The Effects of Exposure to Chinese Numeral Classifiers on the Categorization of Objects by Native-English Speakers

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Abstract

The current research investigated whether exposure to numeral classifiers (NCs) in Mandarin Chinese impacts non-classifier language speakers' object categorization. As classifier selection depends on the physical attributes of the associated noun, NCs are ideally suited to exploring the link between language and semantic categorization (e.g., Mandarin 'zhi' is used for long and rigid objects and 'tiao' for long and flexible objects). Prior research on the role of NCs in object categorization (Sera, Johnson & Kuo, 2013, among others), compared speakers of classifier languages (e.g., Chinese) and non-classifier languages (e.g., English) but did not address the causal relationship between exposure to NCs and object categorization. We sought to address this gap through a training study comparing object categorization among two Native-English speaking groups (experimental versus control). We hypothesized that the experimental group, which was exposed to Mandarin NCs, would demonstrate a bias towards grouping together objects sharing the same classifier. Native-English speaking undergraduate students (N=99) were randomly assigned to the experimental or the control group. The experimental Group (but not the control group) was systematically exposed to NCs using a visual, auditory and haptic integration module. Two categorization tasks (Forced-Choice and Go/No-Go) were used to evaluate the participants' object categorization preferences. The results indicated that the experimental group produced a significantly greater number of responses based on classifier-based selection than the control group in both the Forced-Choice task and the Go/No-Go task. The experimental group's bias towards grouping together classifier-sharing objects in both tasks supported our hypothesis that exposure to NCs influences non-classifier language speakers' object categorization. The implications of the findings for cognitive approaches to categorization and the link between linguistic and conceptual structure is discussed.

Keywords: language and cognition, Chinese numeral classifier, object categorization

1. Introduction

The link between language and cognition has been of interest to cognitive scientists (e.g., Fodor, 1975; Pinker, 1994), linguists (e.g., Chomsky, 1997) and philosophers (e.g., Humboldt, 1836; Wittgenstein, 1971). Various theories attempt to answer the question of whether language shapes the way we think and the way we view the external world. This interest has largely been motivated by how different languages represent the world.

Linguistic relativity theory, popularized with the Sapir-Whorf hypothesis, indicates that language experiences determine thought. Research studies examining number conception among the Pirahã people (Everett, 2005) and color perception among the Zuni people (Brown & Lenneberg, 1954) provided evidence that people can only perceive certain ideas based on the language that they use. However, the Sapir-Whorf hypothesis has been heavily criticized for lack of empirical support and vague formulation on the influence of language (Pinker, 1994; Fodor, 1975).

To address the lack of empirical support and vague formulation on the influence of language in the Sapir-Whorf hypothesis, some studies (Lucy, 1992; Levinson, 1996; Boroditsky, 2001; Srinivasan, 2010) used empirical research methods to examine how specific linguistic structures influence thought and other non-linguistic behaviors. Empirical evidence is used to explain the interrelatedness and influences between language, cognition, and culture. Much of the recent research in this area of language and cognition examines the differences in cognitive processing which corresponds to differences in language-specific features, such as grammatical gender in Spanish (Phillip & Boroditsky, 2003) and linguistic tones in Vietnamese (Deutsch, Henthorn & Dolson, 2004). The present study builds on this empirical research, with a focus on numeral classifiers in Mandarin Chinese.

Numeral classifiers are free or bound morphemes that stem from lexical-semantic implications but are bound to the agreement and grammatical rules of the language. Numeral classifiers are often described synonymously as measure words; however, these two terms are cognitively and semantically distinct (Her & Hsieh, 2010). One of the main differences can be observed within the classification of countable nouns.

In English, in the case of an uncountable noun (e.g. water) a measure word (e.g. glass) accompanies it, as for example in the phrase, 'one/a glass of water'. The uncountable noun is contained in a measuring unit in the noun phrase, necessitating the use of measure words. In contrast, in the case of a countable noun (e.g. pen) in English, a measure word is not required. (See Table 1).

Language	Uncountable Nouns	Countable Nouns
English	One glass of water	One pen
Mandarin Chinese	一 杯 水 yi4 bei1 shui3 'One CL water'	一 支 笔 yi4 zhi1 bi3 'One CL pen'

Table 1: Comparison between English (non-classifier language) measure words and Mandarin (classifier language) numeral classifiers
Note. Pinyin, the standard transliteration used for Chinese characters are given below the Chinese characters. The numeral beside the pinyin indicates the tone in Mandarin Chinese.

However, in classifier languages such as Mandarin Chinese, a semantically compatible classifier or measure word must be placed before the noun when a numeral is present. For example, 'one X pen' will be the grammatically correct noun phrase to describe one pen where X represents the appropriate numeral classifier zhi that provides semantic information (i.e., long and rigid) corresponding to the countable noun 'pen'. Therefore, the classification of countable nouns with numeral classifiers is the distinguishing factor between a classifier language (Mandarin Chinese) and a non-classifier language (English).

In addition to their function in language, numeral classifiers also reflect the cognitive constructions of our sensation and perception. Based on a typological study of classifiers by Allan (1977), composition, shape or dimensionality and size are three configurational aspects that are relevant to the Chinese numeral classifier systems. To determine the appropriate numeral classifier, Chinese speakers need to identify and categorize objects based on specific physical characteristics. Furthermore, Allan (1977) proposed that classifier systems were constructed based on knowledge that comes from the body via different sensory modalities (e.g., vision, haptic), which corresponds to Lakoff's (1987) notion of linguistic embodiment. Classifier language speakers use their understanding of certain physical features of an object to understand the higher-order conceptual representation of categories using language.

Lakoff (1987) proposed that classifiers reflect speakers' conceptual representation and form the structure of conceptual categories through linguistic categorization. Since then, many studies have been carried out from this perspective to explore the motivating factors for the categorization of Chinese classifiers. For example, Tai & Wang (1990) pointed out that 条 (tiao "branch") represents a certain type of human categorization, based on the perceptual property of 'extension in length', which stems from the original meaning of the character. Similarly, using the same analysis, 张 (zhang) represents the property of 'extension in length and width', a human categorization for flat objects (Tai & Chao,1994).

Thus, given the relevance to linguistic embodiment and conceptual representation, numeral classifiers are ideally suited to exploring the link between language and cognitive processing. Previous research on language and cognition has focused largely on comparing cognitive processes among monolingual speakers of different languages (e.g. English Speakers vs. Mandarin Chinese Speakers) and bilinguals (e.g., Chinese-English Bilinguals) to address cross-linguistic comparisons. However, these cross-linguistic studies were not successful in establishing a causal relationship between language and cognitive performance due to lack of a random procedure for the assignment of participants to groups.

The issue with non-randomization is precisely where an experimental training study can provide a clearer focus. A training study controls for non-language factors (e.g., culture, age) by comparing, for example, Native-English speakers trained in the target language-specific structure with another group of Native-English speakers, who have been randomly assigned to their respective group conditions. Also, it is assumed that this sample of English speakers, having a 'blank slate' without prior exposure to numeral classifiers, would help to establish a clearer language effect. By controlling various aspects of the training and confounding variables, systematic cognitive differences among groups of participants can be attributed to the language training. This inference of causality is an aspect that has not been adequately addressed in many previous studies.

Among many language and cognition studies, Boroditsky (2001) is one of the few research studies which utilized a training module to examine the influence of Mandarin language structures among English speakers. In English, time is expressed horizontally (e.g. from left to right). For example, the week before and the week after. In contrast, time can be expressed both horizontally (e.g. from left to right) and vertically (e.g. from top to bottom) in Mandarin Chinese. For example, 上周 "up" week ('the week before') and 下周 "down" week ('the week after'). Chinese speakers and English speakers showed group differences in representation of time corresponding to their respective languages.

In addition to the two groups (Chinese and English speakers), a third group that consisted of native-English speakers that were trained to view time vertically, showed a shift from an English-based "horizontal" perspective of time to the Chinese-based vertical time arrangement. The training utilized a priming paradigm to familiarize the participants with example sentences that used vertical orientations, for example "Monday is above Tuesday" or "Monday is higher than Tuesday". Boroditsky's research showed the influence of language-specific features on the participants' conception of time which demonstrates a directional interaction between language and cognition.

Boroditksy's (2001) study motivated the present research to utilize an experimental training module to assess the causal relationship between numeral classifiers and cognitive processing. Specifically, the present study sought to examine whether training English speakers to learn Mandarin Chinese Numeral Classifiers would influence how they perceive and categorize objects.

2. Predictions

Previous nonrandomized research designs that examined linguistic relativity in relation to Chinese numeral classifiers relied on non-parametric designs that were only able to show a non-directional interaction between language and cognitive processing (Saalbach & Imai, 2012; Huettig, Chen, Bowerman & Majid, 2010).

To address the causal relationship, which is lacking in the field, this study sought to examine whether exposure to numeral classifiers is a causal factor that explains differences in cognitive processing. To our knowledge, there are no randomised controlled training studies involving Chinese numeral classifiers and categorization. In addition, this study contributes unique insights into examining the influence of Mandarin Chinese numeral classifier knowledge on categorization among non-Chinese speakers (e.g. Native-English speakers).

In seeking to establish whether there is a causal link between language-specific structures and cognitive processing, the present study compared the cognitive performance of "trained" (i.e., exposed to Mandarin Chinese numeral classifiers) and "untrained" English speakers on two object categorization tasks. Our prediction was that English speakers would perform differently corresponding to their exposure to Chinese numeral classifiers. We hypothesized that the experimental group would demonstrate a stronger preference for categorizing objects using a Chinese classifier-based (i.e. shape-based) system than the control group in two cognitive tasks (Forced-Choice task and Go/No-go Task), indicating a language-specific effect on non-linguistic cognitive processes.

3. Method

3.1 Participants

Permission was sought and obtained from the Human Subjects' Committee at Southern Illinois University for conducting the study before data collection. 124 undergraduate students (18-25 years of age) at a Mid-Western University in the US participated in this study. All the participants received course credit for their participation. Before the experiment, each participant completed a questionnaire (adapted from Lakshmanan, 2004) that required information about their general background and prior language experience. Upon providing their written informed consent, the participants were randomly assigned to the experimental or control group. The specific purpose of the study was, however, not revealed to the participants prior to their participation.

Individuals (n=25) were excluded from the data analysis due to (a) their having prior knowledge of a Chinese language, and/or other classifier languages (e.g., Korean, Thai and American Sign Language) (n= 23) and (b) failure to achieve a classifier accuracy score of more than 70% in the training phase (n= 2). The remaining 99 participants were included in the data analysis. In addition to the main research, a preliminary study was conducted with an independent group of participants (n=38) to determine the object pairs that were used in the testing phase. Table 2 shows the demographic information for the preliminary study and the main study.

Table 2
Participant demographic information (Main Study and Preliminary Study)

	n	Male/ Female	Age (in years) Mean (SD)
Preliminary Study	38	15/23	18.68 (1.165)
Main Study			
Control Group	50	19/31	18.940 (1.544)
Experimental Group	49	17/32	18.918 (1.967)

Table 2 : Participant demographic information (Main Study and Preliminary Study)
Note. SD= Standard Deviation

3.2 Materials and Procedure

The study consisted of two phases, namely a training phase and a testing phase. The training phase for the experimental group was designed to introduce and familiarize the group with Chinese numeral classifiers. Concurrently, the control group completed an analogous task that required a similar duration and effort as the experimental group. In the testing phase, participants from both groups were then assessed with two cognitive tasks: a triad Forced-Choice Task and a Go/ No-Go task. The two tasks in the testing phase were identical for both groups. The entire experiment was programmed using E-Prime and took approximately one hour to complete. All experimental sessions were conducted in a lab where participants were tested individually using a computer.

3.2.1 Preliminary study.

The purpose of the preliminary study was to control for other categorization approaches (e.g., taxonomic, thematic and shape-based). Participants were required to label the object pairs (presented as images) and rate the level of similarity between the pairs using a 7-point Likert scale, with 1 being very dissimilar to and 7 being very similar. An average similarity rating score was computed for each object pair, and the score was used to determine the object pairs to be included in the testing phase. All the object pairs that were used in the testing phase had a comparable similarity baseline (i.e., rated as “not similar”) based on the similarity ratings obtained from 38 participants independently from the main study. Participants were presented with 140 object pairs. Of these, 16 object pairs were excluded from the testing phase due to their high similarity rating scores (mean= 4.32). Table 3 shows the descriptive statistics on the remaining 124 object pairs that were used in the testing phase.

Variable	Mean	Median	SD
Mean Similarity Rating	1.53	1.45	0.45

Table 3: Descriptive Statistics of Object Pairs Rating in the Preliminary Study

3.2.2 Multisensory training phase

In the training phase, participants (in the experimental group) received exposure to Chinese numeral classifiers integrating sensory input from multiple modalities (i.e., auditory, visual and haptic). Throughout the training phase, participants are exposed to four Chinese numeral classifiers (zhi, tiao, zhang, ke). These numeral classifiers were selected based on their relevance to daily Mandarin Chinese usage (Erbaugh, 1986) and their representation of primary shapes (i.e., long-rigid, long-flexible, flat-flexible and round) that were identified in other classifier systems (Adams & Conklin, 1973).

A challenge for training designs such as the one adopted in this study was how to ensure that both groups have an analogous experience in this study without influencing the outcome of the study. Given that certain parts of the training phase were modified, all effort was taken to ensure both groups were presented with identical object stimuli throughout the study and the tasks required a similar degree of effort and time to complete. The video stimuli presented in the training phase were vital in establishing the numeral classifier knowledge among the experimental group. On the contrary, precautionary measures were taken to ensure that no information about numeral classifiers was visible in the control group's modified videos. First, the videos presented to the control group were cross-checked with two independent reviewers to examine the possibility of lip reading from the video despite muting the volume. Both examiners were not able to decipher the content of the conversations that took place in the videos when the volume was on mute. Second, the control group was asked about their opinion on the videos after the experiment, and they were not able to figure out the context of the videos.

Participants completed three tasks in the training phase (for a detailed description, see Tio, 2016). First, the experimental group learned the four Chinese numeral classifiers via four video stimuli and 12 comprehension questions (e.g., "zhang is used to describe objects that...?", "Objects that are long and rigid use the classifier...?"), based on the video. The videos involved a conversational interaction between two students in a college setting to ensure that the video stimuli are pragmatically appropriate. Numeral classifiers (using Chinese characters) were shown, and the Chinese speaker in the video explained the use of each of the four numeral classifier with different objects. In contrast, the control group viewed a modified version of the same videos. The videos were presented with the sound on mute, and the scenes that contained instructions on Chinese numeral classifiers were removed. The comprehension questions for the control group included mundane questions about the video such as, “How many individuals appeared in the video?” and “which of the following objects appeared in the video?”. This was done to ensure that the control group participants remained engaged throughout the task.

Next, for the haptic task (7 trials), both groups were presented with an object concealed in a box, one at a time. Participants could only rely on physical touch to identify the objects. The objects presented were identical for both groups. The participants in the experimental group were required to identify the numeral classifier that is appropriate for that object while the control group was required to identify the label of the object in English. For the matching task, the participants in the experimental group were asked to indicate as quickly as possible whether an object matched the Chinese numeral classifier (presented on the computer screen); similarly, the control group participants were asked to indicate whether an object matched the English label provided on the computer screen as quickly as possible. There were 24 matching trials with two practice trials and 22 experimental trials. Participants received feedback after each question in the training phase.

The experimental group participants’ accuracy rates in the comprehension task, haptic task and matching task were used to determine their Chinese numeral classifier proficiency. Two participants that failed to demonstrate satisfactory numeral classifier knowledge (i.e., having less than 70% accuracy rate in any one of the three tasks in training phase) were removed from further analysis. This criterion was set to ensure every participant in the experimental group had a good understanding of Chinese numeral classifiers. Numeral classifiers were introduced explicitly to the experimental group only in the training phase.

3.2.3 Testing phase

The Forced-Choice Task consisted of 28 trials, with four practice trials, eight filler trials, and 16 experimental trials. This task involved a forced choice between two selections based on a target object (presented above the two selections, see Figure 1). The target object was one that in Mandarin Chinese took one of the four numeral classifiers (ke, tiao, zhi, zhang) while the two selections were a classifier-sharing object (sharing the same classifier as the target stimulus) or a distractor object. Participants were instructed to select one of the two objects that matched the target stimulus (i.e., that they perceived to be more similar to the target object) as quickly as they could. However, this paradigm has received criticism due to its susceptibility to the Simon effect, where responses are faster when stimulus location corresponds to a response location (Ratcliff & Smith, 2004). Therefore, to control for this stimulus location correspondence effect, the left and the right placement of the selections (classifier and distractor objects) were counterbalanced in each trial.

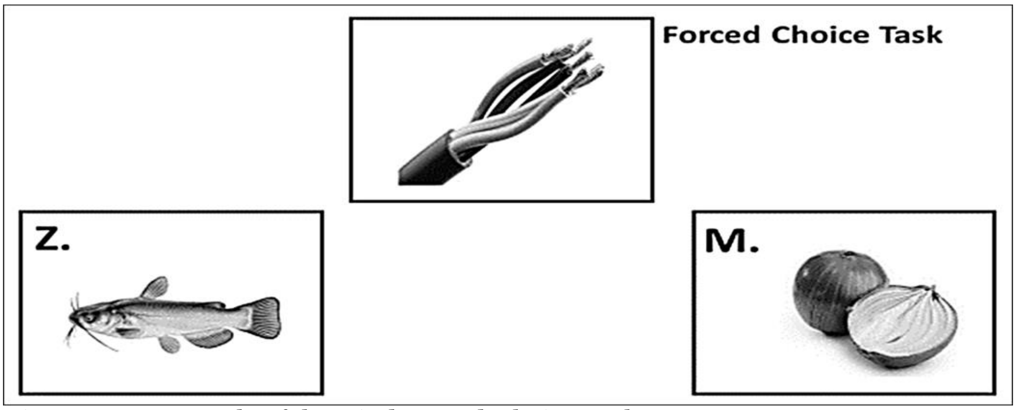

Figure 1. An example of the triad Forced-Choice Task.
Note. Z and M can be a classifier-sharing object or a distractor object. In this example, the target ("wires") and Z ("fish") share the same numeral classifier tiao.

The second task was an adaptation of the Go/ No-Go Task commonly used in neuropsychology assessments (Donders, 1969; Luria, 1969). Like priming tasks, the G0/No-Go Task indexes preferences by assessing the strength of the association between a target category and two poles of an attribute dimension (e.g., similar-dissimilar) (Nosek and Banaji, 2010). This task requires a response selection process between either executing or inhibiting a motor response (i.e. press a key on the keyboard), triggered by a go- or no-go stimulus. This task included two practice trials and eight experimental trials (four go trials and four no-go trials). In each trial, a target object (Object A) was presented in the centre of the screen followed by a string of objects (five distracter objects and three classifier-sharing objects) presented one at a time (see Figure 2). There are three recorded responses for each trial corresponding to the three classifier-sharing objects. A fixation cross was presented before every object stimulus. The order of presentation of the objects was randomized.

In the Go trials, participants were required to press on "R" (on the keyboard) as fast as possible when the stimulus object matches the target object shown on the first slide and ignore the objects that do not match the target object. Whereas in the No-go trials, participants were required to press on "U" (on the keyboard) when the items displayed matches the target object and to ignore the objects that match the target object. Go trials assessed participants' ability to categorize objects using classifier-related features (shapes, dimensionality, consistency) while No-go trials assessed their ability to inhibit those categorization preferences when instructed. Findings from Go trials and No-Go trials reveals the participants' capability to execute classifier-based categorization effectively.

Each object appeared on the screen for 2000 milliseconds unless a response took place before the response deadline. Since the similarity ratings for all stimuli pairs used in the study were comparable (findings from the Preliminary study), the control group was expected to have an equal preference for both classifiers-sharing objects and distracter objects.

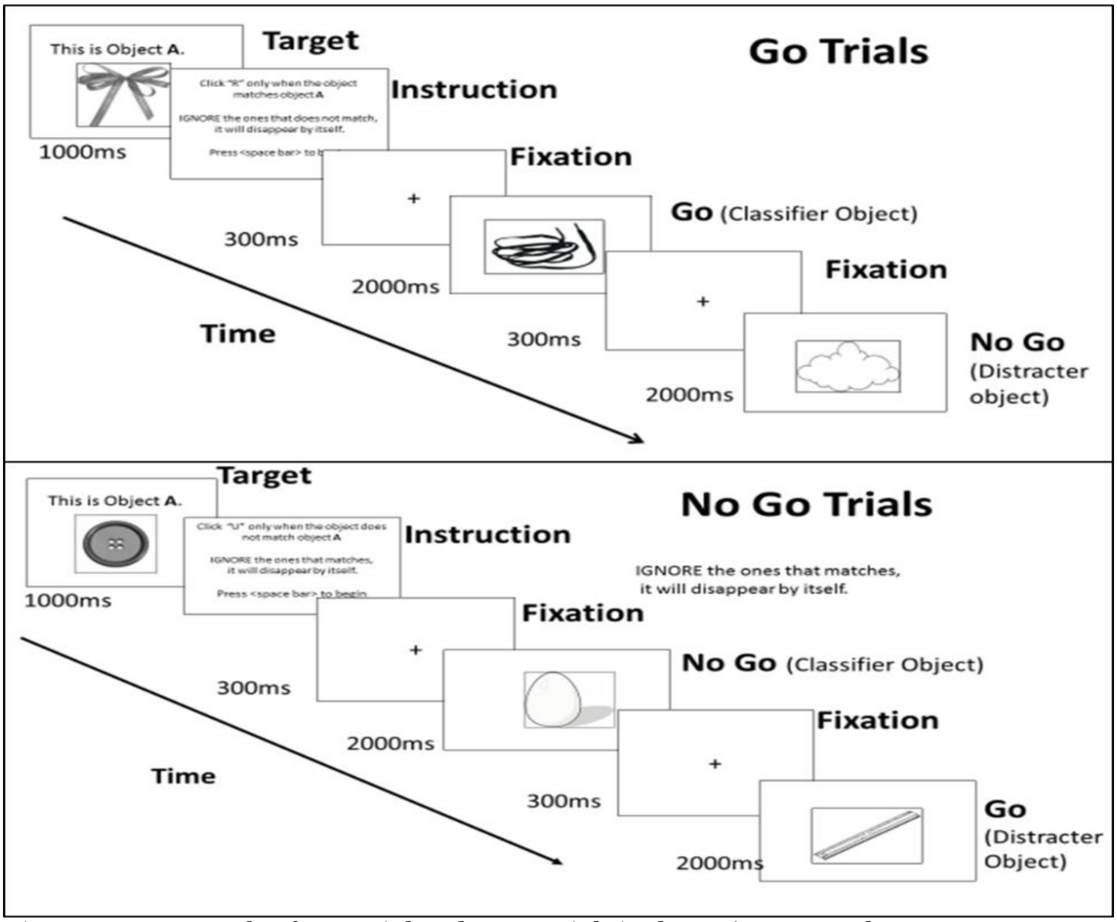

Figure 2. An example of a go trial and no-go trials in the Go/ No-Go task.

3.3 Statistical Analyses

A 2 × 4 mixed-design ANOVA with group (experimental vs. control) as the between-groups factor and classifier type (*zhi*, *tiao*, *zhang, ke*) as the repeated measures, was conducted based on the participants' frequency of selecting classifier-sharing objects on the Forced-Choice Task. The analysis produced tests for Main Effects of Group, Main Effects of classifier type and the interaction between them. Simple effects analysis was conducted to determine whether group differences are present with individual classifier types.

For the Go/No-Go Task, a 2×2 mixed-design ANOVA was conducted with Group (Control, Experimental) as the between-subject factor, Trials (Go Trials, No-Go trials) as the repeated measure, and frequency of selecting the classifier-sharing object as the dependent variable. The analysis tested for Main Effects of Group, Main Effects of Trial and the interaction between them.

Although error rates and response times were recorded for both tasks, the scope of this paper is limited to considering only the analyses pertaining to the frequency of selection of a classifier-sharing object. The participants' responses were categorized in terms of hits (Go trials) and false alarms (No-Go trials). In the context of this study, a hit rate is the proportion of responses where a classifier-based object is selected in the Go trials while false alarm rate is the proportion of responses where participants failed to inhibit a classifier-based selection in the No-Go trials.

4. Results

4.1 Multisensory Training Phase

A mean accuracy score was computed for each task in the training phase for the experimental group (see Table 4). Additionally, the control group's accuracy rate in the training phase was computed to assess the participants' level of attentiveness. The main purpose of the tasks in the training phase was to ensure that the control group remained engaged in a comparable activity while the experimental group received exposure to numeral classifiers. Recall that the control group was asked to respond to visual information that was presented in the video (e.g., the number of individuals in the video) and labels of objects in English (e.g., an image of a toothbrush and the label 'toothbrush' in English). As expected, all participants in the control group have accuracy scores greater than 90%, reflecting their attentiveness to the tasks.

Table 4.
Accuracy Rate in the Training phase

Task	Control Group (n=50) Mean (SD)	Experimental Group (n=49) Mean (SD)
Comprehension	0.973 (0.054)	0.958 (0.058)
Haptic	0.917 (0.064)	0.834 (0.088)
Matching	0.982 (0.037)	0.883 (0.056)

Table 4: Accuracy Rate in the Training phase
Note. The mean value reflected the proportion of accurate responses.

4.2 Forced-Choice Task

The mixed-design ANOVA indicated a significant main effect for group, F (1, 97) = 78.039, MSE =0.430, p < .001, η_p^2 = .446, demonstrating that the experimental group (M =3.245, SE =0.094) had a stronger preference for the classifier-based objects than the control group (M = 2.087, SE= 0.094) regardless of the classifier conditions. There was a significant interaction effect between group and classifier condition, F (2.711, 97) = 10.469, MSE =0.919, p < .001, η_p^2 = 0.098. This effect indicates that the frequency of classifier-based object selection differed based on the classifier condition in the control and the experimental group. To break down this interaction, a simple main effect analysis on each classifier condition was conducted. The analysis revealed that the experimental group had a significantly higher classifier-based object selection in relation to the zhi, tiao and zhang classifier conditions but not in the case of the ke condition (see Figure 3). The main effect of classifier condition was also significant, F (2.686, 260.499) = 22.759, MSE = 0.961, p <.001, η_p^2 = .190.

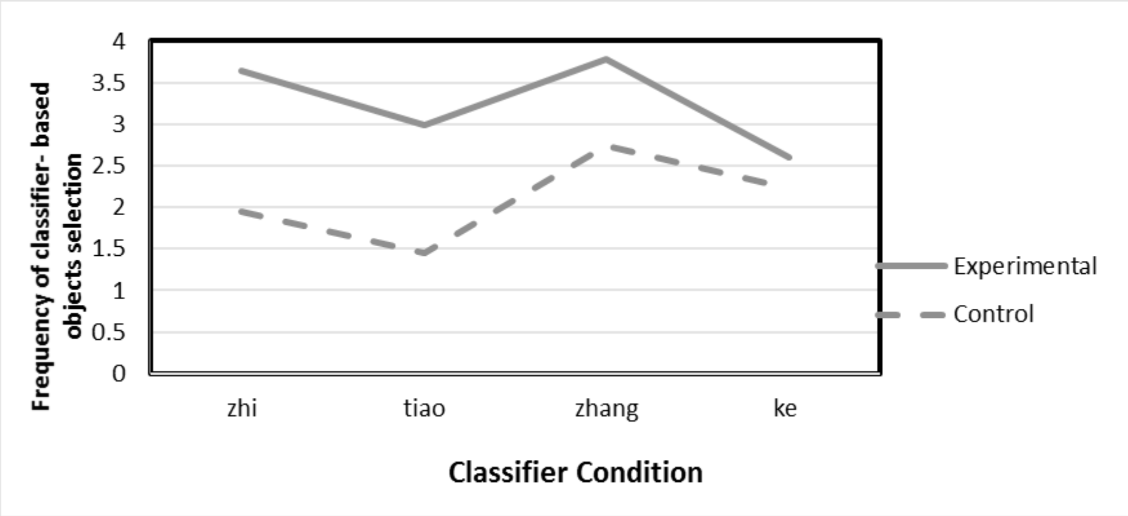

Figure 3. The effects of group and classifier condition on the mean frequency of classifier-based object selection.

Thus, the results of the Forced-Choice Task supported our overall prediction that the native-English speakers in the experimental group, who received training on Mandarin Chinese numeral classifiers would select a classifier-based object significantly more frequently than the native-English speakers in the control group. The simple main effect analysis highlighted the effect of the four individual numeral classifiers on the categorization process. Interestingly, as the results of the tests for simple main effects showed, the zhi, tiao, and zhang classifier conditions had a more prominent effect on the experimental group than the classifier ke condition.

4.2 Go/No-Go Task

The mixed-design ANOVA indicated a significant main effect of Group, F (1, 97) =141.51, p < .001, demonstrating that the experimental group (M =6.08, SE =0.20) was more sensitive towards the classifier-based objects than the control group (*M = 4.51, SE=0.51)* regardless of the trial type. There was a significant interaction between Group (between-subjects factor) and trial type (within-subjects factor), *Wilk's Lambda* = .913, F (1, 97) = 9.218, p =.003 (see Figure 4). This effect indicated that the experimental group and the control group's response rate differed with trial type. As predicted, the control group showed a similar response rate regardless of trial type, responding at chance level, while the experimental group responded more towards the classifier-sharing objects in the Go trials than the No-Go trials. This difference between the two groups' pattern of responses suggested that the experimental group's response rate was more influenced by the classifier sharing property of the target than the control group in both the Go/ No-Go trials.

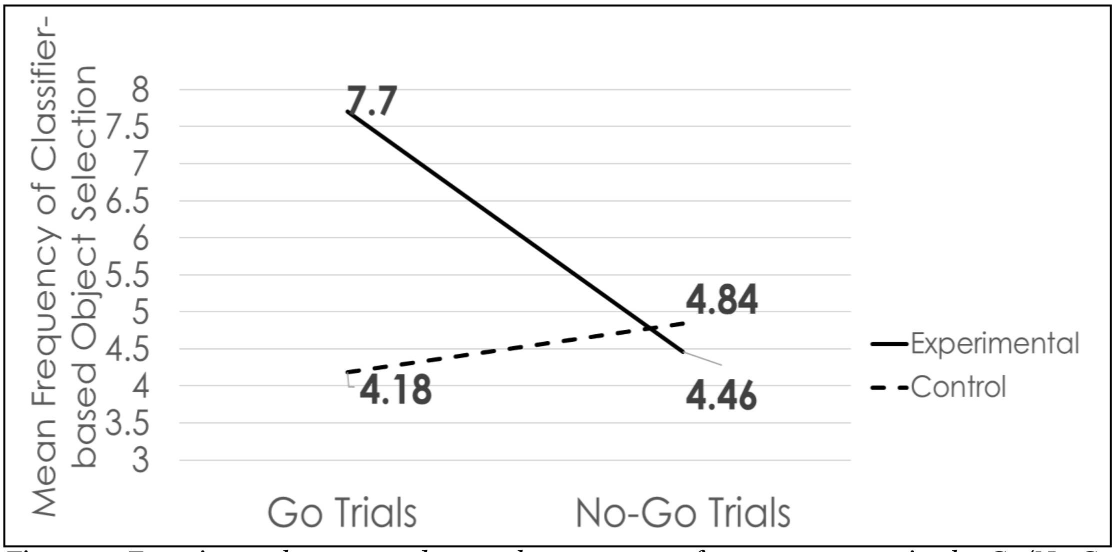

Figure 4. Experimental group and control group mean frequency scores in the Go/No-Go Task. Note. The graph presents hit rates for the Go trials and false alarm rates for the No-Go trials.

5. Discussion and Conclusion

The overarching goal of the current study was to shed light on the causal relationship between language and cognition. The current research utilized a randomised training design to examine if exposure to Chinese numeral classifiers influences object categorization among Native English Speakers. The results of the two categorization tasks overall support the findings of previous research regarding differences in object categorization among classifier and non-classifier language speakers (Sera, Johnson & Kuo, 2013; Gao & Malt,2009; Saalbach & Imai, 2007). Additionally, and importantly, in relation to our goal of seeking to understand the causal relationship between language and cognition, our findings indicated that exposure to (i.e., the learning of) Chinese numeral classifiers significantly impacts non-classifier language (i.e. English) speakers' categorization. The "trained" experimental group showed heightened sensitivity towards certain physical properties of the object. Based on the results from the Forced-Choice task and the Go/No-Go task (i.e. Go trials), compared to the control group, the experimental group displayed greater sensitivity towards objects that shared the same classifier as the target object. In comparison to the control group, the experimental group showed higher hit rates in Go trials and lower false alarm rates in the No-Go trials indicating their ability to discriminate classifier-related characteristics (see Figure 4). The bias towards classifier-sharing objects showed the experimental group's ability to attend to classifier-related features but also to inhibit those responses when needed, as indicated in their lower false alarm rate in the No-go trials.

The experimental group sorted objects using the classifier based categorization system (i.e., categorization based on certain physical features of an object). Receptiveness towards classifier-relevant properties (e.g., shape, dimensionality, consistency and size) is also evident in the form of heightened sensitivity towards an object's composition among classifier language speakers of Mandarin Chinese (Li, Dunham & Carey, 2009) and Yucatec Mayan (Lucy, 1992).

One interesting finding was reflected in the post-hoc analysis of the Forced-Choice Task. As shown in Figure 3 despite the group difference in response rate (selection of classifier-based objects) the trend or patterning of selection is the same for both groups. Regardless of group membership (i.e., experimental or control group), the frequency of selecting a classifier-based object was highest in the classifier zhang conditions (M=3.26), followed by zhi (M=2.7), ke (M=2.41), and tiao (M=2.21). This pattern highlights the three primary shapes: (a) long-rigid, which corresponds to zhi, (b) flat-flexible, which corresponds to zhang and (3) round, which corresponds to ke. These primary shapes were identified in classifier systems across Southeast Asia and East Asia (Adams & Conklin, 1973). The shape, long-flexible, which corresponds to tiao, is less prominent compared to the other three shapes as reflected in the lower response rate. The similar pattern suggests that the classifier system in Chinese (and other classifier languages) might stem from basic or fundamental aspects of human perceptual cognition in advance of any specific language experience.

The results from this study provides support for the notion that language reflects general human cognition and cognitive processes (Lakoff, 1990; Ellis & Robinson, 2008; Boroditsky, 2011). There seems to be a predisposition toward categorization based on the object's physical property (e.g. shape and size) evidenced in classifier-based languages. Moreover, evidence from children's language development (Sera, Johnson & Kuo, 2013; Ken, 1991) supports this predisposition across classifier and non-classifier languages as well. Children often overgeneralize their use of words or labels based on an entity's physical properties. For example, they may use the word ball for all objects that are round (e.g., door knobs). Children's default categorization system is likely driven by fundamental perceptual factors of shape, size, etc.

It is evident from the results that numeral classifier exposure has an impact on the categorization process. This study demonstrates that transfer of classifier knowledge is possible with short latency. In other words, even a brief exposure to a language-specific element in a foreign language might be adequate to influence a speaker's way of thinking. However, a recency effect or temporary accessibility of a concept could very well explain these language effects. Therefore, the long-term effects of classifier exposure and the duration of this sensitivity toward classifier-based object categorization remains to be clarified.

In a longitudinal study on Hebrew children, Kugelmass and Lieblich (1979) observed a change in the representation of temporal sequences corresponding to the directionality of the writing system that they were exposed. Shortly after they learned to read English, the children started to sequence pictures and names from left-to-right, which are inverse of the Hebrew's right-to-left directionality. However, these changes dissipate with time (Tversky et al., 1991). Therefore, examining the temporal aspect of the classifier effect by monitoring classifier categorization in specific durations (e.g. a week, a month, six months or a year) would provide strong evidence to determine if the effects of learning classifiers are permanent or temporary in nature. If the effects are temporary, what is the time span before the classifier effect is lost? In what conditions or contexts will classifier knowledge be best retained? These are vital questions that need to be addressed.

Another related question that remains is if these conceptual changes will generalize outside the controlled experimental settings and the consequences of not considering the cultural factor of language learning that has been a prominent issue in many bilingualism studies. Future studies on language and cognition should consider a real-life language learning setting to address the generalizability of experimental studies. Future studies can also consider replicating the tasks in the testing phase with groups of English-speaking learners of Chinese L2 that have been immersed in the L2 speaking environment for different periods of time and with varying levels of proficiency in Chinese L2. This population would provide a more ecologically valid context of language exposure. English-speaking learners of Chinese L2 could be systematically exposed to not only Chinese numeral classifiers but also to the learning of and immersion in the Chinese language from a more holistic perspective. By controlling the course materials used and the duration of exposure to Chinese, these learners' cognitive shift can be observed more systematically, and the findings could be more informative than other research methodologies.

Apart from the implications for research design, this study also provided supportive evidence for the effectiveness of multisensory-based language learning/teaching. Given previous reports that multisensory convergence could vastly improve object preference (Jao, James & James, 2014), the training phase in this study was designed to incorporate multisensory encoding of the numeral classifiers. The multisensory design allowed the experimental group to maximize their short learning experience by encoding Chinese numeral classifiers in visual, auditory and haptic modalities. Based on the results displayed in Table 1, the experimental group participants were able to successfully learn and apply Chinese numeral classifier information despite the short exposure. All but two participants had an accuracy rate of more than 70%. Despite the brief exposure, learning and practicing classifier knowledge with different modalities helped to increase participants' attentiveness and retention of new information.

To conclude, this study showed support for the causal relationship between Chinese numeral classifiers and cognitive processing in Native-English speakers. The results showed that exposure to classifier knowledge influences non-classifier language speakers' categorization of objects. Apart from the pedagogical implications utilizing multisensory integration, the current study also developed a methodological foundation which can be extended to address different classifier languages (e.g. Thai, Korean, Malay) and different cognitive domains (e.g., memory and cognitive control).

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