

Balancing Conventional Pairings and Semantic Fit: Classifier Production in Mandarin-Speaking Children

Erjing Zhang (zerjing@g.ucla.edu)

Department of Psychology, University of California, Los Angeles

Ying Hao (ying.hao@njnu.edu.cn)

School of Chinese Language and Literature, Nanjing Normal University

Catherine M. Sandhofer (sandhofer@psych.ucla.edu)

Department of Psychology, University of California, Los Angeles

Abstract

This study examined how classifier-noun conventions and classifier semantic compatibility influence the selection of classifiers in Mandarin-speaking children aged five to seven. Results indicated that children's classifier use was shaped not only by conventional associations between classifiers and noun categories but also by semantic congruence, particularly in the absence of explicit noun labels. Older children demonstrated greater sensitivity to labels in guiding classifier selection than younger children. Furthermore, explicit noun labels most strongly boosted children's choice of conventional classifiers for non-prototypical stimuli, while having a much smaller impact on prototypical stimuli. Overall, these results highlight the interplay between memorization and semantic compatibility in classifier acquisition and underscore the importance of semantic and perceptual features in shaping language learning.

Keywords: Mandarin Chinese; Classifier Selection; Semantic Compatibility; Child Language Acquisition

Introduction

Language provides a framework for understanding objects, ideas, and experiences by emphasizing culturally significant attributes (Lucy, 1992) and facilitating their effective encoding and retrieval (Gentner & Medina, 1997). These linguistic frameworks often differ across languages, shaping how information is categorized and quantified. For example, English distinguishes count nouns (e.g., 'three fish') that can be directly quantified from mass nouns (e.g., 'three glasses of water') that require a unit of measurement for quantification. In contrast, Mandarin employs classifiers, linguistic markers that link numerals to all nouns (Sera et al., 2013; Zhu et al., 2020). Classifiers in Mandarin follow the syntactic structure of 'numeral + classifier + noun' (Imai & Gentner, 1997). For instance, to refer to 'three fish,' Mandarin uses 'sān (three) tiáo (classifier) yú (fish),' where the classifier 'tiáo' specifies the unit of measurement.

Semantics of Mandarin Classifiers

In Mandarin, classifiers provide semantic information in quantifying and organizing objects based on a variety of features, unlike languages like English, where quantification relies more on syntactic distinctions (Hu, 1993). Classifier languages like Mandarin use unique sets of classifiers to reflect conceptual categories, grouping objects by shared features, such as shape or size (Lakoff, 1987; Saalbach & Imai, 2012). For instance, 'tiáo' is used for long, thin objects like fish and

roads, while 'lì' is used for small, round objects like rice and pearls (Erbaugh, 2006; Zhang & Schmitt, 1998).

The choice of classifiers is primarily governed by the feature of the noun it pairs with, as classifiers must be appropriate to match the noun category (Shao, 1993). However, a single noun can pair with multiple classifiers, highlighting different perceptual features. For instance, 'fish' can pair with the classifier 'tiáo', associated with long, thin objects, or the classifier 'zhī', which applies broadly to animals. Among the selection of classifiers, we define conventional classifiers (e.g., tiáo for fish) as, in part, the classifier used more frequently than other appropriate classifiers for the noun category. However, not all members of a noun category perfectly align with the semantic meaning of its conventional classifier. For example, while 'tiáo' suits the appearance of long, thin fish, it may not be well suited for round fish like a pufferfish.

Two mechanisms of classifier selection

We propose that classifier selection for an object involves two potential mechanisms: memorization-only selection and memorization-semantic-combined selection.

The first mechanism, memorization-only selection, relies exclusively on noun category membership. In this approach, speakers apply the conventional classifier associated with a known noun category to new instances, without considering the semantic attributes. For example, when encountering a fish, a speaker would automatically pair it with the classifier 'tiáo,' based on its conventional association with the noun category 'fish', regardless of whether the specific fish aligns with the long, thin shape that 'tiáo' denotes. This strategy prioritizes linguistic convention over specific characteristics.

The second mechanism, memorization-semantic-combined selection, builds upon but extends beyond the first mechanism. This approach involves identifying the noun category and assessing whether the instance aligns with the conventional classifier's semantic meaning. If the object does not align with the expected attributes, speakers may choose a different classifier, even if it is not the one that is most commonly paired with the noun category. For example, when encountering a pufferfish, which deviates from the long, thin features associated with 'tiáo,' speakers might choose the classifier 'zhī' instead.

We investigate whether speakers ever employ the sec-

ond mechanism—evaluating semantic compatibility between a classifier’s meaning (e.g., ‘*tiáo*’ for ‘long, flexible’) and a noun’s perceptual features (e.g., shape)—or default exclusively to the first mechanism, adhering to memorized pairings even when semantic mismatches arise.

Acquisition of classifiers

Classifier acquisition involves both memorization and semantic abstraction. By ages two to three, children begin to use classifiers when quantifying objects and adopt the correct syntactic structure, although their accuracy in selecting appropriate classifiers remains low (e.g., Erbaugh, 1986; Fang, 1985; Ying et al., 1983). During this period, children frequently overgeneralize the general classifier ‘*gè*’ to fill in gaps in their knowledge (Hao et al., 2021; Hu, 1993; Loke, 1991).

As children gain linguistic exposure they gradually recognize that specific classifiers typically pair with certain nouns. This marks a critical milestone in classifier acquisition, where children may learn classifiers primarily from memorization of common classifier-noun pairings. Also, children’s proficiency in classifier selection varies depending on the frequency and consistency of these pairings in their linguistic input (Hao et al., 2021).

Therefore, young children’s classifier selection is likely to be guided primarily by memorization. Over time, children begin to discern the semantic meanings of classifiers, identifying shared features among nouns grouped under the same classifier. Although no studies have directly tested children’s performance in verbalizing classifiers’ meanings, Mandarin-speaking adults can explicitly identify shared features among nouns grouped under the same classifier (Gao & Malt, 2009). This semantic understanding likely underpins the potential development of semantic approach during classifier selection.

While prior studies speculated that rote learning likely precedes semantic abstraction in classifier acquisition, our work is the first to explicitly propose and show children use of memorization-only and memorization-semantic-combined strategies. Our findings will reveal how children select classifiers during production and when semantic abstraction is developed and utilized in classifier selection. Do children actively consider a classifier’s semantic meaning when pairing it with a noun, or do they rely primarily on memorized associations?

The impact of prototypicality in classifier selection

Rosch’s (1975) seminal work posits that categories are organized around prototypical members that best represent the shared features of items within the category. Prototypicality likely influences classifier selection, as the choice of classifiers is typically governed by the nouns they pair with. Prototypical examples of a noun category are more likely to be paired with the conventional classifier, aligning closely with the classifier’s semantic meaning.

For non-prototypical members of a category, deviations from the conventional classifier’s semantic meanings are

more likely. This raises a key question: Does this result in reduced use of the conventional classifier for non-prototypical members, supporting the use of a memorization-semantic-combined selection? Or do speakers select classifiers for non-prototypical members in the same way as prototypical members, suggesting a reliance on memorization-only selection?

Previous research and literature gap

Previous research suggests that knowledge of classifiers’ meanings influence performance in cognitive tasks, creating language-specific categorization for speakers of classifier languages (e.g., Mandarin and Japanese) compared to speakers of non-classifier languages (e.g., English and German) (Imai et al., 2010; Kuo & Sera, 2009; Lin & Murphy, 2001). For example, Imai et al. (2010) found that Mandarin-speaking children were more likely than German-speaking children to group objects based on classifier categories. However, this difference has not been consistently observed across studies. The influence of classifiers appears to interact with shape-based categorization and is stronger when classifiers are explicitly labeled or elicited. For example, Huang and Chen (2014) found Mandarin speakers made no groupings based on classifiers unless the classifiers were explicitly labeled.

While these studies provide insights into the influences of classifier-related categorization, they do not address the mechanisms of how this knowledge guides classifier use in development. Furthermore, the experimental contexts in prior studies are not representative of natural classifier usage, such as in quantifying and measuring tasks (Li et al., 2008; Li et al., 2010). Moreover, these studies often rely on a single prototypical stimulus for each noun category, underexploring the variability within categories and the potential for nouns to pair with multiple classifiers. Investigating how children handle non-prototypical cases could provide deeper insights into classifier selection mechanisms.

Current study

This study examines how Mandarin-speaking children select classifiers for instances of known noun categories and how noun categories and the semantic compatibility of classifiers influence their selection. We focus on three key questions:

(1) Do nouns primarily govern the choice of classifiers? (2) Are there developmental changes in how children consider the semantic meaning of classifiers, or do they primarily rely on memorized associations with noun categories, regardless of prototypicality, at all ages? (3) How does explicitly labeling the noun categories influence classifier selection?

We expect that the explicit label of objects might reinforce memorized classifier-noun pairings, while their absence could shift focus to the perceptual features that may prompt the use classifiers other than the conventional one. By manipulating the availability of noun labels, this study examines the interaction between semantic meaning and conventional knowledge in classifier selection.

Methods

Participants

Eighty-seven children aged 5 to 7 years were recruited from two kindergartens and two elementary schools in Ningbo, China. The participants were divided into three age groups: 29 five-year-olds (16 females, $M_{\text{age}} = 5.49$ years, $SD = 0.28$), 30 six-year-olds (14 females, $M_{\text{age}} = 6.58$ years, $SD = 0.29$), and 28 seven-year-olds (15 females, $M_{\text{age}} = 7.52$ years, $SD = 0.31$). All participants came from monolingual Mandarin-speaking households where Mandarin was the primary language used at home. None had reported auditory or visual or language impairments. Most parents (61.76%) had a college-level or higher degree.

The 5-7 age range was selected based on research indicating that by age six, 80% of Mandarin-speaking children accurately comprehend and produce common classifiers (Ying et al., 1983). Thus, children in this age range are proficient in common classifier-noun pairings and are aware of the importance of selecting appropriate classifiers to pair with nouns. However, they are still developing a full understanding of classifiers, likely leading to variability in classifier selection. This age range also allowed investigation of age-related changes in classifier selection.

Before the study, parents and teachers completed a sociodemographic form on parents' education levels, children's language exposure, and familiarity with nouns and classifiers used in the study. The results indicated that the selected nouns and classifiers were well-known by the children. Among 21 nouns and 9 classifiers examined, parents reported: 5-year-olds averaged 1.31 unfamiliar nouns and 1.38 classifiers; 6-year-olds, 0.7 nouns and 0.37 classifiers; and 7-year-olds, 0.54 nouns and 0.39 classifiers.

Classifier-noun pairings and visual stimuli

We selected 10 classifier-noun pairings (Table 1). These classifiers are semantically linked to nouns by features such as shape, size, or specific characteristics (e.g., *bǎ*, used for objects with handles). The conventional classifiers were chosen based on their high frequency in Chinese adult texts (Da, 2004), indicating their likely prevalence in child-directed speech. For each noun category, the "conventional classifier" semantically aligned with the prototypical features of the noun category.

Each conventional classifier was paired with three types of stimuli associated with a noun category (Figure 1): 1) *Prototypical objects* matched both the conventional classifier's meaning and the corresponding noun category (e.g., long flexible fish paired with 'tiáo,' used for long, narrow, and flexible objects). 2) *Non-prototypical objects* belong to the noun category but diverge from the conventional classifier's semantics (e.g., a round pufferfish paired with 'tiáo'). 3) *Cross-category objects* do not belong to the noun category but share perceptual features (e.g., a fish-shaped cookie with features such as fins. Cookies are typically paired with the classifier 'kuài'). This approach allowed us to examine how

Table 1: Classifier-noun pairings

Noun Category	Target Classifier and meaning
Fish	Tiáo (long and flexible)
Candy	Kē (round and small)
Comb	Bǎ (with a handle)
Pen	Zhī (straight and thin)
Carrot	Gēn (straight and solid)
Leaf	Piàn (thin)
Airplane	Jià (machine made, with a pillar)
Mirror	Miàn (with a flat surface)
Wood	Gēn (straight and solid)
Card	Zhāng (thin and flat)

children select classifiers based on category membership and semantic alignment across these three stimulus types.

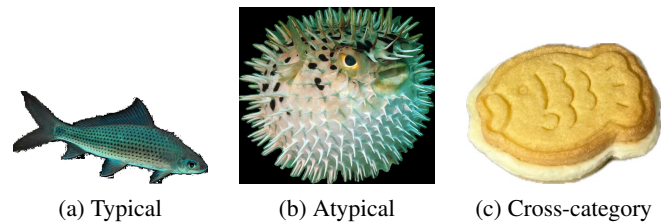


Figure 1: Three type of stimuli for fish category

Validation

Stimuli were created from internet images. Thirty native Mandarin-speaking adults in China rated the images on a 7-point scale based on: 1) Fit with the conventional classifier's meaning: How well the image aligns with the semantic features of the conventional classifier; 2) Prototypicality: How typical the image is for the noun category; and 3) Perceptual similarity: The degree of similarity between the cross-category image and the prototypical image of the noun category (e.g., how similar is this image of a fish-shaped cookie to the image of a prototypical long, thin fish). Random distractor pairs were added to test whether the testing pairs were significantly more perceptually similar than the distractor pairs. Each participant rated 30 images (three for each noun category) separately on each of the four criteria.

Procedure

Children were tested individually in a quiet classroom. In each trial children saw quantities 1-5 identical objects equally spaced on a slide. A native Mandarin speaker prompted children to say how many items they see, which syntactically obligated them to produce classifiers along with the number words. Each trial used one stimulus type (prototypical, non-prototypical, or cross-category), and the order was randomized.

Children were randomly assigned to a label or no-label condition. In the label condition, the experimenter explic-

itly labeled the images using a noun. For example: “Look! There are some *fish*. How many *fish* are here?” “看，这里有些鱼，让我们数数这里有多少鱼?” Prototypical and non-prototypical stimuli were referred to by the same noun category (e.g., “fish” for both long/thin fish and round fish), while the cross-category item received its own proper label (e.g., “cookie” for a fish-shaped cookie). In the no-label condition, the experimenter did not label the images with a noun, instead using an indefinite pronoun: “Look! There is *something*. How many *things* are here?” “看，这里有些什么，让我们数数这里有多少?” The requests were delivered in a child-friendly tone. Importantly, the experimenter never used classifiers in their speech at any time. Children were prompted to produce full classifier-noun pairings (e.g., *sān tiáo yú* [three-CL fish]), and their responses were recorded and analyzed.

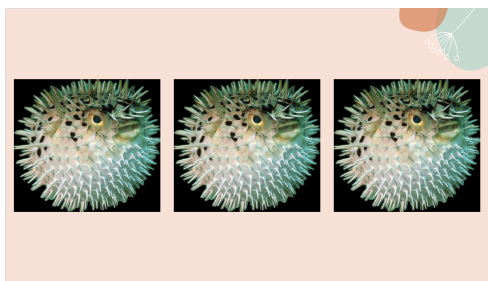


Figure 2: Example test trial

Results

Validation

Fit with the target classifier’s meaning. Adult participants rated the prototypical members as the best match for their corresponding conventional classifiers (mean = 6.70, SD = 0.75), followed by non-prototypical members (mean = 5.14, SD = 1.92), and lastly, cross-category members (mean = 3.48, SD = 2.23). All differences were statistically significant.

Prototypicality. Participants rated the prototypical images as significantly more prototypical than the non-prototypical images for the noun categories (mean = 6.78 vs. mean = 5.81 on a 7-point scale; $t = 10.396$, $p < 0.001$).

Perceptual similarity. The average perceptual similarity across pairs of prototypical and cross-category images was 4.71, (range 3.47 - 6.0). Significant differences in perceptual similarity were observed between the groups ($F = 17.29$; $p < 0.001$), however, all pairs were significantly more similar to each other than to random distractor pairs.

Primary findings

The primary research question examined whether differences in children’s classifier selection arise from trial type (prototypical, non-prototypical, and cross-category), labeling condition (label and no label), age group (5-, 6-, and 7-year-olds), or their interactions. To address this question, a generalized linear mixed-effects model was conducted, which in-

cluded random intercepts for participant ID to account for repeated measures. Only trials where children correctly labeled the stimuli according to their actual noun category were included in the analyses. For cross-category stimuli, children’s noun responses were coded as correct only if they used the item’s proper noun (e.g., *cookie* or equivalent for a fish-shaped cookie). Responses using the target noun (e.g., *fish*) for cross-category items were excluded to ensure categorical distinctness.

Trial type main effects Supporting our hypothesis, trial type significantly influenced conventional classifier production. See Fig. 3, compared to prototypical trials, the non-prototypical trials showed a reduced likelihood of producing conventional classifiers (beta = -0.541, SE = 0.253, $p = 0.033$). Cross-category trials demonstrated an even more pronounced reduction (beta = -2.338, SE = 0.386, $p < 0.001$) compared to prototypical trials. Pairwise comparisons confirmed higher odds of producing conventional classifiers in prototypical trials, compared to non-prototypical trials (log odds ratio = 1.561, SE = 0.127, $p < 0.001$) and cross-category trials (log odds ratio = 3.283, SE = 0.188, $p < 0.001$). Non-prototypical trials outperformed cross-category trials in the likelihood of eliciting conventional classifiers (log odds ratio = 1.721, SE = 0.197, $p < 0.001$).

These findings suggest that children considered the semantic meaning of classifiers when deciding which classifier to use. They were less likely to produce a classifier if the stimulus’s characteristics deviated from the classifier’s semantic meaning. Cross-category trials further emphasized the dominant role of nouns in classifier selection, as children were unlikely to select the conventional classifier for stimuli outside the noun category—even when those stimuli were perceptually similar to members of that category.

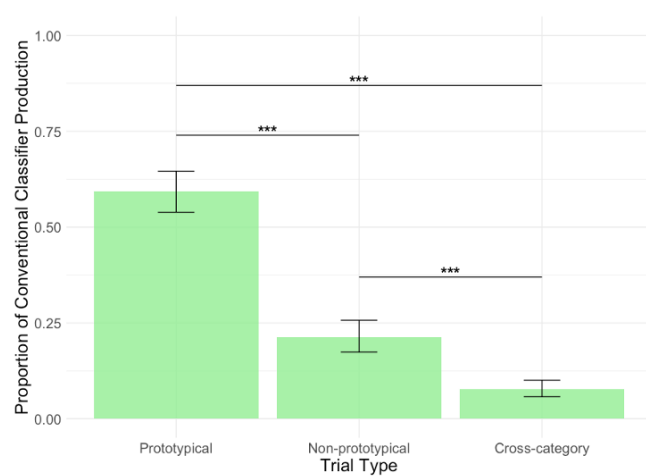


Figure 3: Main effects of trial type

Interaction between age group and condition There was a significant interaction between age group and condition, indicating varied effects of labeling across age groups.

See Fig. 4, Pairwise comparisons in the label condition revealed that both 6-year-olds ($\beta = -0.687$, $p = 0.006$) and 7-year-olds ($\beta = -1.105$, $p < 0.001$) were more likely to select the conventional classifiers compared with 5-year-olds. However, no significant differences were observed between age groups in the no-label condition. Additionally, within-group comparisons between the label and no-label conditions did not yield significant differences. These findings indicate a developmental trajectory in classifier production, with marked increases when nouns were explicitly provided.

While not statistically significant, these results suggest that labeling led older children to use conventional classifiers linked to nouns, supporting our hypothesis. When labels were provided, the labels themselves may have directed older children’s attention toward conventional classifier selection. Without labels, some attention may have shifted toward evaluating the congruence between classifiers’ semantic meanings and the stimuli’s perceptual attributes.

In contrast, when explicit labels were provided to younger children who are still developing counting skills, they may have focused more on counting and paid limited attention to selecting the specific classifiers for the label. For example, younger children frequently overused the general ‘gè’. When no labels were provided, younger children appeared to attend more to the perceptual features of the images. This observation aligns with evidence suggesting that children’s reliance on concrete perceptual information diminishes with age, while labels become increasingly important for linking to conceptual knowledge (Gelman & Davidson, 2013; Noles & Gelman, 2012).

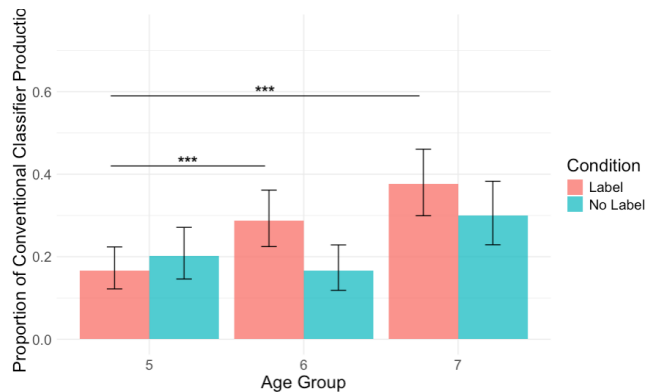


Figure 4: Interaction between age group and condition

Interaction between trial type and condition A significant interaction between trial type and condition indicated that the effects of the conditions differed across trial types.

See Fig. 5, the absence of explicit labels (no label condition) significantly reduced the odds of producing the conventional classifier in non-prototypical trials ($\beta = -1.429$, $SE = 0.442$, $p = 0.001$). In other words, when nouns were provided, children were more likely to use the conventional classifiers with non-prototypical images, even when the im-

age’s perceptual features mismatched the classifiers’ semantic meanings. However, in the no-label condition, children focused more on the stimuli’s perceptual features and were more likely to switch to different classifiers when the features did not align with the conventional classifiers’ meanings. This finding again underscores the critical role that nouns play in classifier selection.

Pairwise comparisons further clarified these effects. In non-prototypical trials, labels significantly increased conventional classifier production ($\beta = 0.884$, $SE = 0.264$, $p = 0.011$), supporting the hypothesis that explicit noun labeling encourages children to prioritize noun category membership over semantic fitness. In contrast, labeling had minimal impact in prototypical and cross-category trials.

For prototypical trials, the lack of a labeling effect can be attributed to the images’ close alignment with both the noun category and the meanings of conventional classifiers, making additional labels unnecessary. In contrast, for cross-category trials, despite perceptual similarities to prototypical stimuli, children avoided using conventional classifiers, reflecting the dominant influence of noun category over classifier selection in these instances.

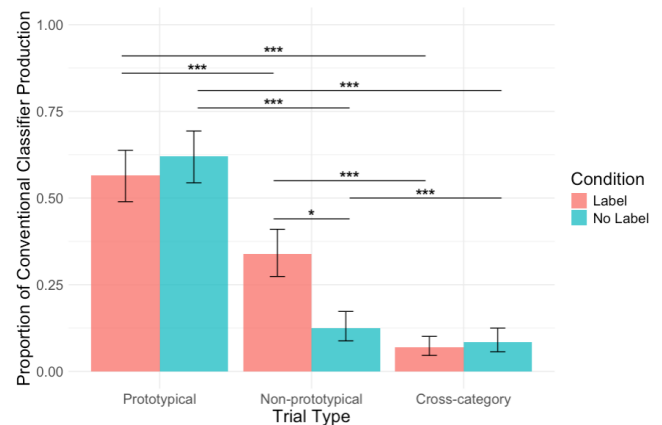


Figure 5: Interaction between trial type and condition

Discussion

This study provides insights into the mechanisms Mandarin-speaking children use when selecting classifiers, highlighting key factors that shape classifier acquisition. Consistent with previous studies (Gao & Malt, 2009; Li et al., 2008), our results underscore the complexity of classifier acquisition and selection, revealing that it involves more than mere memorization—many children actively engage with the semantic properties of classifiers when selecting them in context.

Influence of prototypicality and semantic compatibility

Our research extends existing knowledge by demonstrating that children’s classifier selection is influenced by the prototypicality of specific images and the semantic compatibility

of classifiers with these instances. This aligns with prototype theory (Rosch, 1975), which posits that cognitive categories are organized around prototypical examples that best represent the category's characteristics. In prototypical trials, where the images closely matched both their noun categories and the semantic attributes of the specific classifiers commonly associated with these categories, children were more likely to produce the conventional classifiers.

However, this tendency decreased in non-prototypical trials where deviations from the semantic meanings of the classifiers were pronounced. These findings suggest that children demonstrate a nuanced ability to assess semantic congruence, particularly in the absence of explicit noun labels.

While children's use of a memorization-semantic-combined mechanism was evident, the findings do not rule out the use of a memorization-only strategy, which relies solely on noun category membership. A notable portion of participants applied conventional classifiers to non-prototypical images, even when the classifiers' semantic meanings did not align. This highlights individual differences in the strategies used for classifier selection and suggests that the memorization-only approach remains influential for some children. These individual differences challenge the notion of a uniform acquisition pathway and underscore the need to incorporate inter-speaker variability into models of classifier learning.

Developmental and contextual variability in the impact of labeling

Our findings reveal that the influence of labeling on classifier selection varies across age groups. While older children were more likely to produce the conventional classifiers when objects were explicitly labeled, younger children often overlooked these labels, relying heavily on the general classifier 'gè' and prioritizing accurate counting. In the absence of object labels, 6- and 7-year-olds paid greater attention to the congruence between classifiers' semantic meanings and the images' perceptual features than when labels were provided. This aligns with broader developmental theories suggesting a shift from reliance on perceptual cues to more conceptual reasoning based on labels or, in this case, noun category membership (Gelman & Davidson, 2013; Noles & Gelman, 2012). Also, these findings highlight the significant developmental progress occurring between ages 5 and 7, during which children not only increase their ability to use classifiers appropriately but also begin to understand and apply the underlying semantic properties (Fang, 1985; Ying et al., 1983).

The interaction between trial type and labeling condition further revealed children's flexibility in adapting classifier use to different contexts. This flexibility was particularly evident in the non-prototypical trials, where explicit object labels significantly boosted the use of conventional classifiers. These results suggest that labels help children prioritize noun category membership over perceptual mismatches when the noun category and classifier's semantic meanings conflict. In contrast, labels had minimal impact in prototypical and cross-

category trials. For prototypical trials, the strong alignment between the stimuli and noun categories rendered additional linguistic cues unnecessary. In the cross-category trials, despite the perceptual similarity to the prototypical stimuli, children rarely used the conventional classifiers, highlighting the dominant role of noun category membership in these cases.

Implications and future directions

This research examines how children navigate the interplay between memorization and semantic reasoning when extending classifiers, shedding light on the broader role of classifiers in cognitive processing and language development.

Our findings primarily address whether semantic abstraction is developed and employed during classifier selection. While our data suggest that memorization and semantics both influence classifier selection and are not dichotomous (i.e., memory *versus* semantics), our cross-sectional design and focus on a narrow age band preclude mapping the full developmental trajectory of classifier acquisition regarding how these mechanisms interact. For example, it remains unclear why some children persisted in using conventional classifiers for non-prototypical stimuli while others opted for alternative classifiers. This divergence likely reflects general cognitive trade-offs between efficiency (memorization) and adaptability (semantic evaluation); however, longitudinal studies tracking individual learners across developmental stages are needed to disentangle these dynamics.

The low prevalence of conventional classifier use among 5-year-olds in the label condition (<20%), even for prototypical members, raises questions about the constraints that classifier production paradigm imposes on young children. Children master in classifier comprehension earlier than production (Sera et al., 2013; Hao et al., 2021). The limitations in the current study underscore the value of employing classifier comprehension paradigms to disentangle semantic reasoning from speech production demands. Future research should investigate whether similar memorization-semantic interactions govern comprehension. Additionally, incorporating naturalistic input data (e.g., classifier-noun frequency and consistency in child-directed speech) could clarify how linguistic exposure shapes children's classifier use.

In conclusion, this study enriches linguistic research on classifier languages by providing insights into cognitive mechanisms underlying their acquisition. It highlights how children balance memorization and semantic reasoning in classifier selection, advancing understanding of the relationship between language and cognition during development.

Acknowledgments

The authors gratefully acknowledge the financial support provided by the Patricia Greenfield International Out-of-State Field Research Award. We also thank the children and families who participated in this research; the graduate students and research assistants (Qi Qi, Nicole Xu, Quentin Mei, Jason Guo, Winnie He, and RAs from China) from Dr. Hao's lab;

the UCLA LCD lab; and the China Cultural Group (Dr. Patricia Greenfield, Winnie He, Aiya Wang, and Ruochen Yang) for their help with data collection, coding, and feedback.

References

- Da, J. (2004). A corpus-based study of character and bigram frequencies in chinese e-texts and its implications for chinese language instruction. In P. Zhang, T. Xie, & J. Xu (Eds.), *Proceedings of the fourth international conference on new technologies in teaching and learning chinese* (pp. 501–511). Beijing: Tsinghua University Press.
- Erbaugh, M. (2006). Chinese classifiers: Their use and acquisition. In P. Li, L. H. Tan, E. Bates, & O. Tzeng (Eds.), *The handbook of east asian psycholinguistics* (pp. 39–51). Cambridge: Cambridge University Press.
- Fang, F. (1985). An experiment on the use of classifiers by 4- to 6-year-olds. *Acta Psychologica Sinica*, 17(4), 384–392.
- Gao, M. Y., & Malt, B. C. (2009). Mental representation and cognitive consequences of chinese individual classifiers. *Language and Cognitive Processes*, 24(7-8), 1124–1179.
- Gelman, S. A., & Davidson, N. S. (2013). Conceptual influences on category-based induction. *Cognitive Psychology*, 66(3), 327–353. doi: 10.1016/j.cogpsych.2013.02.001
- Gentner, D., & Medina, J. (1997). Comparison and the development of cognition and language. *Cognitive Studies*, 4, 112–149.
- Hao, Y., Bedore, L., Sheng, L., Zhou, P., & Zheng, L. (2021). Exploring influential factors of shape classifier comprehension and production in mandarin-speaking children. *First Language*, 41(5), 573–604.
- Hu, Q. (1993). *The acquisition of chinese classifiers by young mandarin-speaking children* (Ph.D. dissertation). Available from ProQuest Dissertations & Theses A&I; ProQuest Dissertations & Theses Global.
- Huang, S., & Chen, J. (2014). The effects of numeral classifiers and taxonomic categories on chinese and english speakers' recall of nouns. *Journal of East Asian Linguistics*, 23, 27–42.
- Imai, M., & Gentner, D. (1997). A cross-linguistic study of early word meaning: Universal ontology and linguistic influence. *Cognition*, 62(2), 169–200.
- Imai, M., Saalbach, H., & Stern, E. (2010). Are chinese and german children taxonomic, thematic, or shape biased? influence of classifiers and cultural contexts. *Frontiers in Psychology*, 1, 194.
- Kuo, J.-Y. C., & Sera, M. D. (2009). Classifier effects on human categorization: The role of shape classifiers in mandarin chinese. *Journal of East Asian Linguistics*, 18(1), 1–19.
- Lakoff, G. (1987). Cognitive models and prototype theory. In U. Neisser (Ed.), *Concepts and conceptual development: Ecological and intellectual factors in categorization* (pp. 63–100). Cambridge University Press.
- Li, P., Barner, D., & Huang, B. H. (2008). Classifiers as count syntax: Individuation and measurement in the acquisition of mandarin chinese. *Language Learning and Development*, 4(4), 249–290.
- Li, P., Huang, B., & Hsiao, Y. (2010). Learning that classifiers count: Mandarin-speaking children's acquisition of sortal and mensural classifiers. *Journal of East Asian Linguistics*, 19(3), 207–230. doi: 10.1007/s10831-010-9060-1
- Lin, E. L., & Murphy, G. L. (2001). Thematic relations in adults' concepts. *Journal of Experimental Psychology: General*, 130, 3–28.
- Loke, K. K. (1991). A semantic analysis of young children's use of mandarin shape classifiers. In A. Kwan-Terry (Ed.), *Child language development in singapore and malaysia* (pp. 98–116). Singapore: Singapore University Press.
- Lucy, J. A. (1992). *Language diversity and thought: A reformulation of the linguistic relativity hypothesis*. Cambridge University Press.
- Noles, N. S., & Gelman, S. A. (2012). Effects of categorical labels on similarity judgments: A critical analysis of similarity-based approaches. *Developmental Psychology*, 48(3), 890–896.
- Rosch, E. (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology: General*, 104(3), 192–233.
- Saalbach, H., & Imai, M. (2012). The relation between linguistic categories and cognition: The case of numeral classifiers. *Language and Cognitive Processes*, 27, 381–428.
- Sera, M. D., Johnson, K., & Kuo, J. (2013). Classifiers augment and maintain shape-based categorization in mandarin speakers. *Language and Cognition*, 5, 1–23.
- Shao, J. (1993). 量词的语义分析及其与名词的双向选择. *中国语文*, 3(289), 2.
- Uchida, N., & Imai, M. (1999). Heuristics in learning classifiers: The acquisition of the classifier system and its implications for the nature of lexical acquisition. *Japanese Psychological Research*, 41(1), 50–69.
- Ying, H., Chen, G., Song, Z., Shao, W., & Guo, Y. (1983). 4–7 sui ertong zhangwo liangci de tedian [characteristics of 4-to-7-year-olds in mastering classifiers]. *Information on Psychological Sciences*, 26, 24–32.
- Zhang, S., & Schmitt, B. (1998). Language-dependent classification: The mental representation of classifiers in cognition, memory, and ad evaluations. *Journal of Experimental Psychology: Applied*, 4(4), 375–385.
- Zhu, S. (2020). An empirical study of the classifier effect in advanced l2 users of chinese. *International Journal of Bilingualism*, 25, 151–167.