The Grammatical Root of Learning Bias: Evidence from Mandarin-Learning Toddlers' Early Word Order Sensitivity

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1. Introduction

The recurrence of patterns in human language often has a cognitive root. In the artificial language learning literature, generalizations made by learners typically reflect regularities that are widespread across languages (see Culbertson, 2023 for a review). Though the exact nature of the link remains unresolved, different views are clearly instantiated in one particular domain of investigation, namely NP internal word order. Built on prior theoretical and artificial language learning research in this domain, the present study adds to the literature by leveraging the properties and early acquisition of NP forms that differ in typological commonness in Mandarin Chinese.

Among the twenty-four logically possible combination orders of the NP categories—namely, demonstrative (DEM), numeral (NUM), adjective (ADJ), and noun (N)—some occur more frequently than the others in natural languages. In a recent large-scale typological investigation, Dryer (2018) reports that most languages encode N-ADJ-NUM-DEM or DEM-NUM-ADJ-N as their basic noun phrase orders. The privileged status of these NP forms is also consistently reflected in artificial language learning experiments across speakers of different languages (Culbertson & Adger, 2014, et seq.). For example, in the first experiment of Culbertson & Adger (2014), which trained English-speaking adults on stimuli such as N-ADJ and N-DEM from a miniature language, the authors found that participants preferred forms that respected the typologically common ordering among NP categories (e.g., ADJ preceding DEM when they were post-nominal) even when that went against the surface distribution (e.g., ADJ following DEM) in the participants' native language English. With the two lines of research combined, it is plausible to assume that certain NP forms are cognitively biased.

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One possible origin of the bias is the grammatical system, in line with the broader assumption that surface forms across languages are constrained by underlying linguistic structure (e.g., Chomsky, 1965). More specifically, with respect to the NP categories, it is widely assumed in the literature that DEM, NUM, ADJ, and N are inherently distinct primitives, which in turn determines the basic composition order of NP: ADJ first combines with N, followed by NUM, and then DEM (e.g., Abels & Neeleman, 2012; Cinque, 2005; see also Martin et al., 2020 and other references cited there for discussion of the exact nature of this derivation). With the preference for a transparent mapping between underlying structure and surface order assumed, NP forms that straightforwardly reflect the composition order are expected to be commonly found and meanwhile privileged among language learners who are equipped with the knowledge of the properties of different NP categories.

The alternative explanation is that the bias emerges from processing efficiency, comporting with the idea that linguistic forms can be shaped by language use (e.g., Hawkins, 1983). It is proposed in the literature that putting highly-associated items close to each other decreases the effort of processing (e.g., Hahn et al., 2021). In examination of the co-occurrence statistics between different DEM/NUM/ADJ and N items in the corpus, Culbertson et al. (2020) showed that across languages, ADJ items in general have the strongest association with nouns, NUM items have a weaker one, and the relation between DEM and N items is the weakest. With all these assumed, language learners might develop a preference for NP forms in which the linear proximity of different NP categories corresponds to their overall association strength, presumably after abstracting away from a stage in which this preference is determined on an item-by-item basis. Given the universality of the association strength differences, those preferred forms are expected to have a clear advantage in typology and artificial language learning among adults, for whom the category-based preference would have been formed after a long-term exposure to any language(s).

The two accounts can both cover the basic generalization of previous typological and experimental research, i.e., ADJ has the strongest tendency to appear close to N, followed by NUM, and then DEM. One possible way to further the understanding of the issue is to look for evidence in young children. If this category-based ordering bias is due to the inherent properties of different NP categories that do not have to be inductively learned, we expect it to be present from an early age. By contrast, if it emerges gradually from tracking the co-occurrence statistics between different items, young children's early ordering preference might be based more on the association strength differences among specific item (rather than category) pairs. The NP system in Mandarin Chinese gives us a testing ground to investigate this issue from the perspective of natural language acquisition, which obviates the potential difficulty of teaching young children artificial items of different NP categories.

To begin with, Mandarin allows for two forms of NP differing in typological markedness. As (1) shows, with a classifier (CL) always attached to NUM and a

functor DE marking phrasal modification, Order 1 respects the ordering generalization specified above, while Order 2 does not.

(1) a. na yi-ge piaoliang-de dangao (Order 1: DEM-NUM-CL-ADJ-DE-N)
that one-CL pretty-DE cake
b. piaoliang-de na yi-ge dangao (Order 2: ADJ-DE-DEM-NUM-CL-N)
pretty-DE that one-CL cake
Both (roughly): 'that one pretty cake'

Though different theoretical accounts diverge with respect to how the two forms are derived (e.g., Sio, 2006; Zhang, 2015), it is a general consensus that Order 1 constitutes the basic case, while Order 2 is more marked since it tends to occur in more restricted scenarios, typically when there exists some contrastive entity (e.g., a cake that is not pretty in the case of (1b)), as is documented in Ding et al. (1961). In other words, the Mandarin NP system again reflects the general finding of the literature, in the sense that it encodes an NP form conforming to the universal ordering preference as the basic case.

Further, the Mandarin classifier system displays interesting properties that are relevant to the issue. Generally speaking, classifiers in Mandarin fall into two broad categories, the general and the specific types (henceforth CL_g and CL_s), which have distinct co-occurrence restrictions in relation to nouns. The choice of specific classifiers often depends on the semantics of the nouns in dimensions such as shape, animacy, and size (e.g., Tai, 1994), but there is no similar restriction regarding the use of the general classifier. For instance, as shown in (2), between the specific classifiers *tiao* and *kuai*, which generally feature long and block-like shapes respectively, only the latter can be used with the noun *dangao* 'cake' given their natural congruence in shape—an aspect the general classifier is oblivious to.

(2) {yi-ge | *yi-tiao | yi-kuai} dangao
one-CL_g one-CL_s cake
(Intended:) 'one (piece of) cake'

On the one hand, classifiers are generally argued to be an instantiation of some grammatical function that is present but realized differently in other languages. For instance, Krifka (1995) views it as an externalization of a built-in measure function of the NUM domain in languages like English. On this view, for accounts that attribute the universal ordering preference to the inherent properties of NP categories, it is natural to extend the insights regarding NUM in non-classifier languages to NUM-CL in Mandarin. On the other hand, for approaches that consider the universal ordering preference derived from the association between individual items, the usage of specific classifiers might make the NUM-CL domain more strongly associated with N than the ADJ domain is, which could influence child learners' ordering preference when their universal category-based bias has yet to develop.

We set out to test young Mandarin-learning toddlers' sensitivity to the two grammatical forms in (1) in our recent research (Luo et al., 2023). With three experiments, we found that children could reliably distinguish the Order-1 items from the stimuli in the form of an ungrammatical order (i.e., Order 3: *DEM-ADJ-DE-NUM-CL-N) by 30 months, while children's sensitivity to the Order-2 items was more ambiguous at the same age—they were neither discriminated from the Order-3 items, nor from the Order-1 items. In addition, based on our over-200,000-utterances input analysis, these results did not seem like a simple input effect: Utterances with NPs approximating either form were extremely infrequent (roughly accounting for less than 0.2% of total utterances), and if we counted the subparts of the two orders (e.g., bigrams and trigrams), Order 2 had an overall advantage. Though our previous experimental and corpus findings point to an early learning bias for Order 1, it is worth noting that in the experiments we conducted earlier, the association between the specific ADJ and N items we used was set up to be strong, while the one between NUM-CL and N was weak (see Section 2 for more details). Therefore, even though we tested young children, our previous results could not unambiguously determine whether the advantage of Order-1 items was based on the properties of different NP categories, or the differences in association strength of distinct item pairs.

The present paper synthesizes the results of our prior and new experiments. As we will show below, the two sets of experiments are largely identical, except for the association strength among specific lexical items, which we manipulated to differ systematically. By comparing the results, we aim at clarifying whether the privileged order in early development is contingent on the combination order of different categories, or specific items' association strength.

2. The experiments

Both our previous (Study 1) and new (Study 2) experiments targeted 30-month-olds, because it has been reported that children's knowledge of (at least some) items of different NP categories is in place at this age (e.g., Hao et al., 2008; Lee, 2010; Li et al., 2010; Miao et al., 2020). We tested children's sensitivity to the two grammatical orders in (1) with the visual fixation procedure, a task that relies on participants' looking time (i.e., listening time) differences to probe their ability to discriminate different linguistic stimuli (Cooper & Aslin, 1990). Further, as alluded to in the previous section, we also constructed stimuli in which DE-marked ADJ items were placed between DEM and NUM (i.e., Order 3 in (3)), which is considered unacceptable by many (e.g., Lu, 1998; Zhang, 2015, among others), as our ungrammaticality baseline.[1]

(3) *DEM-ADJ-DE-NUM-CL-N (Order 3)

[1] We did not use a more clearly ungrammatical form (e.g., putting ADJ-DE between NUM and CL) because that might introduce extra confounding factors. For instance, children's attention might be directed to the disruption of prominent strings (e.g., NUM-CL), and therefore could be distracted from processing the overall ordering of the NP items.

2.1. Participants

The 144 participants in our study were around 30 months (n=24 in each experiment; mean: 2;6;18; range: 2;5;2-2;8;18; 67 females). They all lived in or near the capital city of China, with Mandarin being the predominant language input. Before the experiments, written informed consents were obtained from their guardians. Another 54 toddlers were tested but not included in the final analysis due to ceiling looking (9, never looked away throughout the experiments), parental interference (13), fussiness or inattentiveness (14, judged by researchers who did not know about the design of the experiments), failure to complete (14), and experimenter mis-operation (4).

2.2. Stimuli

In both familiarization and test phases (see Section 2.3 for experimental design), the word items were the simplest ones and familiar for 30-month-olds, according to the information from parental reports in the Wordbank database (Frank et al., 2016; Hao et al., 2008), the input speech of the Tong Corpus in CHILDES (Deng & Yip, 2018; MacWhinney, 2000), or existing empirical studies (e.g., Li et al., 2010; Miao et al., 2020). The stimulus structure in the familiarization phase was also a common one in the input. Familiarization items were all simple sentences containing some of the word items appearing in the test phase, without any complex NPs. The utterances had the frame [NP ADV ADJ], with exclamations and sentence-final particles (SFP) added to make them more attractive. As for the test phase stimuli, they were all complex NPs in the forms of Orders 1-3.

The exact words appearing in those structures were manipulated to differ slightly across the two studies (see next section for design details). In particular, the NPs in the familiarization phase of Study 1 were the two nouns used in the test phase *dangao* 'cake' and *xiaoxiong* 'bear', while they were replaced with the general pronoun *ta* 'he/she/it' in Study 2. For the test phase in Study 1, the two nouns were both paired with the general classifier *ge*. As for Study 2, two specific classifiers *kuai* and *tiao* were used, with the former paired with *dangao* 'cake' and the latter with another noun *jinyu* 'goldfish', a change serving to satisfy the CL_S-N co-occurrence restriction. The remaining word items were identical in the two studies, including two adverbs *zhen* 'really' and *hao* 'very', one demonstrative *na* 'that', two adjectives *piaoliang* 'pretty' and *keai* 'cute', the modification marker DE, and one numeral *yi* 'one'. The sample familiarization and test (exemplified in the form of Order 1) stimuli in Studies 1 and 2 are as follows.

Table 1. Example audio stimuli

Familiarization phase	
Study 1 Wa, xiaoxiong hao keai ya! wow bear very cute SFP 'Wow! The bear is very cute!'	Study 2 Wa, ta hao keai ya! wow he/she/it very cute SFP 'Wow! He/she/it is very cute!'
Test phase	
Study 1 na yi-ge keai-de xiaoxiong that one-CL_g cute-DE bear 'that one cute bear'	Study 2 na yi-tiao keai-de jinyu that one-CLs cute-DE goldfish 'that one cute goldfish'

Familiarization utterances were directly produced by a female speaker in a child-directed manner. Due to the unnaturalness that might arise in producing the unacceptable Order-3 items, all test phase NPs (including the ones in the forms of Orders 1 and 2 for control purposes) were made by putting together two pieces extracted from other grammatical utterances. For instance, to derive the Order-3 counterpart of the test phase example of Study 1 listed in Table 1, we first asked the speaker to produce the two grammatical phrases in (4a) and (4b), and then extracted the first part of (4a) and the second part of (4b) to form an ungrammatical Order-3 item, i.e., (4c).

(4) a. na keai-de yangmao yifu
that cute-DE wool clothing
'that pretty wool clothing'
b. zhe shi wo-de yi-ge xiaoxiong
this is my one-CL_g bear
'this is my bear'
c. *na keai-de yi-ge xiaoxiong
that cute-DE one-CL_g bear
Intended: 'that one cute bear'

The visual stimulus played along with the audio stimuli was a lip-sync puppet, as if she was uttering the items during the experiments. When the utterances were not played, a cartoon animation accompanied by pleasant music (i.e., the attention-getter) was presented to children to attract their attention.

2.3. Design

Each study consisted of three experiments with comparable settings. Across the two studies, the crucial manipulation was the association strength of specific item pairs. As indicated in Table 1, the familiarization phase of Study 1 highlighted the relation between the specific nouns and adjectives used in the test phase (e.g., the association between *cake* and *pretty*), while the adjectives in Study

2 were indicated to broadly modify nouns since they were paired with a general pronoun. In the test phase, the noun items in Study 1 bore a loose relation with the NUM-CL domain given that the general classifier was used, while the connection between NUM-CL and N in Study 2 was tighter because we used specific classifiers that are selective about the nouns they can combine with. In this way, the association between the specific nouns and the items in the two domains—NUM (with CL attached) or ADJ (marked by DE)—was manipulated to contrast each other across the two studies, as summarized in Table 2.

Table 2. Association strength of specific item pairs in Study 1 and Study 2

	Study 1	**Study 2**
{ADJ-DE, N}	strong	weak
{NUM-CL, N}	weak	strong

Across the three experiments in each study, the manipulation was the noun phrase orders presented to the participants in the test phase. Within each study, children heard the same familiarization materials for 20s (see examples in Table 1). The pause between two familiarization utterances was 1 second. Test stimuli in each experiment consisted of two types of trials, i.e., NPs in the form of two of the three orders. The three orders were compared in a pairwise manner across three experiments. Each trial contained two different NPs, each of which was produced with three different intonations, thereby yielding six tokens in total for each trial. All trials lasted for 23 seconds, also with a one-second interval added between two adjacent NP tokens. The two trials were played in alternation, with each repeated for five times, and the initial trial type presented to the participants was counterbalanced. The design of the three experiments is summarized in Table 3.

Table 3. Experimental design across experiments

Familiarization (20s)		
[NP ADV ADJ] utterances		
Test (23s/trial, 10 trials in total)		
Experiment 1	Experiment 2	Experiment 3
Order 1 vs. *Order 3	Order 2 vs. *Order 3	Order 1 vs. Order 2

2.4. Procedure

Each toddler participant was tested in a sound-proof room, accompanied by a parent or guardian. They were seated in front of a TV, on which the experimental stimuli would be played. The adult was asked to put on earphones and listen to music during the experiment, so that they would not influence the toddler's behavior. An experimenter monitored the participant from another room through an HD camera and initiated the experiment once the child fixated on the TV screen.

The experiment was run with an in-house program, specifically designed to automatically switch between experiment trials and the attention-getter based on the experimenter's button presses. The experimenter would press a button if the child looked at the screen and release it when the child looked away. Looking durations would be recorded by the computer. Whenever the button was released for 2 consecutive seconds, or the maximum trial length was reached, the attention-getter would show up. For the familiarization phase, the trial would start over when the experimenter pressed the button again, until the accumulated listening time reached 20s. For the test phase, a new trial would begin. This setup ensured that the experiments progressed in an infant-controlled manner.

2.5. Predictions

The crucial measurement was participants' listening time difference between the two orders presented to them in each experiment. Successful discrimination between the two would indicate their distinct grammatical status for children, regardless of the preferential direction (see Hunter & Ames, 1988 for discussion about possible factors resulting in familiarity and novelty preferences). In our Study 1, we found successful discrimination in Experiment 1, but not the other two, indicating that the grammatical status of the Order-1 items was clear enough to enable their discrimination from the ungrammatical Order-3 items, while the status of Order-2 stimuli was less clear, because they were not treated differently from the ungrammatical items, nor from the grammatical Order-1 stimuli by the participants as a group.

The inter-study manipulation of the association strength of specific item pairs would lead to different predictions depending on the nature of the asymmetry between Orders 1 and 2 found in Study 1. On the one hand, if the sensitivity advantage of Order 1 was attested because in Order-1 (but not Order-2) stimuli, different NP categories were combined adhering to their grammatical properties (see discussion in Section 1), on which the item-specific manipulation would have no effect, children should consistently privilege Order 1 over Order 2 in acquisition. In other words, the asymmetry captured in Study 1 should be preserved in Study 2. On the other hand, the Order-1 advantage in Study 1 could also be related to the difference in association strength of specific item pairs. Specifically, with the connection between ADJ and N items highlighted and the general classifier attached to the NUM domain in Study 1, it would be natural to put ADJ items closer to the nouns and the NUM-CL items further away—exactly as Order 1 does—if children were sensitive to such information. In other words, we should expect children to be more sensitive to the Order-1 items as compared to the ones in the form of Order 2. Crucially, the same reasoning should be extended to Study 2, in which the item-specific association was manipulated to reverse. As a result, Order-2 items should be reliably distinguished from the ungrammatical Order-3 items, while children's sensitivity to the Order-1 items should be less clear.

2.6. Results

Following the common practice in the literature, we calculated the average looking durations of the two trial types in each experiment for every participant, with the initial trial of each type removed. Given that our predictions hinged specifically on the comparison between Study 1 and Study 2, we first submitted our data to three linear mixed-effects models, with each predicting the looking time in one experiment from Study (Study 1 vs. Study 2, sum-coded as 1 and -1), Order (the two order types in each experiment, also coded as 1 and -1), and their interaction. By-participant random intercepts were also included in the models, yielding the formula: Lookingtime ~ Study * Order + (1 | Participant). We found no significant main effects of Order (all p's > 0.1), and the only significant interaction was the one in Experiment 1 ($\beta = 1.03$, SE = 0.37, $p = 0.008$). Other effects were not of interest for the current research.

Let's consider first the Experiment 1 results. Though there was no indication of discrimination when the two studies were combined, the significant interaction pointed to a meaningful inter-study difference. Note that this could mean a difference in the presence/absence of a discrimination effect, or the preferential direction—i.e., both studies could show a significant discrimination effect, but one with familiarity preference and the other with novelty preference. The statistical tests separately conducted in the two studies (model formula: Lookingtime ~ Order + (1 | Participant)) indicated the plausibility of the latter. Participants in Study 1 listened longer to the grammatical Order 1 (Mean=15.25s; SE=0.81) than to the ungrammatical Order 3 (Mean=13.31s; SE=1.01), showing a reliable familiarity preference ($\beta = 0.97$, SE = 0.46, $p=0.045$). On the contrary, there was a marginally significant effect indicating a reversed pattern in Study 2 ($\beta = -1.09$, SE = 0.58, $p=0.074$), with the Order-1 listening time (Mean=11.20s; SE=0.82) overall shorter than that of Order-3 (Mean=13.38s; SE=1.07). The results of the two studies are plotted in Figure 1.

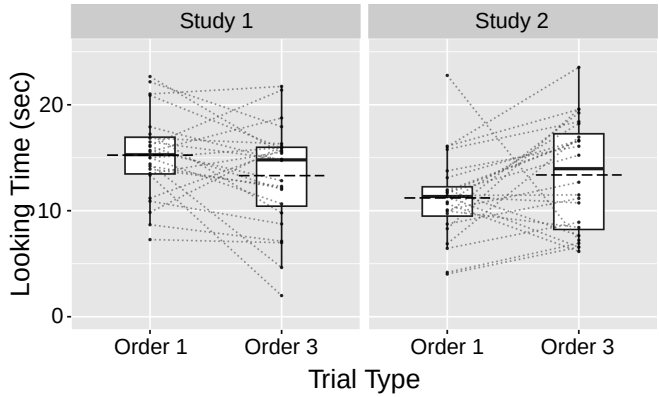

Figure 1. Experiment 1 looking time distributions, medians (horizontal solid lines), and means (horizontal dashed lines) of both studies. The connected dots represent data points of each individual.

Note that a novelty preference is often associated with more robust processing of the stimuli in the literature (e.g., Hunter & Ames, 1988). That is to say, participants in Study 2 might capture the distinction between Order-1 and Order-3 items from very early on during the test phase. This was borne out by a clearer discrimination effect of Study 2 when the data of the initial test trials were included in the statistical analysis (p=0.039). Putting aside for now the preferential direction, which we will further discuss in the last section in light of prior studies in the literature, we can see that our participants showed comparably robust sensitivity to the typologically common Order 1 in both studies.

Now let's turn to the remaining experiments. The absence of Order main effect pointed to a null discrimination overall, and the lack of interaction indicated that the experiments in the two studies shared similar patterns. Taken together, they suggested that in both studies, the grammatical but typologically rare Order 2 was not reliably distinguished from the ungrammatical Order-3 stimuli, nor from the Order-1 items that we already know children are sensitive to. The lack of discrimination effects can be seen from the trivial looking time differences at the group level (Study 1: Experiment 2 Mean=0.82s, SE=0.99; Experiment 3 Mean=-0.77s, SE=0.95; Study 2: Experiment 2 Mean=0.20s, SE=0.87; Experiment 3 Mean=0.66s, SE=1.05), as well as the high degrees of variation of individual looking patterns, as visualized in Figure 2.[2]

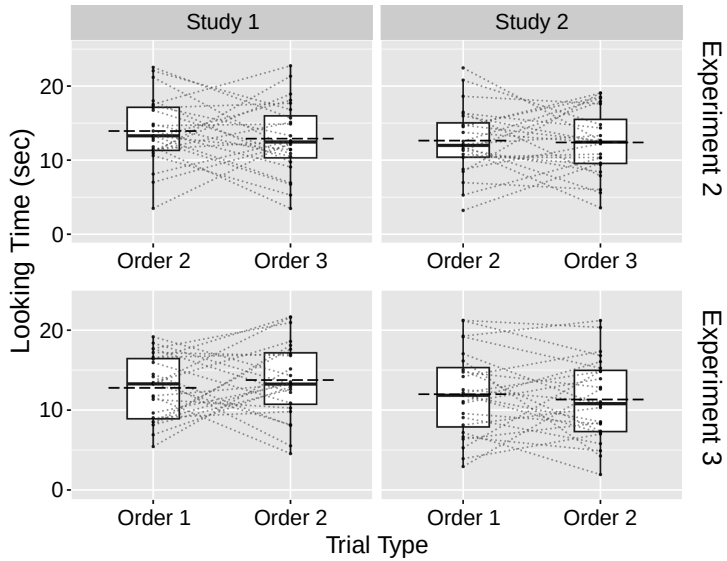

Figure 2. Looking time distributions, medians (horizontal solid lines), and means (horizontal dashed lines) of Experiments 2 and 3 in both studies. The connected dots represent data points of each individual.

[2] We also analyzed the data of Experiments 2 and 3 in both studies separately, but did not find any discrimination effects with or without the inclusion of the initial trials (all p's >.1).

3. Discussion

We compared two sets of experiments, one from our prior study (Luo et al., 2023), and the other from our latest. Across the two studies, we manipulated the association strength between different prenominal items and the nouns, but the Mandarin-learning 30-month-olds tested consistently showed a clearer sensitivity to the typologically common Order 1 (DEM-NUM-CL-ADJ-DE-N) than to the cross-linguistically marked Order 2 (ADJ-DE-DEM-NUM-CL-N). In particular, children could reliably distinguish the former from the ungrammatical baseline Order 3 (*DEM-ADJ-DE-NUM-CL-N), but failed to discriminate the latter from either Order 3 or Order 1 as a group. It appears that most 30-month-olds treated Order 1 as grammatical, while Order 2 might be considered grammatical for some but ungrammatical for the others.

Since we have argued in our prior input investigation that this is unlikely a frequency effect (see Section 1), the acquisition asymmetry between the two grammatical orders should have a learner-internal source. Given our results, the asymmetry is probably category-based, rather than contingent on the association strength difference among specific item pairs. This is because even with the increase in the specific nouns' association with the NUM-CL items as well as the decrease in that with the adjectives in our latest study as compared to the previous one, Order 1, in which ADJ is put closer to N than NUM-CL is, is still the privileged order in acquisition. Therefore, our results would be better understood if we assume children by this age have already understood the distinctive properties of different NP categories, and thus prefer combining them in an order that adheres to their properties, much in line with the bias postulated in prior adult artificial language learning research (Culbertson & Adger, 2014, et seq.).

Note that there is an assumption of this inference: Children would need to be sensitive to our inter-study manipulation. In other words, we need to ensure that the consistent Order-1 advantage did not arise simply because children were oblivious to the changes we made in familiarization and test items—for instance, they could have ignored the classifier items altogether in processing the test stimuli. One support for this critical assumption is the interesting change of the preferential direction observed in Experiment 1 between the two studies. Though several factors could cause such a change, one possibility that is featured in the literature and highlighted in our discussion in the previous section has to do with the test stimuli (see also Cyr & Shi, 2013). Specifically, we conjecture that the Study 2 test stimuli might be easier to process for 30-month-olds than the ones in Study 1 are, which in turn suggests children's awareness of our manipulation, i.e., the usage of specific classifiers in Study 2 and the general classifier in Study 1.

This might not be intuitive at first sight, since specific classifiers are typically considered to bear richer semantic information (e.g., the shape features of the objects denoted by the nouns they co-occur with), and therefore should be more difficult for children—this is borne out by the widely-reported earlier acquisition of the general classifier (e.g., Hu, 1993). However, children by our test age (i.e., 30 months) should have already acquired the two specific classifiers we used in Study 2, namely *tiao* and *kuai*, as shown in prior studies (e.g., Li et al., 2010; Miao

et al., 2020). Further, given the absence of a referential context in the visual fixation experiments, no semantic processing should be needed during the process. Therefore, the issue becomes a comparison of formal accessibility, rather than semantic learnability, between the general classifier and the specific ones. Interestingly, processing advantage for lexically idiosyncratic cases (comparable to specific classifiers that only co-occur with a subset of nouns) over the default ones (analogous to the general classifier) is not uncommon in psycholinguistic research (see Yang, 2016 Chapter 3 for a review on this point). For instance, the lexically specific plural suffix *-er* in German is found to be retrieved faster than the default *-s* is (Sonnenstuhl & Huth, 2002). A similar mechanism may also be at play in toddlers' accessing different classifier forms, resulting in the easier processing of stimuli containing specific classifiers.[3] We will take this as a tentative explanation, which the major arguments made in the present paper do not depend on, and leave the exact reason for future study.

In sum, our research has revealed an early acquisition bias for the typologically frequent NP form in Mandarin, and suggested it to be based on the inherent properties of different NP categories. This not only replicates in young children the findings of prior adult artificial language studies (Culbertson & Adger, 2014, et seq.), but also highlights the more endogenous, rather than emergent, nature of the bias that aligns more with the grammatical view in the literature (e.g., Abels & Neeleman, 2012; Cinque, 2005).

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[3] Though the classifiers' different frequencies may independently influence their processing difficulty, note that all items were repeatedly presented for many times in our experiments, which might mitigate any potential frequency effects.

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