive processes, would acquiring a second language affect bilinguals' cognitive processes? (Athanasopoulos, 2006) Bilinguals who are proficient in two languages, representing two distinct worldviews, may perceive the world differently than monolinguals, and may assist them in

perceiving things beyond the limitations of their native languages (Bassetti & Cook, 2011).

Most studies investigating bilingualism and cognition have focused on different aspects of grammar. Studies concerning the influence of second language acquisition on speakers' cognition have been conducted with regard to grammatical categories, such as grammatical tense (e.g., Aemdit & Prasithrathsint, 2016), grammatical gender (e.g., Thongnium, 2017), and countability (e.g., Athanasopoulos, 2006, 2007; Cook et al., 2006; Athanasopoulos & Kasai, 2008). Counterfactual reasoning has also been used to study bilingualism and cognition (e.g., Ruthirago, 2011). Additionally, several studies indicate that the cognitive processes of bilinguals with varying proficiency levels are influenced by the extent of their proficiency in their respective second languages (e.g., Aemdit & Prasithrathsint, 2016; Athanasopoulos, 2006, 2007; Athanasopoulos & Kasai, 2008).

Therefore, understanding the influence of language on cognition in both monolingual and bilingual speakers becomes crucial, especially in analyzing how grammatical aspects of languages, such as grammatical number, influence cognition. Prior research has demonstrated that speakers of languages with grammatical number (e.g., English) are more conscious of the number of objects than speakers of languages lacking grammatical number. (e.g., Thai, Japanese, Yucatec Maya) While these studies primarily focus on numerical cognition in monolingual contexts, there is a need for further exploration in both monolingual and bilingual settings. Recent findings show that bilinguals speaking languages with distinct grammatical structures may shift their cognitive preferences based on their language proficiency level, highlighting the importance of analyzing these aspects across both groups.

This study aims to bridge the gap by investigating the extent to which bilinguals' cognitive behavior—specifically their numerical cognition—is influenced by their proficiency in both languages. While the studies noted above have investigated the effects of second language acquisition on bilinguals' cognition across various grammatical aspects, the influence of grammatical number on bilinguals' cognition remains underexplored. Research in this area is crucial as it can sheds light on how bilinguals manage differing grammatical number systems in two languages and whether these differences affect their cognitive processes. Proficiency in a language with obligatory grammatical number distinctions, such as English, may enhance attention to numerical detail and improve memory performance. Additionally, learning a language with distinct grammatical number systems may enhance cognitive flexibility and adaptability related to numerical cognition. This suggests that when bilinguals whose first languages lack grammatical number systems learn other languages that possess such systems,

they may become more attuned to numerical distinctions, thereby enhancing their overall learning ability. By focusing on monolinguals (native Thai speakers and native English speakers) and bilinguals (Thai-English speakers), this research provides a comparative analysis of how grammatical number influences cognition. It is hoped that through its examination of how varying levels of language proficiency impact cognitive processes in both monolingual and bilingual contexts, it will contribute to a deeper understanding of linguistic relativity.

Background

This study aimed to explore the influence of grammatical number on the cognition of monolinguals (native Thai speakers and native English speakers) and bilinguals (Thai-English speakers). In this study, the monolingual Thai speakers are native Thai speakers who use Thai as their mother tongue, while the monolingual English speakers are native English speakers who use English as their mother tongue. The bilinguals are native Thai speakers who use English as a foreign language. Prior to commencing the project, it was crucial to conduct a review of relevant literature. The review was conducted in relation to: 1) the linguistic relativity hypothesis and grammatical number; 2) the role of grammatical number in English and Thai; and 3) the linguistic relativity hypothesis and bilingualism. The details are presented below.

The Linguistic Relativity Hypothesis and Grammatical Number

Kibort and Corbett (2008) argue that "grammatical number is one of the grammatical categories, representing the quantities of things indicated by nouns or nominal elements. It arises from the ability to recognize something as a token, an example of a group of referents, and the ability to distinguish between one and more than one (e.g., the 'plurality' of) examples of the referent." In most languages, grammatical number can be expressed explicitly or implicitly. The appearance of grammatical number is obligatory in some languages (e.g., English and Finnish). In these languages, speakers are not allowed to refer to an entity without explicitly specifying grammatical number markings, articles, quantifiers, or numerals, the absence of which will render such references ungrammatical. On the contrary, in certain other languages (e.g., Thai, Japanese, Chinese) it is optional to express grammatical number. In general, nouns do not require grammatical number markings and may be employed without such indications, even in references to specific entities. Most languages in the former category require reference to be made to the value of the grammatical number, either via nominal components or through

agreement with a numeral or other quantifier. Number values, according to Corbett (2004), reveal the distinctions that exist within numbers, such as in the cases of singular, plural, dual, trial, paucal, quadral numbers as well as greater numbers and composed numbers.

Previous studies investigated the linguistic relativity hypothesis in relation to grammatical number, comparing languages with obligatory grammatical number (e.g., English) and languages lacking grammatical number (e.g., Thai, Japanese, Yucatec Maya). Most found that differences in the grammar of languages corresponded to differences in cognition between their respective speakers, seeming to supports the linguistic relativity hypothesis. For example, Lucy (1992b) found that English speakers performed better than Yucatec Maya speakers in relation to paying attention to and remembering the number of objects. Yucatec Maya speakers classified objects into the same category based on the substance that they were made of, whereas English speakers did so based on their shape. Charunrochana (2000) duplicated Lucy's (1992b) study, collecting data from Thai and English speakers. Charunrochana found that the English speakers paid attention to and memorized the number of objects more than the Thai speakers. The Thai speakers in her study paid less attention to the shape of objects and memorized the shape of objects to a lesser extent than the English speakers. These findings were comparable to what Lucy had reported. In another study, the English-speaking research subjects displayed much greater accuracy than the Japanese-speaking ones when it came to correctly recalling the number of objects, perhaps reflecting the presence and absence of grammatical number in English and Japanese respectively (Kirjavainen et al., 2020).

While studies such as those noted above suggest that English speakers are more aware of numerical concepts and perform better in cognitive tasks than speakers of languages lacking grammatical number, we found hardly any research investigating the correlation between grammatical number and cognition among bilingual speakers, and especially among native Thai speakers with a knowledge of English as a foreign language. Content related to grammatical number has been taught in English classes for Thai students in Grades 1 to 12 since 2009 (Ministry of Education, 2008; Office of Basic Education Commission, 2022). Thus, it may be assumed that most native Thai speakers possess knowledge related to grammatical number. It is interesting to examine how Thai-English bilinguals perform cognitive tasks in terms of grammatical number. The findings can provide us with insights concerning bilinguals' cognitive processes. We therefore intend to investigate the effect of grammatical number on the cognitive processes of English speakers, Thai speakers and Thai-English bilinguals. Specifically, we are interested in determining if proficiency in a second language affects the

cognition of bilinguals at different levels. At this point, it is worth firstly reviewing the role of grammatical number in English and Thai.

The Role of Grammatical Number in English and Thai

As grammatical number is not obligatory in Thai, Thai speakers are able to refer to situations without explicitly specifying the numbers of the entities involved. In contrast, English speakers must use grammatical number markings to indicate whether they are referring to one or more entities. English speakers also employ articles, quantifiers, and numbers when referring to entities (Kirjavainen et al., 2020). English speakers need to specify the number when referring to a countable noun through inclusion or omission of the bound morpheme, using an article or a numeral according to the rules of grammar. Thai speakers lack grammatical rules for expressing number, and they can choose to exclude any reference to number altogether, regardless of the number of entities involved. In terms of grammar, Thai speakers tend to use classifiers, context, and other linguistic markers to convey the quantity of entities rather than explicitly using numerals. This flexibility means that while English speakers must always indicate grammatical number, Thai speakers can omit such references entirely or use other strategies to convey meaning. As noted above, and in accordance with the linguistic relativity concept, English speakers are more aware of the number of nouns than Thai speakers, a difference which is likely to reflect the obligatory and non-obligatory use of grammatical number in the respective languages. Previous studies (e.g., Aemdit & Prasithrathsint, 2016; Athanasopoulos, 2006, 2007; Athanasopoulos & Kasai, 2008; Cook et al., 2006) have found that bilinguals tend to be conscious of the grammatical rules of the second language they have learned. Thus, bilinguals who have learned a second language with grammatical number may be more aware of the number of nouns than monolinguals using a language in which the expression of grammatical number is optional.

The Linguistic Relativity Hypothesis and Bilingualism

Increasing interest among scholars in testing the linguistic relativity hypothesis in the context of bilingualism has led many to raise the question of whether the acquisition of a second language may influence certain cognitive processes, given that the grammar of monolinguals' native languages has been found to affect their cognition (Athanasopoulos, 2006). Bilinguals who possess knowledge of two languages that express different viewpoints on the world may experience the world differently to those who only speak one language. This ability may enable bilinguals to go beyond the

limitations of their native languages and obtain a broader understanding of the world (Bassetti & Cook, 2011).

In previous studies, bilinguals' cognition has been investigated through having research subjects engage in non-linguistic tasks that employ different aspects of grammar, following the approach taken by Lucy (1992a). For instance, the countability of nouns is often used to test the cognition of bilinguals, as demonstrated in studies conducted by Athanasopoulos (2006, 2007) and Athanasopoulos and Kasai (2008). These researchers conducted several similar investigations using different groups of Japanese-English bilinguals based on their different L2 proficiency levels and control groups of English and Japanese monolinguals. The majority of the studies demonstrated that the level of second-language (L2) proficiency of bilinguals had different effects on their cognitive ability. To elaborate, bilinguals with intermediate-level proficiency in a second language exhibited cognitive behavior similar to that of native speakers of the first language, while those with advanced-level proficiency in a second language exhibit cognitive behavior similar to that of native speakers of the second language (Athanasopoulos, 2006, 2007; Athanasopoulos & Kasai, 2008). This finding corresponded to that of Aemdit and Prasithrathsint (2016) in their investigation of the effect of English on the cognition of Thai-English bilinguals in terms of grammatical tense. Their research showed that advanced-level Thai-English bilinguals had a greater awareness of time than Thai-English bilinguals with basic or intermediate-level proficiency in English, demonstrating the existence of a connection between level of language proficiency and cognition among bilinguals.

Other factors also seem to play a minor role in relation to bilinguals' cognition. These include length of stay in L2 countries, language of instruction, and experiment context. In relation to the length of stay in L2 countries, Cook et al. (2006) found that the length of stay in an L2 country may affect how bilinguals categorize objects. Japanese-English bilinguals who had stayed in English-speaking countries for more than three years categorized objects in a similar manner to native speakers of their second language. Cook et al. (2006) did not collect data from Japanese and English speakers by themselves. They compared their findings to the results of a study by Imai and Gentner (1997). Later, Athanasopoulos (2007) and Athanasopoulos and Kasai (2008) duplicated Cook et al.'s (2006) work, comparing its findings with data on Japanese and English speakers. Their findings showed that the length of stay in L2 countries did not significantly affect bilingual cognition. Also, language of instruction and experimental context did not significantly influence categorization preference. Despite this, bilinguals showed a shift in cognition even when instructed in their first language by a native speaker of their first language in the L1 country.

Previous research showed the effect of second-language proficiency on the cognition of bilinguals with intermediate and advanced-level proficiency (Athanasopoulos, 2006, 2007; Athanasopoulos & Kasai, 2008). However, Aemdit and Prasithrathsint's (2016) study separated bilinguals into basic, intermediate, and advanced-level groups but did not compare them with monolinguals. The findings revealed that bilinguals' cognition was influenced by their level of proficiency in their respective second languages. The higher level of proficiency a bilingual had in their second language, the more similar their cognitive processes would be to native speakers of that language. Thus, it was decided that it would be interesting to study the influence of the presence or absence of grammatical number in a language on the cognition of speakers and to broaden the parameters of the study with respect to bilingualism.

This study addresses gaps in previous research by examining how Thai-English bilinguals with different levels of English proficiency process grammatical number and how their cognitive behavior compares to that of monolinguals. We decided to separate bilingual subjects into three groups: basic-level Thai-English bilinguals, intermediate-level Thai-English bilinguals, and advanced-level Thai-English bilinguals. The terms "basic," "intermediate" and "advanced" in this study refer to level of English proficiency, and all of the bilingual research subjects had Thai as their first language. We then compared their cognitive behavior with that of monolingual speakers of both languages. Our intention was to deepen our understanding of how grammatical number affects cognition among monolinguals and bilinguals and explore the cognitive shifts that occur as bilingual proficiency increases. Additionally, we sought to gain an understanding of the nature of bilinguals' cognition as well as insights into whether bilinguals with different levels of language proficiency had distinct types of cognition.

Method

Participants

For the purposes of this research, data was collected from five groups of participants consisting of thirty monolingual Thai speakers (mean age = 37.27 years; median age = 35.50), thirty monolingual English speakers (mean age = 36.28 years; median age = 31.50), thirty basic-level Thai-English bilinguals (CEFR A1-A2; mean age = 24.97 years; median age = 23), thirty intermediate-level Thai-English bilinguals (CEFR B1-B2; mean age = 20.93 years; median age = 21) and thirty advanced-level Thai-English bilinguals (CEFR C1-C2; mean age = 21.70 years; median age = 22)

Monolinguals participants were defined as native speakers of either Thai or English residing in Thailand. While finding true monolinguals in today's digitally connected world can be challenging, for this study, we defined monolinguals as individuals who possessed little to no functional proficiency in a second language and who exclusively used their native language in daily communication. We conducted rigorous screening to recruit participants who met these criteria, ensuring that they had minimal exposure to other languages.

Bilingual participants were native Thai speakers with varying levels of English proficiency, these levels being determined according to their performance in standardized tests (i.e., TOEFL, TOEIC, IELTS) aligned with the Common European Framework of Reference for Languages (CEFR). Proficiency levels among the bilingual research subjects ranged from A1 (Beginner) to C2 (Advanced).

Participants in the study were recruited using a purposive sampling method in order to ensure representative distribution across specified qualifications. Recruitment was conducted via social media platforms, targeting individuals who met the inclusion criteria for each group.

Materials

Three versions of the experiment were used: English, Thai, and bilingual (Thai-English). The English version was used for monolingual English speakers. The Thai version was used for monolingual Thai speakers. The bilingual (Thai-English) version was used for Thai-English bilinguals. Reliability of the three versions was ensured by tailoring each to the participants' language proficiency. We conducted several pilot studies with groups of native Thai speakers, native English speakers, and Thai-English bilinguals to test for consistent understanding of the tasks across all groups. The monolingual versions, with the instructions written in their mother languages, allowed participants to respond naturally in their respective mother languages, while the bilingual version, with the instructions provided in both Thai and English, permitted research subjects to write their answers in Thai or English. While structural differences between Thai and English could influence cognitive behavior, the tasks were matched in complexity to maintain consistency across versions.

Additionally, participants were asked to record their ages and years of birth as well as their language experience (the countries that they had visited within the previous six years.) The study required participants to be at least eighteen years of age. We requested both the current age and the year of birth of each participant in order to verify that they met this criterion. Additionally, knowing the countries that the participants had visited during the past six

years helped us to assess the extent of their exposure to different linguistic environments. This information was utilized for the recruitment of participants in this study.

A quantitative approach was adopted in this study, with attention tests as well as memory tests used to test participants' cognitive behavior. We created drafts of the pictures for all of the tests ourselves and then asked a graphic designer to create final versions of them using a computer program while maintaining alignment with the objectives of the study. To ensure their suitability, the pictures were designed to reflect key linguistic elements relevant to both English and Thai, such as grammatical number and object recognition. After pictures had been designed, several pilot studies were conducted in order to test the clarity, relevance, and effectiveness of the pictures in eliciting the desired cognitive responses from participants.

For data analysis, ANOVA (Analysis of Variance) was conducted to compare differences in means, both within and between groups and across all participants. For between-group comparisons, Scheffe's test was applied to identify statistically significant differences between specific pairs of groups. A p-value of 0.05 was set to determine statistical significance.

The hypothesis of the study was based on the notion of linguistic relativity hypothesis, which suggests that grammar in languages influences the cognitive processes of their speakers. In our experiments, it was anticipated that participants who were native English speakers, due to the grammar of their language, would be more likely to pay attention to and memorize the number of objects and answer questions about them correctly, while Thai speakers would be likely to ignore this aspect. Additionally, advanced-level Thai-English bilinguals were expected to perform better in recognizing the number of objects than those with intermediate and basic-level proficiency and Thai speakers respectively, but that they would display less accuracy than native English speakers. Details of these tests are presented below.

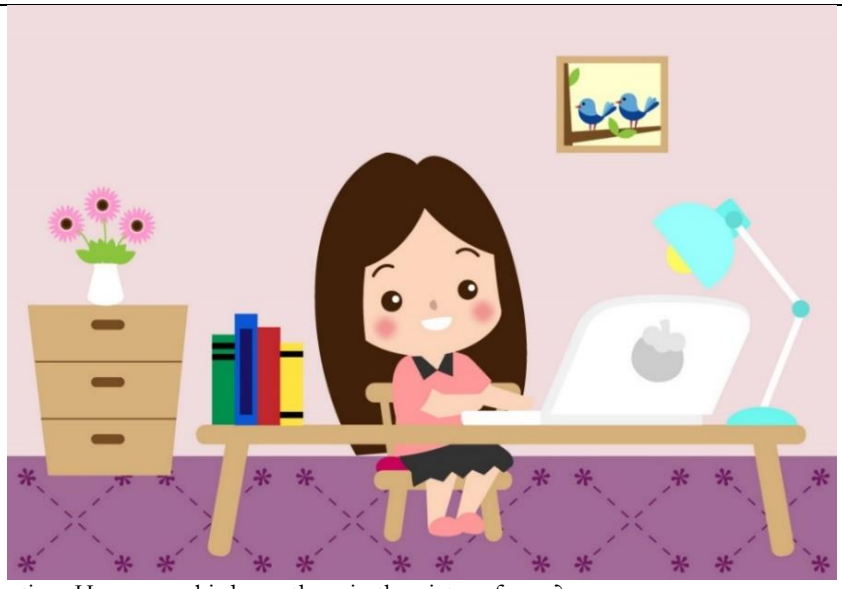
Attention Test

The attention test was designed following the notion of the bottleneck theory and the capacity theory (Broadbent, 1958; Kahneman, 1973; Treisman, 1964). This test aimed to test participants' attention to the number of objects. We hypothesized that if participants were conscious of the number due to the characteristics of the grammar of their languages, they would be likely to pay attention to the number of objects in this task. We further hypothesized that proficiency levels in English would possibly affect the experiment, i.e. that the more advanced the participant's proficiency in English, the more they would pay attention to the number of objects in the task.

There were ten pictures in the attention test, each one measuring. 14.8 x 21.0 cm (A5 size). Five pictures were used for testing and evaluation, and these are hereafter referred to as "test pictures." Test pictures were pictures containing varying quantities of several types of entities, but some of the entities used to formulate questions were not prominent. Questions concerning the five test pictures related to the number of objects in the pictures. If the participants paid attention to the number of entities, they would be able to correctly answer questions regarding quantity. The remaining five pictures, hereafter referred to as "non-test pictures," were used to reduce participants' awareness of what they were being tested on, so their scores were not included in calculations. Non-test pictures were also pictures containing multiple types of entities. However, these pictures were more complex, requiring participants to focus on multiple entities simultaneously. The aim was to create confusion and obscure the objective of the experiment. Questions concerning the non-test pictures related to the color of objects and the situations in the pictures. Participants received one point for each correct answer concerning the number of objects in each of the test pictures. The total number of points that a participant could obtain in the test was five points. Figure 1 below shows an example of a test picture in the attention test.

Figure 1

Example of a Test Picture in the Attention Test



Question: How many birds are there in the picture frame?
Answer: Two.

Memory Test Using Short-Answer Questions

A memory test using short-answer questions was designed following the notion of short-term memory (Friedenberg & Silverman, 2006). In order to test memory, we adopted the "free recall" technique proposed by Kalat (1991). A free recall task involves recalling something without hints, such as in a short-answer test. This test aims to test participants' ability to retain information related to the number of objects. We hypothesized that if participants were conscious of the number due to the characteristics of the grammar of their languages, they would be likely to remember the number of objects in each task. We further hypothesized that proficiency levels in English would possibly influence bilinguals' cognitive processes. The more advanced the participant's proficiency in English, the more accurately they would memorize the number of objects in the task.

There were five pictures in the memory test, which included short-answer questions. Each picture measured 14.8 x 21.0 cm (A5 size). Three pictures were used for testing and evaluation, and are hereafter referred to as "test pictures." Test pictures were pictures containing varying quantities of several types of entities, but some of the entities used to formulate questions were not prominent. Questions concerning the test pictures related to the number of objects in the pictures. Participants who were conscious of the number of entities could accurately answer questions about quantity. Two pictures, hereafter referred to as "non-test pictures," were used to reduce participants' awareness of what they were being tested on, so their scores for these pictures were not included in calculations. Non-test pictures also featured various types of entities, but in more complex arrangements, requiring participants to be conscious of multiple entities simultaneously. This complexity was intended to obscure the actual objective of the experiment and induce confusion about what was being tested. Questions concerning the non-test pictures related to the color of objects and the situations in the pictures. Participants received one point for each correct answer concerning the number of objects in each of the test pictures. Participants could receive a maximum score of nine points for the memory test, the maximum score for each picture being three points. Figure 2 below shows an example of a test picture in the memory test using short-answer questions.

Figure 2

Example of a Test Picture in the Memory Test Using Short-Answer Questions

Question 1: How many rats are there in this picture?
Answer: Three.
Question 2: How many ducks are there in this picture?
Answer: Four.
Question 3: How many shampoo bottles are there on the vanity?
Answer: Two.
Question 4: What is the color of the T-shirts?
Answer: Red and blue.
Question 5: Where is the rat on the left standing?
Answer: On a box.

Procedures

Each participant was checked prior to testing. Only qualified participants were allowed to participate in the test. Participants were tested individually or in small groups, depending on the situation. A presentation was created using Microsoft PowerPoint to be used for the test. We used functions in this program to set slide timings. Slide timings were used to control the time that each slide was displayed on the screen. Participants were shown the slide presentation on a computer and recorded their responses on the answer sheets provided.

Before the test, participants were asked to provide personal data and information about their language experience. They were then asked to complete the attention and memory tests.

The Attention Test

Participants were shown the following instructions for the attention test:

1. There are 10 pictures in this test.
2. Each picture will be shown for 5 seconds, then it will disappear.
3. A question related to the picture will be displayed. Please answer the question.
4. If you do not know the answer, please leave it blank or write "uncertain."

According to the instructions for the attention test, participants were shown the first picture on the screen for five seconds, after which that picture disappeared. They were then asked to answer one question related to that picture by writing their answer on the answer sheet. For example, in relation to the example in Figure 1, the question was: "How many birds are there in the picture frame?" If a participant had paid attention to the number of objects, they would have answered "Two birds," which was the correct answer. The instructions also informed participants that they could answer: "Uncertain." They could also decide not to write anything if they did not know the answer. If a participant tried to guess an answer and that answer was correct, the testing method could be considered to have failed because it did not accurately reflect the cognition of the participant.

After they had completed the first question, participants were shown the second picture for five seconds and asked to answer the question for that picture. They had to go through this process for each of the ten pictures. Before testing, participants were asked to perform one practice run before completing the real test in order to ensure that they understood what was involved. Scores for the practice runs were not included in calculations.

The Memory Test Using Short-Answer Questions

Participants were shown the following instructions for the memory test, which included short-answer questions:

1. There are 5 pictures in this test.
2. Each picture will be shown for 10 seconds, then it will disappear.
3. Five questions related to the picture will be shown. Please answer these questions.
4. If you do not know the answers, please leave them blank or write "uncertain."

According to the instructions for the memory test, which included short-answer questions, participants were shown the first picture for ten seconds. That picture then disappeared, and they were asked to answer five questions about the number of objects, the color of objects and the situation in the picture by writing their answers on their answer sheets. For example, in relation to the example in Figure 2, there were three questions asking about the number of objects. They were: "How many rats are there in this picture?" (Question 1); "How many ducks are there in this picture?" (Question 2); and "How many shampoo bottles are there on the vanity?" (Question 3). If participants had been able to memorize the number of objects, they would have answered: "Three rats," "Four ducks," and "Two shampoo bottles" respectively, which were the correct answers. If participants did not know the answer, they could choose to write nothing or write: "Uncertain." They were asked not to guess the answers because doing so might have affected the experiment.

After completing the first question, they were shown the second picture for ten seconds and were asked to answer the questions for that picture. They had to go through this process for each of the five pictures. Before testing, participants were asked to perform one practice run in order to confirm their understanding of the test. Scores for the practice runs were not included in calculations.

The percentages of correct answers achieved were used to analyze the accuracy rate of participants in paying attention to and memorizing the number of objects. To examine the overall pattern, ANOVA was used to compare the difference in averages among and between all groups of participants. In addition, Scheffe's test was used to analyze which pairs of groups were different to a statistically significant degree. The significance level (p-value) was set at 0.05.

Results

In line with predictions, most of the monolingual English speakers participating in the experiment were conscious of the number of objects, while most of the monolingual Thai speakers were unaware of the number of objects in the cognitive tasks. The monolingual Thai speakers mainly focused on the colors of objects and the situations in the pictures. In addition, all of the Thai-English bilinguals tended to be conscious of the number of objects. The higher the level of English proficiency of the Thai-English bilinguals, the more conscious they were of the number of objects. The Thai-English bilinguals with advanced-level English proficiency displayed a higher accuracy rate in relation to paying attention to and memorizing the number of objects than those with intermediate-level and basic-level English as well as the

monolingual Thai speakers, but had lower accuracy than the monolingual English speakers. Conversely, the monolingual English speakers recorded the highest accuracy rate in relation to paying attention to and memorizing the number of objects among all of the groups of participants. Details of these results are presented below.

Attention test

The responses to the attention test were scored according to the frequency with which each participant provided accurate answers concerning the number of objects. Scores were then converted into percentages for calculation. Table 1 below presents a summary of the accuracy rates of participants.

Table 1

Accuracy Rates of Responses in the Attention Test

Group of participants	Accuracy rate in relation to paying attention to the number of objects	Total score (out of 150)
Monolingual Thai speakers (n = 30)	15.33%	23
Basic-level Thai-English bilinguals (n = 30)	26.67%	40
Intermediate-level Thai-English bilinguals (n = 30)	50.67%	76
Advanced-level Thai-English bilinguals (n = 30)	65.33%	98
Monolingual English speakers (n = 30)	80.00%	120

The accuracy rate in relation to paying attention to the number of objects was calculated as: (scores of each participant for paying attention to the number of objects × 30 participants) × 100 / total possible scores in the attention test (30 participants × 5 scores)

Table 1 above shows the accuracy rate of each group of participants in paying attention to the number of objects, with a total possible score of 150 when answering the questions included in the test. The monolingual English speakers demonstrated the highest accuracy rate, 80.00% (120 out of 150), while the monolingual Thai speakers had the lowest, 15.33% (23 out of 150). Notably, among the bilingual participants, the advanced-level Thai-English bilinguals followed closely with an accuracy rate of 65.33% (98 out of 150), followed by the intermediate-level Thai-English bilinguals at 50.67% (76 out of 150), and the basic-level Thai-English bilinguals at 26.67% (40 out of 150). This comparison underscores the significant difference in attentional accuracy between the monolingual Thai and English speakers and illustrates how bilingualism, across proficiency levels, positively influences performance on the attention test.

The results of the attention test using the same pictures showed that most of the native English speakers demonstrated their attention to the number of objects by correctly answering questions about them, while most of the Thai speakers either left these questions blank or responded with "uncertain." However, the Thai speakers consistently gave accurate responses regarding the colors of objects and the situations depicted in the pictures. Among the bilinguals, the study showed that higher proficiency in a second language improved the likelihood of correctly answering questions related to the number of objects, with accuracy decreasing as proficiency dropped. The advanced-level Thai-English bilinguals generally answered questions about the number of objects correctly, though less so than the native English speakers. The basic-level Thai-English bilinguals, like the Thai speakers, often left questions concerning number blank or responded with "uncertain," but they still accurately answered questions about the colors of objects and situations. The intermediate-level Thai-English bilinguals had mixed results, their performance ranking between those of the basic and advanced-level Thai-English bilinguals in terms of accuracy when answering questions about the number of objects.

When analyzing the data in Statistics, ANOVA demonstrated the presence of a statistically significant difference among the groups, $F = 83.08$, $p < .05$. The results of Scheffe's test are presented in Table 2 below.

Table 2

Accuracy Rates in Relation to Paying Attention to the Number of Objects

Group of participants	Basic-level Thai-English bilinguals	Intermediate-level Thai-English bilinguals	Advanced-level Thai-English bilinguals	Monolingual English speakers
Monolingual Thai speakers	.119	.00*	.00*	.00*
Basic-level Thai-English bilinguals	-	.00*	.00*	.00*
Intermediate-level Thai-English bilinguals	-	-	.017*	.00*
Advanced-level Thai-English bilinguals	-	-	-	.017*

*Scheffe's test, $p = .05$

Table 2 above shows accuracy rates in relation to paying attention to the number of objects among groups of participants. Among the monolinguals, the English speakers paid more attention to the number of objects than the Thai speakers, with a statistically significant difference present ($p < .05$). In the case of the bilinguals, the advanced-level Thai-English bilinguals paid more attention to the number of objects than the intermediate-level Thai-English bilinguals and the basic-level Thai-English bilinguals, with a statistically significant difference also present ($p < .05$).

When comparing monolinguals and bilinguals, there was a statistically significant difference ($p < .05$) between the advanced-level Thai-English bilinguals on the one hand and the intermediate-level and the basic-level Thai-English bilinguals on the other. There was also a significant statistical difference ($p < 0.05$) between the monolingual English speakers and the advanced-level Thai-English bilinguals. However, there was no statistically significant difference between the basic-level Thai-English bilinguals and the monolingual Thai speakers ($p > .05$).

Memory Test Using Short-Answer Questions

For the memory test using short answer questions, we scored the responses according to the frequency with which participants provided correct answers concerning the number of objects, converting scores into percentages for calculation. Table 3 below presents a summary of findings concerning accuracy rate.

Table 3

Accuracy Rates of Responses in the Memory Test

Group of Participants	Accuracy rate in relation to memorizing the number of objects	Total score (out of 270)
Monolingual Thai speakers (n = 30)	20.00%	54
Basic-level Thai-English bilinguals (n = 30)	30.00%	81
Intermediate-level Thai-English bilinguals (n = 30)	58.52%	158
Advanced-level Thai-English bilinguals (n = 30)	71.85%	194
Monolingual English speakers (n = 30)	84.81%	229

The accuracy rate in relation to memorizing the number of objects was calculated as: (scores of each participant for memorizing the number of objects × 30 participants) × 100 / total possible scores in the memory test (30 participants × 9 scores).

Table 3 above shows the accuracy rates in relation to memorizing the number of objects found in response to the questions relating to numbers of objects, with a total possible score of 270 when answering the questions included in the test. The monolingual English speakers achieved the highest accuracy rate, 84.81% (229 out of 270), while the monolingual Thai speakers recorded the lowest, 20.00% (54 out of 270). This difference shows that monolingual English speakers performed much better on the memory task than monolingual Thai speakers. Additionally, it shows how bilingualism influences memory accuracy across proficiency levels, with the advanced-level Thai-English bilinguals scoring an average of 71.85% (194 out of 270), the intermediate-level Thai-English bilingual scoring an average of 58.52% (158 out of 270), and the basic-level Thai-English bilinguals scoring an average of 30.00% (81 out of 270). The table provides clear frequency data, illustrating the impact of grammatical number and bilingual proficiency on memory accuracy.

The results of the memory test in the same pictures revealed that most of the native English speakers demonstrated strong recall of the number of objects by correctly answering related questions, whereas most of the Thai speakers either left these questions blank or responded with "uncertain." However, the Thai speakers consistently provided accurate answers about the colors of objects and the situations depicted in the pictures. Among the bilinguals, the study indicated that higher proficiency in a second language increased the likelihood of correctly answering questions about the number of objects, with accuracy decreasing as proficiency declined. The advanced-level Thai-English bilinguals generally answered these questions accurately, though less often than the native English speakers. The basic-level bilinguals, in common with the Thai speakers, frequently left questions concerning number blank or responded with "uncertain," but still answered questions about the colors of objects and situations correctly. Intermediate-level bilinguals had mixed results, their performance ranking between those of the basic and the advanced bilinguals in terms of accuracy when answering questions about the number of objects.

When analyzing the data in Statistics, ANOVA demonstrated the presence of a statistically significant difference between the results for groups, with $F = 114.81$, $p < .05$. The results of Scheffe's test are presented in Table 4 below.

Table 4

Accuracy Rates in Relation to Memorizing the Number of Objects

Group of participants	Basic-level Thai-English bilinguals	Intermediate-level Thai-English bilinguals	Advanced-level Thai-English bilinguals	Monolingual English speakers
Monolingual Thai speakers	.113	.00*	.00*	.00*
Basic-level Thai-English bilinguals	-	.00*	.00*	.00*
Intermediate-level Thai-English bilinguals	-	-	.011*	.00*
Advanced-level Thai-English bilinguals	-	-	-	.015*

*Scheffe's test, p = .05

Table 4 above reveals accuracy rates in relation to memorizing the number of objects among groups of participants. The results are quite similar to those for the attention test. The monolingual English speakers remembered the number of objects more accurately than the monolingual Thai speakers, with a statistically significant difference present ($p < .05$). In the case of the bilinguals, the advanced-level Thai-English bilinguals remembered the number of objects more accurately than the intermediate-level Thai-English bilinguals and the basic-level Thai-English bilinguals, with a statistically significant difference again present ($p < .05$).

With respect to the monolinguals and the bilinguals, the advanced-level Thai-English bilinguals remembered the number of objects more accurately than the intermediate-level Thai-English bilinguals and the basic-level Thai-English bilinguals, with a statistically significant difference present ($p < .05$). There was also a statistically significant difference ($p < .05$) between the monolingual English speakers and the advanced-level Thai-English bilinguals. Conversely, there was no statistically significant difference ($p > .05$) between the basic-level Thai-English bilinguals and the monolingual Thai speakers.

Discussion

This study demonstrated that grammatical number in Thai and English is associated with cognitive differences between monolingual Thai speakers and monolingual English speakers, in line with the results of research by Charunrochana (2000). Additionally, interesting results were recorded for bilinguals. In this study, we found that basic-level and intermediate-level bilinguals showed an awareness of the number of objects. Basic-level Thai-English bilinguals showed little awareness of the number of objects, with their results similar overall to those for monolingual Thai speakers. Advanced-level Thai-English bilinguals, on the other hand, showed a high level of awareness in relation to the number of objects. Their level of awareness was much higher than that shown by intermediate-level and basic-level Thai-English bilinguals, although it must be acknowledged that significant differences existed in results for advanced-level Thai-English bilinguals and monolingual English speakers. Intermediate-level Thai-English bilinguals" behavior lay between that of basic-level bilinguals and that of advanced-level bilinguals. This suggests that acquiring a second language influences bilinguals' cognition by leading them to gradually align their cognitive behavior with the grammatical structures of their second language, a finding that aligns with those of previous studies (e.g., Aemdit & Prasithrathsint, 2016; Athanasopoulos, 2006, 2007; Athanasopoulos & Kasai, 2008). This implies that language influences the cognitive system of its speakers in ways that are not limited to the respective first languages of the speakers. According to the linguistic relativity hypothesis, speakers of languages with similar grammars have similar cognitive systems, while those with different grammatical structures have different cognitive systems. This is evidenced by the fact that bilinguals have cognitive systems that are more similar to those of speakers of their second language than their first, indicating that a language learned later in life can influence speakers' thought processes.

The results of this study show that changes in cognition may occur when bilinguals start to gain proficiency in a second language. Significant change may occur when bilinguals have a higher proficiency level in a second language. Therefore, proficiency in a second language influences bilinguals at different levels. The higher the proficiency level bilinguals have in a second language, the greater awareness they display of the number of objects in cognitive tasks, which is relatively similar to that of monolingual English speakers. A similar phenomenon was found in Athanasopoulos's (2006) study. Athanasopoulos also found that cognitive changes may happen to bilinguals with low levels of proficiency in a second language.

Regarding language of instruction, the bilinguals in this study were asked to use the bilingual (Thai-English) version when completing the

cognitive tasks. It was found that most of the advanced-level and the intermediate-level Thai-English bilinguals answered the questions in Thai. 40% and 16.67% of participants in each group, respectively, answered the questions in English. When analyzing accuracy rates, there were no significant differences between the intermediate-level and the advanced-level Thai-English bilinguals when answering questions in English or Thai. The findings were consistent with those of Athanasopoulos (2007) and Athanasopoulos and Kasai (2008), even though the experiment designs were different. Bilinguals in these studies were asked to perform cognitive tasks in their first and second languages. The researchers found no cognitive shift when bilinguals were tested in their first and second languages.

This finding called into question the notion of "thinking for speaking" proposed by Slobin (1996) on the issue of apparent cross-linguistic influences on cognition that Athanasopoulos (2007) mentioned. According to the notion of "thinking for speaking," human thought should be restricted in speech production, such as in comprehending, speaking, etc. Thus, it might be assumed that bilinguals would show their preferences based on the language of instruction that they engaged with in an experiment. However, we and Athanasopoulos found that the shift in bilingual cognition, without regard to the language of instruction, may indicate that language, as Lucy (1992a) initially proposed, may influence habitual cognition at a deeper level.

In addition, length of stay in English-speaking countries did not seem to influence the bilinguals' cognition. To be clear, staying in English-speaking countries offers the opportunity to use English in daily life. It may be assumed that the longer bilinguals stay in English-speaking countries, the higher their proficiency level in English will be. Due to the COVID-19 pandemic, some participants in this study had a chance to stay in English-speaking countries for very short periods of time, typically around one week to three months. We found no statistically significant differences between bilinguals who had never been to English-speaking countries and those who had stayed in English-speaking countries. The results correlated with Athanasopoulos (2007) and Athanasopoulos and Kasai (2008). Japanese-English bilinguals in these studies stayed in English-speaking countries for six to ten months. However, the results did not align with Cook et al. (2006). The authors revealed that Japanese-English bilinguals who stayed in English-speaking countries for more than three years exhibited cognitive behavior quite similar to that of native speakers of their second language. In our opinion, this might confirm that a short stay in a country in which their second language is used does not affect bilinguals' cognition. However, based on our findings, it remains unclear which specific length of stay would be necessary to influence cognitive behavior, as no significant differences were observed, even for stays ranging from one week to three months. Further research is needed to

determine whether longer stays, such as those exceeding several years, are required to affect cognitive changes in bilinguals.

Conclusion

This study aimed to test the effect of grammatical number on the cognition of speakers. It also investigated whether knowledge of a second language with contrasting grammar from the first language affected bilinguals' cognitive processes. English is a language in which it is obligatory to express grammatical number, while in Thai this is optional. The experiments focused on testing monolingual Thai speakers, monolingual English speakers, basic-level Thai-English bilinguals, intermediate-level Thai-English bilinguals, and advanced-level Thai-English bilinguals. Attention tests and memory tests using short answer questions were adopted to test their cognitive behaviors. In the attention test, participants were shown pictures and asked to answer one question for each picture. In the memory test, participants were shown pictures and asked to answer five questions for each picture. Non-test pictures were included in the test to reduce participants' consciousness about what they were being tested on.

Parallel results were obtained for the attention and memory tests. We discovered evidence demonstrating the effect of grammatical number on speakers. Among the monolinguals, the English speakers paid attention to and memorized the number of objects, results indicating a significant difference from the monolingual Thai speakers. The advanced-level Thai-English bilinguals paid attention to and memorized the number of objects more than the intermediate-level Thai-English bilinguals, the basic-level Thai-English bilinguals, and the monolingual Thai speakers but less than the monolingual English speakers. However, there was no significant statistical difference between the basic-level Thai-English bilinguals and the monolingual Thai speakers. The results for the monolingual Thai speakers are not surprising due to the fact that Thai is a language in which it is optional to express grammatical number. Therefore, their cognitive behavior in paying little attention to or not memorizing the number of objects corresponds to a lack of grammatical number in Thai. In relation to the basic-level Thai-English bilinguals, although their results were not significantly different from those for the monolingual Thai speakers, their scores on the attention and memory tests were higher than those of the monolingual Thai speakers. The findings of this study support the notion of the effect of grammar in languages on the cognition of speakers. It also provides useful insights into bilinguals' cognitive processes, suggesting the possibility that acquisition of a second language affects bilinguals' cognition.

These findings emphasize the importance of promoting bilingualism in Thailand through language policy. They suggest that Thailand could greatly benefit from fostering bilingualism, not only to boost English proficiency but also to establish bilingualism as a societal norm. Achieving fluency in a second language allows individuals to think and process information more like native speakers, improving communication both locally and internationally. A bilingual society would promote inclusivity, enhance individual opportunities, and strengthen Thailand's position in a globalized world where multilingualism is highly valued. To realize this, language policies should prioritize supporting the equal use of both the first and second languages across all aspects of life, beginning at an early age.

Additionally, the findings highlight the significant impact of a language's grammar on the cognitive processes of its speakers, particularly in cognitive behavior involving attention and memory related to numerical awareness. In this study, the English speakers demonstrated better attention and memory in relation to the number of objects then the Thai speakers. This was, likely due to differences in the grammatical structures of the two languages, such as the existence of singular and plural forms in English. Language proficiency, especially in a second language, plays a vital role in affecting bilinguals' cognition. In light of this, language education policies in Thailand, especially those aimed at improving English proficiency, should not only focus on language skills but also consider how grammatical differences affect cognition. Additionally, raising awareness of how these linguistic differences impact cognitive behavior could enhance both language skills and broader cognitive and cultural understanding.

Further research could specifically look at aspects and issues not addressed in previous studies. If researchers want to prove the linguistic relativity hypothesis in relation to bilingualism, comparisons between monolinguals and bilinguals should be made. Further research should lead to comparing bilinguals with different levels of proficiency in a second language in both directions, such as Thai-English bilinguals and English-Thai bilinguals with different levels of proficiency in their respective second languages. Comparisons should then be made between monolingual Thai speakers and monolingual English speakers. It would be interesting to know whether grammar in languages affects speakers' cognition and whether bilingualism influences bilinguals' cognition at different levels among groups of Thai-English bilinguals and English-Thai bilinguals. Additionally, further research should also examine the effects of spending different durations in second language-speaking countries in order to determine whether different durations spent in second language-speaking countries affect bilinguals' cognition at different levels.

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