Language and Cognition (2023), 15: 4, 815–833
doi:10.1017/langcog.2023.27

ARTICLE

Classifiers in competition for categorization

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(Received 27 December 2022; Revised 11 June 2023; Accepted 15 June 2023)

Abstract
This research probed how classifiers marking an object's membership in the grammar of classifier languages like Mandarin Chinese and Korean may influence their speakers to categorize objects differently compared to speakers of non-classifier languages like English. Surveys in multiple-choice format were given to native speakers of the three languages. Analysis of the results demonstrated that significant proportions of Mandarin Chinese and Korean speakers behaved differently from English speakers due to the classifier-based strategy influencing classifier language speakers' categorization. Adopting the Competition Model, we suggest that among the various categorizing strategies available to language users, the one with the greatest strength at the moment of performing the task wins the categorization competition. Classifiers that are grammaticalized in classifier languages may be providing their speakers with a powerful cognitive tool to notice diverse characteristics shared between objects, which is usually unavailable to non-classifier languages. Therefore, the strength of classifier-based strategy in the minds of classifier language speakers is strong enough to win some of the categorization competitions, which guides them to make different categorizing decisions from non-classifier language users.

Keywords: categorization; classifiers; categorizing strategies; Competition Model

1. Introduction

Language is considered a distinctively human gift, which seems to constantly accompany a broad range of neural or cognitive processes such as learning, remembering events, making decisions, categorizing objects, and experiencing and expressing emotions (Boroditsky, 2019). With more than 7,000 living languages in the world today (Eberhard et al., 2022), it may be difficult to argue that there are more than 7,000 completely distinct ways each language affects such neural or cognitive processes of its speakers, but we can expect that there could be at least some subtle differences between how the languages shape such processes of their users.

Research has already demonstrated that using different languages can lead to different choices in various aspects. For example, when bilinguals participated in incentivized experiments that required cooperation with random other participants,

they were more trusting and trustworthy when the experiments were conducted in their familiar language than when the unfamiliar language was used due to reduced uncertainty when using the familiar language (Li, 2017). Using a different language can even affect moral choice. While communicating in a foreign language, people facing a dilemma were more likely to choose to violate deontological rules and break an ingrained taboo because using a foreign language may decrease deontological responses by weakening emotional reactions (Hayakawa et al., 2017). Such different behaviors attached to distinct languages are also observed in other decision-making processes like risk taking and inferring causal relations (Hayakawa et al., 2016).

Even grammatical features in languages are known to affect human cognition. Speakers of languages with grammatical gender can categorize objects differently than those of languages without grammatical gender; moreover, languages with only two genders, (masculine and feminine), like Spanish and French, seem to influence categorization more than languages with an additional gender category (neuter), like German, because a three-way gender distinction does not accurately reflect the real world (Martinez & Shatz, 1996; Sera et al., 2002).

In an attempt to demonstrate how language can influence our cognitive process, this research investigated whether contrasting structural requirements in different languages can affect people's categorizing decisions. We examined categorizing decisions from native speakers of three of the major languages from around the world that are typologically unrelated: English, Mandarin Chinese, and Korean are respectively ranked as the 1st, 2nd, and 20th most spoken (native and non-native combined) languages in 2021 (Eberhard et al., 2022). Unlike English, Mandarin Chinese and Korean are classifier languages that require classifiers to mark nouns as members of certain categories. Classifiers are independent morphemes that attach to nouns when quantity is specified. As the term suggests, classifiers assign nouns to certain classes based on some of their salient properties perceived by speakers of the language: animacy, shape, function, and size are among the most notable properties of objects that serve as parameters for categorization (Allen, 1977; Friedrich, 1970). Classifier languages, like Mandarin Chinese and Korean, mandate the use of classifiers in nominal contexts specified for quantity. Classifiers can be viewed somewhat similarly to English quantifiers such as *a piece of* (cake) or *a sheet of* (paper), but a key difference between English quantifiers and classifiers in classifier languages is that English quantifiers are used to quantify only mass nouns while classifiers must be applied to all quantified nominals. There are at least two major functions of classifiers (Imai et al., 2010). First, they provide a unit of quantification by linking a numeral to a noun: the Mandarin Chinese classifier *tóu* is required to count the cows in (1a). Second, classifiers can sort nouns based on their semantics (e.g., Lyons, 1977): for example, the Korean classifier *mali* shows that cows and lizards, but not garlic, are classified as animals as in (1b).

(1) a. Mandarin Chinese example
san *tóu* niu/*xiyì/dàsuàn
three CL cow/*lizard/garlic
'three cows/lizards/garlic'

b. Korean example
so/domapaym/*manul sey *mali*
cow/lizard/*garlic three CL
'three cows/lizards/garlic'

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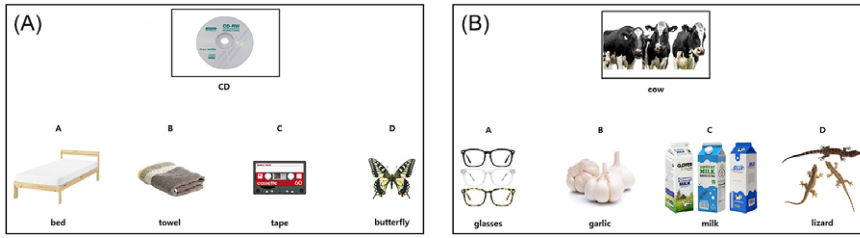

Figure 1. Example singular test item (A) and example plural test item (B).

As in (1), Mandarin Chinese CL *tóu* and Korean CL *mali* follow the numeral[1] and demonstrate cows' membership, but the classifiers in the two languages are not always used identically.[2] Mandarin Chinese *tóu* indicates the head of something and is mostly used for livestock or objects with a head shape while Korean *mali* is used for any nonhuman animal. Thus, due to its head-like shape (Fig. 1B), 'garlic' requires Mandarin Chinese *tóu* but not Korean *mali*, and 'lizard' requires Korean *mali* but not Mandarin *tóu*.

1.1. Categorization strategies and classifiers

Since there is no way of defining categories by means of a single fixed set of criterial (necessary and sufficient) attributes, category membership decisions involve comparing and evaluating various component attributes (Roth & Shoben, 1983). Some of the many possible categorization strategies include, but are not limited to, the following (e.g., Barsalou, 1983; Goldwater & Markman, 2011; Lin & Murphy, 2001): (1) grouping entities by their shared descriptive features into taxonomic categories often based on a hierarchical system (e.g., dogs and cows are mammals), (2) grouping entities that co-occur in a certain situation into thematic categories (e.g., dog and bone), (3) grouping entities playing a common role across situations

[1]Mandarin Chinese nouns follow the numeral and classifier combination while Korean nouns usually precede the numeral and classifier combination. Korean also allows the nouns to follow the numeral and classifier combination with the genitive case particle (optionally) attached to the classifier as the Korean example below demonstrates.

sey	mali(-uy)	so
three	CL(Gen)	Cow

'three cows'

[2]There are also additional differences between the behavior of the classifiers in Mandarin Chinese and Korean, which will not be discussed further in the current paper. For example, Mandarin Chinese classifiers can occur even without numerals, which is ungrammatical in Korean as below. In Korean, the classifier must be either accompanied by a numeral or deleted (and be unspecified in terms of quantity).

Chinese example (from Cheng et al., 2012)				Korean example			
wǒ	mǎi-le	běn	shū	na-nun	chaek	(*kwon)-ul	sa-ss-ta.
I	buy-perf	CL	book	1-Top	book	(CL)-Acc	buy-Pst-Decl
'I bought a book.' (one single book)				'I bought a book.'			

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into role-governed categories (e.g., jar and closet as containers), and (4) grouping seemingly unrelated entities spontaneously to achieve a specific goal into ad hoc categories (e.g., slaves and jewels as things typically taken by conquerors).

As there are various sorting strategies, multiple factors including differences in personal experience, background knowledge, culture, and thinking style could lead to individual differences in categorizing decisions (Lin & Murphy, 2001). It is reported that personal goals, expertise, and interests can impact categorization as was demonstrated by fishermen and university undergraduate students categorizing fish differently (Boster & Johnson, 1989) or tree experts with different domain knowledge using different principles for tree categorization (Medin et al., 1997). Category membership decisions can also be context dependent. For example, 'cow' was recognized faster as a representation for the 'animal' category after subjects read a sentence describing milking an animal than after a sentence describing riding an animal (Roth & Shoben, 1983), and was even falsely recognized when the context of milking an animal was previously given (McKoon & Ratcliff, 1989). Therefore, depending on how such factors interact and are involved in a certain given situation, using categorization strategies that lead to choosing 'pickles' (thematic match) and 'closet' (role match) as to categorize with 'jar' are both very plausible options (Goldwater & Markman, 2011).

An additional potential categorization strategy is grouping entities that share the same classifier for classifier language speakers. There have been studies examining whether grammaticalized categories exhibited by classifiers can affect categorizing decisions made by speakers of classifier languages. They report mixed findings with some concluding classifiers do indeed affect the language users' categorizations (e.g., Kang, 2020; Kuo & Sera, 2009; Lucy & Gaskins, 2003; Sera et al., 2013;) while others providing counterevidence to such claims (e.g., Saalbach & Imai, 2007; Speed et al., 2016). For example, Kuo and Sera (2009) found that, in a forced classification task, speakers of Mandarin Chinese make more categorical decisions based on shape than speakers of English, a non-classifier language. They attribute their findings to the role of shape classifiers in Mandarin Chinese and report that such categorizing tendency increases as the amount of exposure and accessibility to the language increases. On the other hand, Saalbach and Imai (2007) concluded that speakers of Mandarin Chinese speakers did not use classifier categories for their categorizing decisions more than speakers of German, another non-classifier language, although Mandarin Chinese speakers' experience of using classifiers might have made them more sensitive to similarities among objects.

Contrasting reports about the influence of classifiers on categorization from previous studies may be attributed to various factors such as the different methodologies used for the research. However, in this research, we attempt to provide a framework for the mechanism of how categorization decisions are made: we expect that the framework can account for the results of not only this research but also previous studies.

1.2. The Competition Model: A framework for understanding differences in categorization

We constantly make decisions and choices in our everyday lives, which usually involves selecting among a variety of competing options. For example, when you

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are selecting which shirt you want to wear today, there are likely a number of competing factors influencing your decision: color of the shirt, today's weather, or even your laundry situation could be some of the factors you consider. There are numerous theories in which competition is a fundamental construct across various areas closely related to our everyday activities such as cognitive development (Anderson, 1981), motor control (Carlson et al., 1989), and infant attachment (Van Geert, 1991). Language-related phenomena like speech perception (Massaro, 1987) and word recognition (Seidenberg & McClelland, 1989) are also accounted for using the concept of competition.

As a framework originally designed to account for the language acquisition process with most work related to this model focusing on sentence processing, the Competition Model (Bates & MacWhinney, 1982; MacWhinney, 1989, 2013) is based on the main idea that "mental processing involves a continual decision-making process in which there are many possible candidates competing for each categorization decision and the language user must be able to evaluate the candidacy of each alternative in terms of the cues that support it" (MacWhinney, 1989, p. 197). For the current study, we borrow some of its core issues and extend them to provide an account of how spontaneous categorization decisions might be made as a cognitive process.

Other than the concept of competition, the most important issue of this model for this research is cue strength, which can be roughly seen as the extent to which a certain cue can dominate or control a linguistic choice. If multiple cues available for a particular decision point in different directions, the candidate with the highest cue strength is expected to win the competition. Cue strength can be determined by factors such as task frequency and can also be influenced by neurocognitive, developmental, and social forces that strengthen certain cues and affect the timing of interactions between the cues (MacWhinney, 2013). In the same vein, although the concept of cue in the Competition Model is not identical to the categorization strategies entering competition in this study, the strength of categorization strategies will be important in order to provide an account for the categorization process in this study. Concerning the categorization strategies, we posit that all sources of information related to categorization matter and the information can be used as soon as it becomes available, although the various information sources do not carry equal strength (Elman et al., 2004). We apply this type of cue summation model that is widely accepted in psychological models (MacWhinney, 1989) in the current research.

1.3. The present study

In this study, we probed whether grammaticalized categories manifested in Mandarin Chinese and Korean classifiers would exert a large enough influence to compete with the more common categorization strategies like the ones detailed above, thus leading Mandarin Chinese and Korean native speakers to sort items in different ways compared to English speakers. In addition, based on our results that corroborate the long well-known observation that speakers of different languages categorize differently based on various principles (Lakoff, 1987), we suggest a framework based on competition to demonstrate how categorical decisions are made.

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We hypothesized that different classifier-related characteristics of each language will influence its speakers' categorical decisions in separate ways because grammaticalized categories exhibited by classifiers in Mandarin Chinese and Korean can take part in the categorizing competition, which are not available to English speakers; speakers of the three different languages can use different categorizing strategies, which will lead each language group to select a different object for categorization. However, if classifiers in the Asian languages exert no influence on the users' categorization, speakers of all three languages would show similar behavior.

We also posited classifiers are more likely to be activated when speakers of classifier languages are expected to count objects in the plural version of the survey compared to when they must identify objects in the singular version (Kang, 2020). If so, categorizing decisions between the two versions from classifier language speakers will be inconsistent. Individuals may not be overtly thinking of classifiers while participating in the task, but it is suggested that language does not have to be explicitly used in order to influence its speakers: language can provide tools for cognitive activities even when people are mentally using their language in representing external situations, thus converting a nonlinguistic task into a linguistic task (Dessalegn & Landau, 2013; Haun & Rapold, 2009; Ünal & Papafragou, 2016).

2. Methods

2.1. Participants

Sixty native speakers of each of the three languages were recruited to participate in the survey, adding up to 180 total participants. Half of the participants (30 participants) in each language group participated in the singular version and the other half (30 participants) in each language group participated in the plural version. Since bilinguals are not ideal participants for this research, as linguistic differences regarding classifiers in the two or more languages they speak could be a confounding factor, monolinguals were mainly recruited. While many studies recruit university students to participate in their research, this study did not recruit (university) students because their categorizing decisions could be influenced by taking second or foreign language course(s) that tend to be non-classifier languages in China and Korea. Instead, adults over the age of 30, who had finished their formal education long before and rarely use another language in their daily lives, participated in the research. Chinese participants all self-reported that Mandarin Chinese was the only language they use in their daily lives, whereas some English and Korean native speaker participants self-reported that they use other languages in their daily lives. The other languages that the English-speaking participants used included European non-classifier languages like Spanish and French, which generally constituted less than 20% of their linguistic repertoire. As for Korean participants, English was the only other language they used self-reportedly to be at roughly 5% or less in their daily lives. All participants were over the age of 30: average ages were approximately 39.1 (English singular), 39.2 (English plural), 34.8 (Chinese singular), 35.9 (Chinese plural), 40.3 (Korean singular), and 43.1 (Korean plural). The exact male–female ratio could not be provided since several participants did not provide that information, so it could only be inferred (based on those who did provide the information) that there were similar numbers of male and female participants.

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2.2. Materials and procedure

There were a total of 20 items in the survey: 10 test items and 10 filler items. Each test item in the survey included a pivot object and four options that could potentially be grouped together with the pivot. The pivot is placed in the upper central box and four options (A, B, C, and D) are given below the pivot as in Fig. 1. The four options of the test items can be labeled as (1) reality match, (2) Mandarin Chinese classifier match, (3) Korean classifier match, and (4) unrelated match.

First, reality match options in the survey are either a thematic match or a role-governed match; selecting a thematic match involves a simple associative mechanism of thematically relating entities that co-occur within situations as in the pivot 'cow' matching with 'milk' in Fig. 1B; and selecting a role-governed match involves noticing the common relational role of the pivot 'CD' and 'tape' as types of audio data storage formats in Fig. 1A. Many participants in all three languages were expected to prefer this reality match because the saliency and cohesiveness of the thematic and role-governed match can increase participants' sensitivity toward those options (Goldwater & Markman, 2011; Lin & Murphy, 2001; Saalbach & Imai, 2007). The reality match options did not share the same classifier (CL) with the pivots in both Mandarin Chinese and Korean.

Second, a Mandarin Chinese CL match option requires using the same classifier as the pivot object in Mandarin Chinese but not in Korean: 'bed' shares the same Mandarin Chinese CL zhang with the pivot 'CD' (Fig. 1A), and 'garlic' shares tóu with the pivot 'cow' (Fig. 1B). Third, a Korean CL match option requires using the same classifier as the pivot object in Korean but not in Mandarin Chinese: 'towel' shares the same Korean CL cang with the pivot 'CD' (Fig. 1A), and 'lizard' shares mali with the pivot 'cow' (Fig. 1B). For the Mandarin Chinese and Korean CL match options, objects that can be least considered reality matches were selected. In Fig. 1B, for example, in both languages, 'cow' shares the same classifier with 'pig', which can easily be considered a thematic match (as farm animals) or even a role-governed match (as providing meat for humans). Therefore, 'pig' was avoided as either a Mandarin Chinese or Korean CL match, and 'garlic' for the Mandarin Chinese CL match and 'lizard' for the Korean CL match were presented instead. Many classifier languages would group animals into one class, but it is not unusual for a classifier language to assign a lot of animals to one group and have certain animals fall into another (Allen, 1977). The use of the Mandarin Chinese classifier tóu (which literally means 'head') is believed to be related to the saliency of the head shape of certain animals: tóu is used for 'cow' and 'pig', but not for 'horse'. It can be speculated that the reason tóu attaches to 'garlic' is due to its shape being similar to the head of a 'cow', as it is quite common for a member of a classifier category to be seemingly not related to other members (Allen, 1977). On the other hand, the Korean classifier mali is only used for any nonhuman animal, and thus, an animal that is typically not raised on the farm and does not provide meat for humans had to be selected. If classifier language speakers are searching for objects that share the same classifier, Chinese participants were expected to choose significantly more Mandarin Chinese CL matches while Koreans were expected to choose significantly more Korean CL matches.

Finally, the unrelated match ('butterfly' in Fig. 1A and 'glasses' in Fig. 1B) is a random object that cannot be classified as one of the above three match types and does not share the same classifier with the pivot in both languages. It may be selected based on a participant's individual personal experience, but it would be difficult to

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Table 1. List of test items

No. in survey	Pivot	Reality match	Chinese CL match	Korean CL match	Unrelated match
2	CD	tape	bed (zhang)	towel (jang)	butterfly
4	bee	flower	shoe (zhi)	horse (mali)	chair
6	blanket	pillow	snake (tiao)	tent (chae)	computer mouse
8	brick	hammer	instant noodle (kuai)	handkerchief (jang)	feather
10	raincoat	umbrella	shirt (jian)	pants (bel)	keyboard
12	rose	vase	arrow (zhi)	grape (songi)	grill
14	cow	milk	garlic (tóu)	lizard (mali)	glasses
16	sword	shield	violin (ba)	pencil (jalu)	cheese
18	pill	syringe	leaf (pian)	pearl (al)	bicycle
20	scarf	necklace	fish (tiao)	playing card (jang)	smartphone

generalize the rationale for the selection. Table 1 presents the list of all 10 test items. Classifiers for the Mandarin Chinese and Korean CL match objects are in parentheses.

Then, the filler items were intended to prevent the participants from focusing on a certain categorizing strategy by providing four seemingly unrelated options for the pivot (Table 2). Therefore, the pivot and none of the four options in the filler items shared the same classifier either in Mandarin Chinese or Korean, and could not generally be associated together based on thematic or role-governed strategies. Thus, participants' choices of filler items were expected to be at random and not depend on systematic principles. As expected, the filler item result demonstrated that participants responded by choosing random options. No clear response pattern could be found in all language groups except for in a few items like items 11 and 13 in Table 2; participants predominantly associated 'chicken' with the pivot 'airplane' in item 11 probably because both have wings, and selected 'vacuum cleaner' to go with 'cookie' in item 13 probably because cookie crumbs can be cleaned using a vacuum cleaner. Although we did not intend to present such potential for categorization, the result of these items suggests that the participants are striving to categorize using diverse strategies.

For the survey, two versions were created: singular and plural versions. Two versions (singular and plural) of the survey were prepared with the same items because there was a limited number of combinations of appropriate common objects that are not culture-specific for the pivot, the Mandarin Chinese CL match, and the

Table 2. List of filler items

No. in survey	Pivot	Option A	Option B	Option C	Option D
1	soybean	match	newspaper	air purifier	boat
3	cigarette	stroller	cabbage	eraser	diamond
5	mushroom	toothbrush	dress	credit card	clip
7	grass	car	magazine	earring	envelope
9	TV	lighter	egg	gun	tree
11	airplane	key	chicken	watermelon	table
13	cookie	ruler	helmet	flash drive	vacuum cleaner
15	bullet	excavator	firewood	remote control	soap
17	necktie	toilet paper	book	camera	spoon
19	goose	refrigerator	ashtray	ballpoint pen	toothpaste

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Korean CL match. The singular version presented a single entity of the pivot and options (Fig. 1A), while the plural version presented multiple entities of the pivot and options (Fig. 1B). For the plural version, the number of entities in the pivot and the four options within an item were identical: that is, if there are three cows in the pivot, the number of entities in the four options below were three as well as in Fig. 1B. All 10 test items in the plural version were presented with three entities of the objects, while two, four, or five entities of the objects appeared in filler items. Names of the objects were provided below the pictures in their respective languages. There was always a filler item between the test items. In the survey, the four types of options (reality match, Mandarin Chinese CL match, Korean CL match, and unrelated match) were arranged following these two principles: 1) each of the four options should be placed under each choice (A, B, C, and D) evenly (twice or three times), and 2) the same type of option should not be placed under the same choice in consecutive test items (e.g., reality match options for items 10 and 12 should not be placed under choice A).

English and Korean native speaker participants were given a link to access the survey in Google Forms while Chinese native speakers accessed Wenjuanxing (a platform providing functions equivalent to Google Forms). The survey started by asking for participants' basic personal information and notifying them that the information will be used only for academic purposes and not be revealed. The questions about their personal information concerned their native language, other languages they speak, name (pseudonym could be used), sex, and month and year of birth. Then, a brief written introduction of the survey was provided in the participants' respective native language: the English version is provided below.

The survey has 20 items and it should take around 5 minutes to complete.

First, look at the object inside the box.

Then choose ONE option (among A, B, C, and D) that you think best associates with the object in the box.

Feel free to choose the option you like the best since there is NO fixed correct answer.

Start now!

2.3. Data analysis

Data analyses were performed using SPSS Statistics 20. One-way ANOVAs were performed to compare the scores from three different native speaker groups in each version of the survey. Then, the post hoc Tukey's HSD tests for multiple comparisons were performed to examine the significance of difference between two native language speaker groups.

3. Results

As expected, every group predominantly selected the reality match (among the four options) in both versions of the survey (Fig. 2). English speakers selected the reality match the most (87% in the singular version and 89.3% in the plural version),

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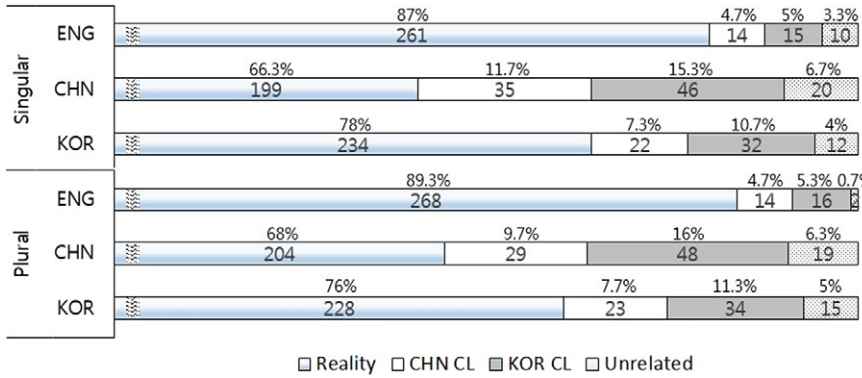

Figure 2. Overall raw scores from all groups out of 300 total responses in each group (30 participants × 10 test items).

followed by Korean speakers (78% in the singular version and 76% in the plural version) and Mandarin Chinese speakers (66.3% in the singular version and 68% in the plural version) speakers. We hypothesized that Mandarin Chinese speakers and Korean native speakers would select more CL matches in the plural version than in the singular version because a stronger activation of classifiers is expected when counting. However, the results indicate that participants' performance on the two versions of the survey was not significantly different (Appendix), suggesting that, contrary to our expectations, classifier language speakers' supposed activation of classifiers in the plural version did not necessarily lead them to categorize differently.

Then, the second most selected option by all six groups was the Korean CL match followed by the Mandarin Chinese CL match (even by Chinese participants). However, a statistically significant difference was not found between the two classifier options except in the Chinese plural group (Table 3). Still, the fact that one Chinese group selected significantly more Korean CL matches than Mandarin Chinese CL matches suggests that classifier language speakers did not simply choose objects that share the same classifier in their respective languages. Lastly, the unrelated match was the least selected option by all six groups.

Based on the results presented in Fig. 2, on average, English speakers selected almost 9 reality matches out of 10 while Mandarin Chinese speakers and Korean speakers only chose around 7 of them (Fig. 3). A one-way ANOVA comparing the reality match scores from the three different native speaker groups in the singular version of the survey revealed that there was a statistically significant difference in mean reality match scores between at least two groups ($F(2, 87) = 6.671$, $p = 0.002$). Tukey's HSD test found that the mean scores were significantly different between English and Mandarin Chinese speakers ($p = 0.001$). However, there was no

Table 3. T-test results comparing Mandarin Chinese versus Korean CL match responses

	English speakers	Mandarin Chinese speakers	Korean speakers
Singular	$t(29) = 0.177$, $p = 0.861$	$t(29) = 1.943$, $p = 0.062$	$t(29) = 1.409$, $p = 0.169$
Plural	$t(29) = 0.360$, $p = 0.722$	$t(29) = 2.617$, $p = 0.014$*	$t(29) = 1.322$, $p = 0.197$

*$p < 0.05$.

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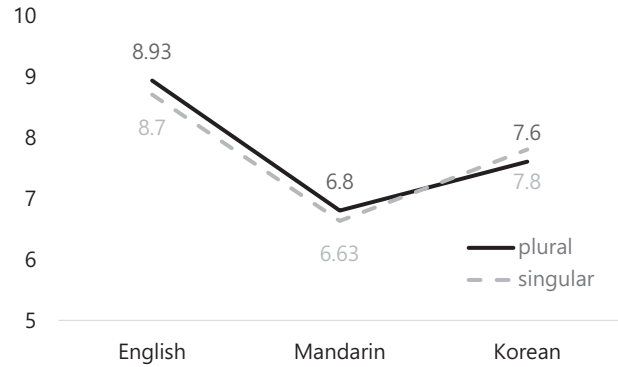

Figure 3. Participants' average number of reality match responses out of a maximum of 10.

statistically significant difference in mean scores between English and Korean speakers (p = 0.257), and between Mandarin Chinese and Korean speakers (p = 0.105). Then, another one-way ANOVA was performed to compare the reality match scores from the three different native speaker groups in the plural version of the survey. It revealed that there was a statistically significant difference in mean reality match scores between at least two groups ($F(2, 87) = 7.581$, $p = 0.001$). Tukey's HSD test found that the mean scores were significantly different between English and Mandarin Chinese speakers (p = 0.001), and between English and Korean speakers (p = 0.047), but not between Mandarin Chinese and Korean speakers (p = 0.322). There was no statistically significant interaction between the effects of language and survey version ($F(2, 174) = 0.17$, $p = 0.89$). The main effect was found only between language (p = 0.00), and not between plural and singular versions (p = 0.83).

Next, Mandarin Chinese and Korean CL match responses are merged for further analysis labeled as CL match responses (Fig. 4): since the result suggests that Chinese and Korean participants are not looking for objects sharing the same classifier in their respective languages (i.e., for example, Mandarin Chinese speakers chose more Korean CL matches over Mandarin Chinese CL matches), we suggest that the existence of classifiers (either Mandarin Chinese or Korean) may be leading its users to pay attention to diverse aspects of objects, which will be discussed later in more

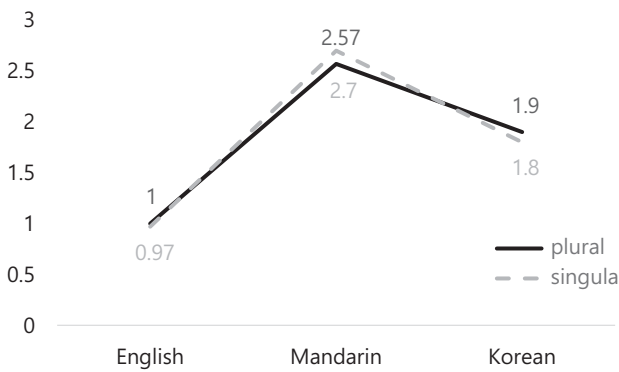

Figure 4. Participants' average number of CL match responses out of a maximum of 10.

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detail. While English speakers selected about 1 CL match on average, Korean speakers selected nearly twice as many and Mandarin Chinese speakers more than 2.5 CL matches in both versions of the survey (Fig. 4). A one-way ANOVA comparing the CL match scores from the three different native speaker groups in the singular version of the survey revealed that there was a statistically significant difference in mean CL match scores between at least two groups ($F(2, 87) = 6.954$, $p = 0.002$). Tukey's HSD test found that the mean scores were significantly different between English and Mandarin Chinese speakers ($p = 0.001$). However, there was no statistically significant difference in mean scores between English and Korean speakers ($p = 0.178$), and between Mandarin Chinese and Korean speakers ($p = 0.135$). Then, another one-way ANOVA was performed to compare the CL match scores from the three different native speaker groups in the plural version of the survey. It revealed that there was a statistically significant difference in mean CL match scores between at least two groups ($F(2, 87) = 6.204$, $p = 0.003$). Tukey's HSD test found that the mean scores were significantly different between English and Mandarin Chinese speakers ($p = 0.002$). However, there was no statistically significant difference in mean scores between English and Korean speakers ($p = 0.114$), and between Mandarin Chinese and Korean speakers ($p = 0.299$). There was no statistically significant interaction between the effects of language and survey version ($F(2, 174) = 0.69$, $p = 0.93$). The main effect was found only between language ($p = 0.00$), and not between plural and singular versions ($p = 0.98$).

Finally, further analysis was conducted to probe the participants' individual preferences in categorizing. While the results reported above show the group behavior of the speakers of the three languages, what criteria each individual participant tended to use to categorize the objects in the survey cannot be inferred from those analyses. For further individual analysis, participants who responded with seven or more reality match options were classified as reality match dominant, and were considered to be wired to apply common categorizing strategies leading to reality matches: as previously mentioned, reality match responses were mostly anticipated regardless of the participants' native language and the result proved the expectation correct. Among the rest of the participants who chose six or fewer reality match options, those who selected more CL matches than unrelated matches were labeled as CL match dominant: these are participants who seem to be more alert to diverse aspects of objects not pertaining to the common categorizing strategies leading to reality matches. The absolute majority of English speakers (all in plural version and 93.3% in singular version) was reality match dominant, while less than 75% of Chinese and Korean speakers were reality match dominant (Fig. 5A). Only one English speaker participant was CL match dominant while 16 Korean and 23 Chinese speakers were CL match dominant (Fig. 5B).[3] This demonstrates that a considerable proportion of Mandarin Chinese and Korean speakers have a tendency to construct categories quite differently than English speakers. There was no statistically significant interaction between the effects of language and survey version ($F(2, 174) = 0.20$,

[3]There were two participants (one English speaker in singular version and one Korean speaker in plural version) not mentioned here, who selected more unrelated matches over CL matches while choosing less than seven reality matches. They can be labelled unrelated match dominant, but the performance of the two individuals will not be further discussed as the rationale for their categorizing decisions seem too individual to be generalized.

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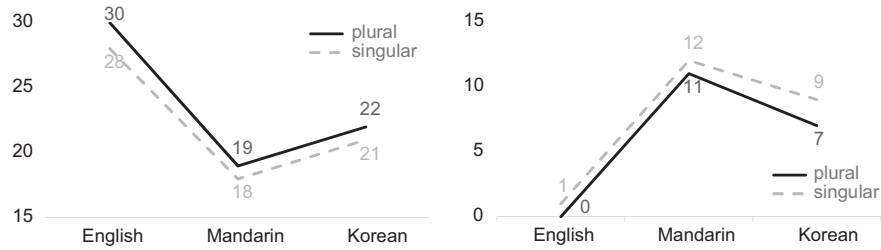

Figure 5. Individual preference in categorization. (A) Number of reality match dominant participants out of a maximum of 30. (B) Number of CL match dominant participants out of a maximum of 30.

p = 0.82). The main effect was found only between language (p = 0.00), and not between plural and singular versions (p = 0.49).

4. Discussion

In this research, we hypothesized that classifiers would guide speakers of classifier languages like Mandarin Chinese and Korean to make more classifier-based decisions when they perform a categorizing task compared to speakers of a non-classifier language like English. Additionally, offering a potential counting context in the plural version of the survey was expected to trigger more classifier-based categorization from the classifier language users than in the singular version. The results provided evidence supporting only our first hypothesis. Although reality matches (based on thematic or role-governed categories) were the most popular choices by all six groups in this study, which was expected, Mandarin Chinese and Korean speakers showed more classifier-based categorization than English speakers. If such overall results were rather weak evidence to support the first hypothesis due to the occasional lack of statistically significant difference between the performance of classifier and non-classifier language speakers, individual analysis turned out to be strong supporting evidence: while only one out of 60 English speakers made classifier-oriented categorizing decisions, 23 Mandarin Chinese and 16 Korean speakers made such decisions. As for our second hypothesis, the participants' overall and individual behavior suggests that providing a counting context in the plural version did not necessarily lead them to categorize more based on classifiers.

Then, how does the classifier system influence its users in categorization? We suggest that rather than looking for objects that share the same classifier in their language, classifier language speakers may be led to pay attention to diverse aspects of objects with help from a powerful cognitive tool (Gentner, 2016), the classifier system that is grammaticalized in the languages they speak. There are numerous collections of features or propositions that define and characterize an object. In Fig. 1B, a 'cow' is a domesticated farm animal that provides milk, meat, leather, and labor if you focus on its relationship with humans, or biologically classified as a bovine animal considered a mammal although laypeople are probably not familiar with its specific zoological classification. If you want to concentrate on its physical characteristics, you can observe its stocky long rectangular body with a long, straight snout on its relatively small head considering the body size. The majority of participants, including English speakers, are most likely aware of these features and characteristics that form a concept of a 'cow' in their minds, but they mostly focus on its relationship with

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humans when forced to find another object that is associated with it and select 'milk' (Lin & Murphy, 2001). However, classifiers may be allowing classifier language users to divert their attention to other aspects of the 'cow' as well, not because they are looking for another object that requires the same classifier as 'cow' but because they are implicitly accustomed to noticing the commonalities between objects that share the same classifier. The common features implied in classifiers of their native languages can be activated when forced to categorize objects thanks to the prolonged use of their classifier language. Thus, when Mandarin Chinese speakers scan the options in Fig. 1B, they are not only paying attention to the thematic relationship between 'milk' and 'cow' but also thinking about the shape similarity between the 'garlic' and head of the 'cow', and the biological features shared by the 'lizard' and the 'cow' (like having a tail and four feet attached to their bodies). Approximately two-thirds of the time (Figs. 2 and 3), they are expected to choose 'milk'. However, they could select the Korean classifier match 'lizard' if they feel that the biological features are more salient or pick the Mandarin Chinese classifier match 'garlic' based on its shape similarity to the head of the 'cow'. English speakers are probably also equally capable of realizing the various aspects of 'cow' but the lack of a powerful cognitive tool like classifiers in the English language probably leads them to predominantly focus on the cow's relationship with humans. This can account for why English speakers rarely selected classifier match while Mandarin Chinese and Korean speakers selected it considerably more often.

Thus, we attempt to provide an account of the mechanism of making categorical decisions. We suggest that there are multiple strategies participating in a competition whenever someone has to make a categorizing decision. As discussed earlier in Section 1.1, category membership decisions involve comparing and evaluating various component attributes (Roth & Shoben, 1983), and some of the well-known classification strategies are taxonomic categories, thematic categories, role-governed categories, and ad hoc categories. These strategies can be considered some of the several contenders taking part in the competition for categorizing. Additionally, a classifier-based category can be another strategy participating in the competition. Rarely, decisions are based on an individual's personal experience, which is too personal to be generalized, as can be seen in the small number of unrelated options selected by the participants of this study (Fig. 2). Among these contenders, one specific strategy will win out depending on several conditions such as the given task in the experiment setting, and lead to a certain type of categorization.

We also have to consider the possibility that other cultural differences between Asians and Westerners not pertaining to classifiers might have participated in the competition for categorizing. For example, Nisbett and Miyamoto (2005) demonstrated that Asians tend to engage in holistic perceptual processes by paying attention to the relationship between an object and the context in which the object is located, while Westerners tend to engage in analytic perceptual processes by concentrating on a salient object regardless of its context. However, since contexts were not provided for our experimental stimuli and culture-specific objects were avoided as test items, such cultural difference seems irrelevant for our analysis. In another study, Nisbett and Masuda (2003) claim that East Asians tend to classify objects based on their relationships to each other and how they are similar to each other, while Americans classify objects based on rule-based category membership. So when Chinese and American children are given a triplet of objects consisting of a cow, a chicken, and grass, and asked to indicate the two objects that go together, the Chinese group the

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cow and grass together because the cow eats grass, and the Americans group the cow and the chicken together because they are both (farm) animals (Chiu, 1972). In order to avoid such a culture-dependent confounding factor, we selected objects that can be least considered reality matches for the Mandarin Chinese and Korean CL match options, as explained in Section 2.2. Thus, although we cannot think of a factor other than the (non)existence of classifiers in the three languages that might have contributed to the results in this study, there is always the possibility that other nonlinguistic differences could have been a factor.

Then, how is the winner of such a competition decided? We suggest that the strength of each strategy, defined here as the probability to win the competition against other strategies, plays a critical role. Based on Saalbach and Imai (2007) who examined category selections of Chinese (a classifier language) and German (a non-classifier language) speakers, the relative strength of some of the contenders participating in the competition can be inferred. When forced to choose between two options for a categorization task similar to the survey in this study, a thematic match was selected nearly twice as much as a taxonomic match by both groups. Then, both thematic and taxonomic matches were the predominant selections over a classifier match: a classifier match consisted of only 11%–17% of both the Chinese and German participants' responses. Finally, a classifier match was selected nearly three times as much as the control (equivalent to the unrelated match in this study). Thus, thematic relation seemed to be the strongest followed by taxonomic relation and classifier relation in the forced choice tasks. However, in similarity judgment and inductive reasoning tasks, a taxonomy-based strategy was the strongest followed by thematic and classifier relations. The inconsistent order of relative strength according to the tasks shows that the strength of the categorizing criteria is not fixed. It seems that the participants were choosing the best strategy for the given tasks: a thematic match seems like a very plausible option if you are forced to select the one that best goes together with the pivot, but you would most likely select a taxonomic match if you are asked to find the one that is similar to the pivot.

Such competition, in which the classifier-based category takes part, probably occurs in the minds of not only classifier language speakers but also non-classifier language speakers. However, the classifier-based strategy may not be equally readily applicable to speakers of a non-classifier language. The strength of the classifier-based strategy is expected to be stronger in the minds of classifier language speakers than that of non-classifier language speakers due to the powerful cognitive tool that classifier language speakers are equipped with thanks to their lifelong use of classifiers. Perhaps classifier language speakers possess 'a magnified sensitivity underlying classifier categories developed through the habitual use of classifiers in association with the names of objects' (Saalback and Imai, 2007, p. 498), which non-classifier language users lack. Of course, this does not imply that classifier language users will mainly use a classifier-based categorizing strategy: as demonstrated in the result of this study and myriad of previous studies (e.g., Kuo & Sera, 2009; Saalbach & Imai, 2007), the predominant strategy used for categorization is not the classifier-based strategy for speakers of both classifier and non-classifier languages.

The same previous studies also report non-classifier language speakers' occasional classifier-based decisions in their categorization, which is usually not accounted for and considered insignificant. From the competition point of view, such infrequent responses are simply a result of an incompetent classifier-based strategy in the competition. Most of the time, the classifier-based strategy is not strong enough to

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beat its competitors in the competition and gives way to other strategies allowing thematic or taxonomic matches to be selected. This does not imply, though, being a speaker of a non-classifier language will make you insensitive to the shared qualities of two objects that require the same classifier in a certain classifier language. Just like our innate ability to quickly recognize which of the two piles of sand is bigger does not have to be fostered by learning how to count numbers through language (Gentner, 2016), humans have the ability to associate two objects based on the shared traits regardless of the existence of classifiers in their language. In Fig. 1B, English speakers are most likely able to recognize 'cow' and 'lizard', which share the same classifier in Korean and are both animals, and may find the shape similarity between the head of 'cow' and 'garlic', that share the same classifier in Mandarin Chinese, quite interesting. This recognition by English speakers may not lead them to make classifier-based categorization as frequently as Mandarin Chinese or Korean speakers would do. Only when certain conditions are satisfied (such as noticing a familiar part of the pivot object), it becomes the favorite to win the competition. This can explain why 10% of English speakers' responses were classifier matches in this study (Figs. 2 and 4).

There are multiple different strategies that can be used to categorize objects. In a categorizing situation, the various strategies with different strengths enter a competition and usually strategies with more strength such as thematic or taxonomic-based categories win. There are also other weaker contenders like the classifier-based category, which mostly does not outduel its competitors in the categorizing competition. However, there is no fixed categorizing strategy for anyone. It may change depending on the situation and which strategy is perceived as salient at the moment. Thus, not only can two people make different categorizing decisions on the same set of stimuli but also the same person may or may not classify the same object as an instance of a certain category on different occasions (Heinze et al., 1998). Even manipulations in experimental settings can influence participants to favor a specific categorization strategy (Goldwater & Markman, 2011). This study demonstrated that the strength of the classifier-based strategy for classifier language speakers tends to be stronger than non-classifier language speakers, which leads to more classifier-based categorizing decisions by classifier language speakers than non-classifier language speakers. Therefore, the next time you meet classifier language speakers such as Mandarin Chinese or Korean speakers, you may be able to witness them categorizing differently than non-classifier language speakers.

5. Conclusion

Among various ways to categorize objects, some strategies seem to be more popular than others: for example, people are generally more sensitive to thematic relations than classifier-based relations as is evidenced by reality match dominant responses from the absolute majority of English speakers and many Chinese and Korean speakers in this research. Adopting the Competition Model to explain how people categorize objects enabled us to account for not only the result of this research but also those of previous studies. When a certain strategy is used for categorization, we proposed that it is selected not because it was the only appropriate option, but rather because it was stronger than all other options competing to be selected. For speakers who use classifiers in their everyday linguistic communication, the strength of classifier-based strategy may be strong and competent enough to win a considerable

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proportion of the categorization competition, thanks to the cognitively salient features encoded in their languages: classifiers typically denote characteristics of entities that are saliently perceived or imputed by speakers of classifier languages (Allen, 1977).

Another significance of this study is that it examined speakers of three major languages in the world using the same survey sets, which allowed us to compare categorizing behaviors of classifier and non-classifier language speakers as well as categorizing decisions from speakers of two different classifier languages. Based on the two types of comparison, we found that classifier language speakers can categorize differently from non-classifier language speakers and observed that speakers of two different classifier languages demonstrated similar categorizing behaviors likely because they are accustomed to noticing diverse aspects shared by objects due to their prolonged use of classifiers in their respective languages. Although this research may provide notable theoretical and methodological implications on how the existence of classifiers in a language could affect its speakers' categorization, it is important for further studies to examine whether the framework based on competition can account for behaviors of other language speakers as well.

Data availability statement. All survey versions used in this study are available at the Open Science Framework: https://osf.io/eqv2m/.

Competing interest. The authors declare no competing interest.

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Appendix. *T*-test results comparing responses of the two survey versions (singular vs. plural)

	English Speakers	Mandarin Chinese Speakers	Korean Speakers
Reality match	$t(58) = 0.668$, $p = 0.507$	$t(58) = 0.232$, $p = 0.817$	$t(58) = 0.362$, $p = 0.719$
Chinese CL match	$t(58) = 0.000$, $p = 1.000$	$t(58) = 0.731$, $p = 0.468$	$t(58) = 0.128$, $p = 0.899$
Korean CL match	$t(58) = 0.177$, $p = 0.860$	$t(58) = 0.182$, $p = 0.856$	$t(58) = 0.197$, $p = 0.844$
Unrelated match	$t(58) = 1.472$, $p = 0.146$	$t(58) = 0.142$, $p = 0.887$	$t(58) = 0.593$, $p = 0.555$

Cite this article: Peng, L., & Kang, S. -G. (2023). Classifiers in competition for categorization, *Language and Cognition* 15: 815–833. https://doi.org/10.1017/langcog.2023.27