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RESEARCH ARTICLE

When less is more: Evidence from Korean-learning children's verb acquisition

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Abstract

Linguistic context supports children's verb learning. For example, upon hearing "the boy is *pilk*ing," children can infer that the novel verb *pilk* names an action that a boy (rather than a girl) engages in. However, more information, such as a modified subject (e.g. "the tall boy is *pilk*ing"), could hinder rather than aid due to increased processing load, as suggested by a previous study with English-learning toddlers (He et al., 2020, *Language Learning and Development* 16, 22–42). In the current study, we found that Korean-learning preschoolers also experienced difficulty when the verb appeared with a modified subject compared to an unmodified one; this difficulty persisted across three situational contexts, even when the additional information was necessary to identify the referent. Our findings, with a typologically different language and diverse contexts, provide cross-linguistic support for prior results in English, consistent with a conceptual replication of the idea that less information can sometimes be more beneficial for learning.

Keywords: verb learning; Korean; preschoolers; syntactic bootstrapping; eye tracking

언어적 맥락은 아동의 동사 학습에 영향을 준다. 예를 들어, "남자가 필키고 있어"라는 문장 에서 아동은 새로운 동사 "필키다"가 (여자가 아닌) 남자가 수행하는 동작을 의미한다고 추론 할 수 있다. 그러나 영어를 모국어로 획득하는 유아를 대상으로 한 선행 연구에서는 "the tall boy is pilking."과 같이 주어가 수식어를 동반할 경우, 처리 부담이 증가하여 동사 학습에 도움이 되기보다는 오히려 방해가 될 수 있다는 것이 보고된 바 있다(He et al., 2020, *Language Learning and Development* 16, 22–42). 본 연구에서는 한국어를 모국어로 습득하는 학령 전기 아동들 역시 동 사가 수식어를 동반한 주어와 함께 제시될 때, 수식어가 없는 주어와 함께 제시될 때보다 동 사 획득의 어려움을 겪는다는 사실을 확인하였다. 이러한 어려움은 수식어가 주어가 지시하는 대상을 명료화하는 데 화용적으로 유용한 맥락에서도 유지되었다. 이러한 결과는 영어 동사 학습에 대한 선행 연구 결과가 유형론적으로 상이한 언어에서도 검증될 수 있음을 보여주며, 언어 학습 과정에서 때로는 적은 정보가 더 효과적일 수 있음을 시사한다.

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1. Introduction

Acquiring a lexicon is not a monolithic task. Different kinds of words pose different kinds of learning challenges. In turn, the optimal type of learning situation may vary depending on the word being acquired. For example, it has long been noted that learning nouns that label concrete objects may be well supported by situations involving joint attention on the object with an interlocutor (e.g. Tomasello & Farrar, 1986). By contrast, identifying the meaning of a verb is often not straightforward from observing the surrounding world (e.g. Gillette, Gleitman, Gleitman, & Lederer, 1999). But the linguistic context in which the verb occurs can offer useful information about its meaning, for example by indicating the agent of a labelled action (e.g. Gleitman, 1990; Landau & Gleitman, 1985). Decades of research have shown that children are able to use a verb's linguistic context in the service of verb learning (e.g. Arunachalam & Waxman, 2015; Fisher, 1996, 2002; Fisher, Hall, Rakowitz, & Gleitman, 1994; Hirsh-Pasek & Golinkoff, 1996; Imai, Haryu, & Okada, 2005; Imai et al., 2008; Naigles, 1990; Naigles & Swensen, 2007; Yuan, Fisher, & Snedeker, 2012). But what constitutes optimal contexts that best support verb learning in any given situation remains a question of discussion. One issue is illustrated in the following example.

Imagine a child and her caregiver are spending their afternoon on a bustling playground. The caregiver utters a sentence like (1), containing a verb that is unfamiliar to the child.

(1) The boy is *pilk*ing.

(2) The tall boy is *pilk*ing.

With numerous activities going on, it may not be obvious to the child which event this verb labels from observing the environment. The sentence does guide the child to look for an event with a boy as the agent, but the playground might be occupied by multiple boys, engaging in different activities. In this case, a sentence with more information, such as (2), will further limit the search to events involving tall boys. Even if there is only one boy on the playground, the modifier "tall" would highlight a particularly salient feature of the agent, and this may improve the speed and/or accuracy with which the child identifies that referent. Given the fleeting nature of many events, rapid identification of the agent should increase the likelihood that the child will have the opportunity to observe the event and map it to the novel verb. Thus, from an information-based perspective, a sentence with more semantic information, compared to less information, is more supportive for learning a novel verb.

However, more information incurs a higher processing load. Given young children's limited processing abilities, more information will not always be more helpful to them. This issue, seated in the bigger picture of language acquisition theory, is part of the discussion on the relation between *input* and *intake* (see, e.g., Lidz & Gagliardi, 2015; He, 2022; He & Arunachalam, 2017; Trueswell & Gleitman, 2007, for reviews). The input, or the language that children are exposed to, for example from caregivers, must be processable so that it can enter into the child's linguistic representation (i.e. the intake).

In fact, in a recent study with English-learning 2- to 4-year-olds, He, Kon, and Arunachalam (2020) demonstrated that sentences like (2), despite providing more information about the agent of an event, are *less* supportive for verb learning than sentences like (1). The task was a novel-verb-learning experiment; verbs were introduced

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in trials involving two phases: familiarization and test. During familiarization, children saw two visual scenes simultaneously displayed on opposite sides of the screen, each depicting a different agent performing a different action (e.g. a man waving, a woman clapping). They heard a sentence with a novel verb describing the target scene, which, depending on their assigned condition, contained either an unmodified subject like (1) or a modified subject like (2). Here, children needed to process the sentence to find the labelled scene and map the novel verb to the corresponding action. Their eye gaze was measured to assess their identification of the labelled scene. Subsequently, in the test phase, children saw the two familiar actions performed by new actors and were asked to point to the referent of the novel verb. Both their eye gaze during familiarization and their pointing during test showed a clear advantage for sentences with unmodified subjects. This advantage also persisted when compared to another condition where the sentence contained a modified subject, but the modifier was necessary for disambiguating the two referents (e.g. a tall man waving, a short man clapping). The authors attributed this advantage to the ease of processing an unmodified subject relative to a modified one, illustrating the idea that "less is more" – while information is important, it can only be utilized effectively if it is processable (see also, e.g., Hu, 2024; Imai et al., 2005, 2008; Kim & Song, 2024).

A processing account of these results might sound surprising, given that children at this age *are* able to process modified noun phrases like "the tall man" (e.g. Davies, Lingwood, Ivanova, & Arunachalam, 2021; Fernald, Thorpe, & Marchman, 2010). Indeed, He et al. (2020) showed that they did: children looked at the target scene at above-chance levels during the familiarization phase, after hearing the modified-subject sentence. However, learning the novel verb in their task involved more than just processing the subject of the sentence; it additionally required children to process the phonological form of the novel verb that came after the subject, establish a semantic representation for that verb that incorporated the action undertaken by the referent of the subject, and then retain that semantic representation long enough to apply it again at test. They suggested that processing the modified subject used so much of the children's processing resources that they had insufficient resources left to learn the novel verb that occurred downstream in the utterance.

Thus, as decades of research have shown, a verb's linguistic context can play a role in its acquisition. The work reviewed above refines this notion, highlighting that particular characteristics of the linguistic context – in particular, the dynamics between informativeness and processability – provide a framework for predicting which types of linguistic contexts most effectively support verb learning (e.g. Horvath & Arunachalam, 2019): they should be sufficiently informative to allow children to identify the verb's meaning, but should not be too difficult to process. However, this framework requires additional empirical support.

The current study seeks to provide this empirical support in two ways: first, by examining a language other than English to broaden our empirical coverage, which is necessary for theories that seek to uncover potential universals about language acquisition; and second, by expanding the situational contexts in which sentences are used, to better explore different dynamics between informativeness and processability. Using the same experimental paradigm as He, Kon, and Arunachalam (2020), we adapted the stimuli to address these issues.

Regarding empirical coverage beyond English, we selected Korean because it is like English in the most fundamental ways required to conceptually replicate previous research, but is otherwise typologically very different from English. First, basic word

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order – a key typological property – differs between Korean (subject–object–verb) and English (subject–verb–object). This structural difference may influence sentence-processing strategies, as Korean speakers must hold both the subject and object in memory before processing the verb, unlike English speakers. Despite this difference, in intransitive sentences – the type we use as our entry point – both languages place the verb directly after the subject. Thus, Korean allows us to carry out the core manipulation of whether the subject is modified or unmodified, while testing whether the English findings extend to a language in which children's overall sentence-processing experiences and strategies may be quite different.

Second, Korean allows sentential subjects to be omitted, unlike English. In child-directed Korean, over 60% of subjects are omitted (Kim, 2000), providing Korean learners with fewer experiences in processing preverbal subjects compared to English learners. This may increase overall processing load when Korean learners are presented with sentences – such as those in the current experiment – that do include overt subjects. Again, Korean allows us to maintain our core manipulation of unmodified versus modified subjects even for children with markedly less exposure to any kind of overt subject.

Third, Korean differs from English in how modified subjects are expressed. Take "the tall man" for example: in English, a simple adjective suffices (e.g. "tall" in (2)), whereas in Korean, the modifier may involve both a noun and an adjective (e.g. "height" and "big," in (4)), a structure that some theories (e.g. Kim, 2002) classify as a relative clause (i.e. the man who has big height). For other types of modified phrases, such as "the standing dog," English uses a participial adjective as a modifier, while Korean employs a relative clause structure (i.e. the dog that is standing). See sentences (3)–(6) for relevant Korean examples. Thus, although both languages place the modifiers before the noun they modify, Korean prenominal modifiers are often syntactically more complex and result in longer phonetic strings than their English counterparts. This difference allows us to explore whether the additional complexity in Korean influences children's ability to identify the subject's referent (e.g. the tall man, rather than the short man) and whether this, in turn, affects verb learning in the same way as in English.

(3) 남자가 필키고 있어.
namja-ga pilki-go-isseo
man-NOM pilk-PROG-DECL
The man is *pilk*ing.

(4) 키 큰 남자가 필키고 있어.
ki keun namja-ga pilki-go-isseo
height big man-NOM pilk-PROG-DECL
The tall man is *pilk*ing. (The man who has big height is *pilk*ing.)

(5) 강아지가 감피고 있어.
puppy-NOM gamp-PROG-DECL
The puppy is *gamp*ing.

(6) 서 있는 강아지가 감피고 있어.
stand-CONN be-PRCP puppy-NOM gamp-PROG-DECL
The standing puppy is *gamp*ing. (The puppy that is standing is *gamp*ing.)

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Given these cross-linguistic similarities and differences, by testing Korean-learning children with an essentially similar experimental manipulation, we aim to determine whether the main patterns observed by He et al. (2020) hold across these two languages. If so, this would further bolster He et al.'s (2020) hypothesis that verb learning is easier for preschoolers when the subject is unmodified rather than modified, due to the processing burden imposed by modified subjects, thus providing a conceptual replication.

Regarding our second goal to explore different dynamics between informativeness and processability by expanding the situational contexts that we test, this study will situate modified-subject sentences in three distinct situational contexts. In He et al. (2020), only two scenarios were examined: one in which referents came from different basic-level categories (e.g. a man, a woman), making the noun sufficient for identification and rendering the modifier unnecessary; and another in which referents belonged to the same category but differed in a salient property captured by the modifier (e.g. a tall man, a short man), making the modifier essential for disambiguation. While both situational contexts involve additional language processing (in comparison to unmodified subjects), they differ in the dynamics between informativeness and processability. In the modifier-necessary context, the extra modification enhances informativeness, unlike in the modifier-unnecessary context. In both of these contexts, the visual stimuli were manipulated so that the modifier was either necessary or unnecessary, but they were not manipulated to make the *noun* either necessary or unnecessary. This missing manipulation, which we add in the current study – using a modified subject when the two referents come from different basic level categories but do not differ in a salient property denoted by the modifier (e.g. a tall man, a tall woman) – allows us to determine whether the previous results were specific to modifiers. In particular, because nouns are, in general, earlier and more easily acquired than adjectives (e.g. Waxman & Booth, 2001), we might expect children to be more adept at recruiting noun information and therefore to perform better when the head noun in the subject phrase provides disambiguating information than when modifiers do.

In sum, the current study aims to provide additional empirical support from another language for He et al.'s (2020) claim that verbs are better learned from unmodified subjects due to their reduced processing load and, more broadly, for a conceptual framework in which we consider trade-offs between the informativity and processing load of linguistic contexts in evaluating whether they are supportive for word learning. We examined verb learning in Korean-speaking children by comparing verbs introduced in unmodified-subject sentences versus modified-subject sentences and exploring three distinct situational contexts for modified subjects. We focus on children aged 4 to 5 years for two main reasons: first, during the preschool years, children's processing efficiency develops rapidly (e.g. Fernald, Perfors, & Marchman, 2006; Peter et al., 2019), enabling us to evaluate whether their enhanced processing skills are sufficient to learn novel verbs from sentences with modified subjects; second, considering that Korean modified sentences may involve more complex syntactic structures and additional phonetic information compared to English, resulting in a higher processing load, targeting slightly older children than He et al. (2020) allows us to assess their ability to handle these complexities.

In terms of measurement, following He et al. (2020), we focus on two primary indicators: one reflecting the children's learning process, which involves analysing their eye gaze patterns during learning, and another representing their learning outcome, which involves analysing their pointing behaviour when asked to identify the novel verb's referent. To preview, our results replicate the advantage of unmodified subjects found by He et al. (2020), providing consistent evidence that "less is more" in a different language.

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Furthermore, comparisons across the three conditions that used a modified subject in varying situations suggest a nuanced role of the situational context.

2. Method

2.1. Participants

A total of 116 Korean-speaking children participated in one of four conditions, 80 of whom were tested in the lab and 36 of whom were tested in their home over videoconferencing (due to COVID-19). In the lab, participants underwent an eye-tracking protocol, providing both pointing and eye gaze responses, though gaze data from three participants were missing due to equipment failure. Those tested at home contributed only pointing data.

For the pointing sample (n = 116), 9 participants did not finish the study due to equipment error or fussiness, and 18 did not meet the inclusion criteria. Thus, 89 participants (40 female and 49 male) were included (age range 48.2–71.0 months, mean age 57.5 months). For the gaze sample (n = 77), 3 participants did not finish, 13 did not meet the inclusion criteria, and 5 were excluded due to excessive track loss (see subsection *Coding – Eye gaze*). Hence, 56 participants (27 female and 29 male) were included (age range 48.2–71.0 months, mean age 58.7 months) in gaze analyses (see Table 1). The same inclusion criteria were applied to both samples to establish a relationship between pointing (learning outcome) and gaze (learning process). Participants were excluded from both samples if they failed to point correctly on at least one of two training trials or failed to point at all on any of the three experimental trials.

According to parental report, these children all had a minimum of 75% exposure to Korean, with no known language, communication, or uncorrected hearing or vision problems. Some participants also took part in a different task (e.g. learning transitive verbs, with no adjectival modifiers, reported in Shi, He, Song, Jin, & Arunachalam, 2023; moral judgment tasks used in Cha & Song, 2024 and Lee & Song, 2024; a novel noun recognition task), either before or after the current experiment.

2.2. Experimental Design

The experiment consisted of three experimental trials. Each trial included a *familiarization* phase during which children were exposed to a novel verb and a *test* phase during which children were asked to find the referent of the novel verb. The familiarization phase varied by condition, while the test phase was identical across conditions.

Table 1. Sample distribution across conditions

Condition	No. of participants included for pointing data	No. of participants included for gaze data
Unmodified	22	15
Modified-Unnecessary	23	15
Modified-Necessary	21	13
Modified-Uninformative	23	13

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There were four conditions, manipulated between participants. The *Unmodified* condition used sentences with unmodified subjects (e.g. "the man") as in (3) and depicted as potential referents a scene with a tall man and a scene with a short woman. The other three conditions all used a modified subject (e.g. "the tall man") in the linguistic stimuli, as in (4), but the visual stimuli differed. In the *Modified-Unnecessary* condition, the visual stimuli were identical to the *Unmodified* condition; here, the noun alone (e.g. "man") distinguished between the two, making the modifier (e.g. "tall") unnecessary. However, despite being unnecessary, the modifier was informative in the sense that it correctly picked out a salient contrasting feature of the referent actor. In the *Modified-Necessary* condition, the visual stimuli included two referents from the same basic-level category, such as a tall man and a short man; the modifier was crucial here to disambiguate, hence necessary. In the *Modified-Uninformative* condition, the visual stimuli depicted two referents sharing the same property, such as a tall man and a tall woman; in this case, it is the noun that disambiguates, and the modifier is neither necessary nor informative (see Table 2).

2.3. Stimuli

The experiment consisted of pointing training trials and experimental trials; both types had the same structure. The visual stimuli for all trials were identical to those used in experiment 2 of He, Kon, & Arunachalam (2020), except that in the current study, there was an extra condition (named "Modified-Uninformative" here) that included new stimuli, though they were modelled after the original conditions. Also, the auditory stimuli were in Korean, whereas those in He et al. (2020) were in English. The timeline in which the stimuli were arranged was identical between the two studies. For the training trials, the visual stimuli were video clips of two familiar animals side by side (e.g. cat, pig), and auditory stimuli were prerecorded sentences prompting children to find one of them ("where's the cat?"). For experimental trials, videos were recordings of two live actors (e.g. a man waving) or objects manipulated by a hand (e.g. a ball moving up and down) side by side, and audio consisted of sentences containing the novel verbs (e.g. "the man is *pilk*ing," "where's *pilk*ing?") and attention-getting/transitional sentences (e.g. "look," "wow"). Auditory stimuli were prerecorded by a female speaker of Korean using child-directed speech, edited in Praat (Boersma & Weeknink, 2014), and combined with the visual stimuli in Final Cut Pro X.

Table 2. Experimental design (one trial example)

Condition	Sentence introducing novel verb	Familiarization events	Role of modifier
Unmodified	The man is *pilk*ing.	Tall man waving, short woman clapping	N/A
Modified-Unnecessary	The tall man is *pilk*ing.	Tall man waving, short woman clapping	Informative but unnecessary
Modified-Necessary	The tall man is *pilk*ing.	Tall man waving, short man clapping	Informative and necessary
Modified-Uninformative	The tall man is *pilk*ing.	Tall man waving, tall woman clapping	Uninformative and unnecessary

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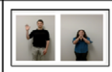
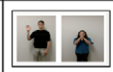
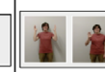
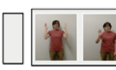
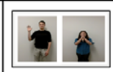
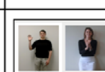
2.4. Procedure and apparatus

Participants either came to the lab in person or took part in the experiment from their home (due to COVID-19 restrictions). For both in-person and online testing, the procedure began with welcoming the family, introducing the experiment, and collecting informed parental consent. When the child felt comfortable and ready to start, the experiment began. For in-person testing, the experiment took place in the lab's testing room, where the child sat in a chair of proper height or on the parent's lap; the parent was asked to close their eyes in the latter case to prevent their own eye gaze from being captured by the eye tracker. Stimuli were presented on a Tobii X2-30 eye tracker affixed to a 1680 by 1050 monitor, positioned 24 inches from the child. An experimenter sat next to the child to elicit and record pointing responses; another experimenter also recorded pointing from behind a curtain via integrated webcam feed. For online testing, the experiment was conducted via Zoom, with the child seated in front of the family's own computer and a parent sitting behind them. The experimenter played the experiment video using screen sharing and recorded the child's pointing behaviour through the Zoom camera. The parent was instructed to avoid interfering, except for attempts to calm the child if they became fussy.

In all cases, children participated in two pointing training trials and three experimental trials. On each training trial, children saw two video clips of animals and were asked to point to one of them (e.g. "Where's the cat?"). Each of the three experimental trials consisted of a familiarization phase and a test phase. As in He et al. (2020), the three trials were presented in a fixed order across participants. See Table 3 for the experiment stimuli varying by condition, using English translations of the Korean sentences; and Table 4 shows the actual Korean sentences used in the experiment. See Appendix 1 of the Supplementary Material for stimuli for all trials.

Familiarization phase. First, two video clips were presented side by side, each depicting a different actor engaging in a different action (e.g. a man waving, a woman clapping),

Table 3. Experimental timeline and stimuli (example of one trial; with English translations)

	Familiarization			Test					
	Familiarization 1 6 sec	3 sec	Familiarization 2 6 sec	1 sec	Test 1 6 sec	2 sec	Test 2		
							6 sec	.5	6 sec
Unmodified	 Look!	The man is *pilking*.	 (silence)	Now look!	 (silence)	 Where's *pilking*?	 Conditioned live prompt*: "Can you point to *pilking*?"		 (silence)
Modified-Unnecessary	 Look!	The tall man is *pilking*.	 (silence)						
Modified-Necessary	 Look!	The tall man is *pilking*.	 (silence)						
Modified-Uninformative	 Look!	The tall man is *pilking*.	 (silence)						

*at 4s into this section, if no pointing had happened after the pre-recorded auditory prompt, the experimenter offers this live prompt.

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Table 4. Korean sentences with English glossing (one trial example)

Condition	Key sentence in familiarization	Key sentence at test
Unmodified	남자가 필키고 있어. man-NOM pilk-PROG-DECL The man is *pilk*ing.	필키고 있는 거 어디 있어? pilk-PROG-PRCP thing where be-PRS-Q? Where's *pilk*ing?
Modified-Unnecessary	키 큰 남자가 필키고 있어. height big man-NOM pilk-PROG-DECL The tall man is *pilk*ing.	
Modified-Necessary	키 큰 남자가 필키고 있어. height big man-NOM pilk-PROG-DECL The tall man is *pilk*ing.	
Modified-Uninformative	키 큰 남자가 필키고 있어. height big man-NOM pilk-PROG-DECL The tall man is *pilk*ing.	

accompanied by a neutral linguistic prompt "look!" (*familiarization 1* subphase). Then, with a blank screen displayed, children heard a sentence that described one of the video clips, introducing the novel verb. The blank screen was intended to allow children to process the linguistic stimulus without visual distraction. The sentence varied by condition (see Table 1).

After that, the two video clips in familiarization 1 reappeared to replace the blank screen. At this stage, children had already had a chance to attend to both the visual and linguistic stimuli individually, but it was their first opportunity to look at the visual stimulus that matched the sentence. We measured their eye gaze during this subphase (*familiarization 2* subphase) to see whether they were able to use the linguistic information to orient to the target video (and hence, the target action).

Test phase. The test phase was identical across all conditions. Two new video clips were displayed, each featuring the same two actions as seen in familiarization. The actor was the same across the two test scenes but differed from the two actors seen in the familiarization phase. After having a chance to examine these new video clips (*test 1* subphase), children heard a prompt asking them about the target action (e.g. "Where's *pilk*ing?"). If the child did not initiate any pointing after this prerecorded prompt, the experimenter would provide a live prompt (e.g. "Can you point to *pilk*ing?"). Children's pointing after the prompts (during *test 2* subphase) was analysed to see whether they correctly identified the target.

Of the two new video clips, the one displaying the same action labelled by the novel verb during familiarization was the *target*, and the other the *distractor*. For all children, the target on each trial was the same (e.g. on the *pilk* trial, all children had the clapping action as the target, rather than the waving action). We counterbalanced, across trials, the positions (i.e. left or right side of the screen) of the target at test and whether it appeared on the same side as it had during familiarization. The test phase for each trial was identical across all four conditions.

2.5. Analyses and coding

Following He et al. (2020), we assessed children's verb learning by examining both their learning process and outcome. We evaluated the learning process by analysing whether children looked at the correct scene during the familiarization phase, just after hearing the novel verb in a sentence. For the learning outcome, we evaluated whether children

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pointed to the target at the test phase after being prompted to identify the referent of the novel verb. The former measure provides an indicator of whether children parsed the sentence containing the novel verb when they first encountered it, and the latter provides an indicator of whether they were able to learn the verb during that encounter and find another instance of its meaning when tested. We specifically measured eye gaze during familiarization 2 to understand sentence processing and used pointing during test 2 to assess verb-learning outcomes. Gaze data during the test phase were not analysed, as children typically obscure the eye tracker when they raise their arm to point to the screen.

Pointing. Children's pointing was independently recorded by two experimenters into three categories: left, right, or uncodable (which includes no pointing at all or pointing that is difficult to discern in terms of direction). Trials that fell into this third category, or 28 of the 267 trials, were excluded from data analysis. Disagreements between the experimenters were rare and were resolved by discussion after the experiment. On each trial, if the child pointed more than once, only the first point was counted. Points to the target were coded as 1 and to the distractor as 0.

Eye gaze. In keeping with He et al. (2020), we calculated track loss during familiarization 2[1] and excluded trials on which there was more than 65% track loss.[2] This resulted in five participants being excluded entirely for contributing no usable trials, and an additional six trials from six participants (four trials from the Unmodified condition, two trials from the Modified-Unnecessary condition) being excluded. For the included trials, we only included the frames on which gaze was captured (i.e. frames with track loss were excluded): 1 for a target look, 0 for all others (including a distractor look, as well as when gaze fell outside any area of interest).

3. Results and discussion

As in He et al. (2020), for both pointing and gaze data, we performed two sets of analyses: (a) by-condition analyses comparing each condition's aggregate pointing/gaze to chance level; and (b) cross-condition analyses to examine the effects of condition (if any) on their verb-learning outcome. Statistical analyses and figure plotting were carried out in RStudio (R version 4.4.1), using the following packages: plyr (version 1.8.9), ggplot2 (version 3.5.1), lme4 (version 1.1.35.4), Matrix (version 1.7.0), optimx (version 2023.10.21), and emmeans (version 1.10.7). We adopted a significance level of .05 in all analyses. Deidentified data can be found at https://osf.io/tjmrv/.

3.1. Pointing data at test

To summarize the descriptive statistics: Unmodified condition (M = 0.67, SD = 0.34), Modified-Unnecessary condition (M = 0.54, SD = 0.37), Modified-Necessary condition

[1]Trial exclusion was based solely on track loss during familiarization 2 because this phase follows the critical sentence and it is where we expect children's eye gaze to reveal their processing of the sentence.

[2]A threshold of 65% was adopted to balance data quality and sample size. Young children often have high track loss due to attention and movement issues, and a stricter criterion (e.g. 25%, 33%) would exclude too many trials, reducing the sample size and statistical power. In addition, the current task focuses on broader patterns rather than fine-grained eye gaze directions (e.g. anticipatory looking), rendering a more lenient criterion appropriate. Similar exclusion criteria have been used in child language acquisition literature, such as Fernald, Perfors, and Marchman (2006) with >70%, and Arunachalam, Escovar, Hansen, and Waxman (2013) with >50%.

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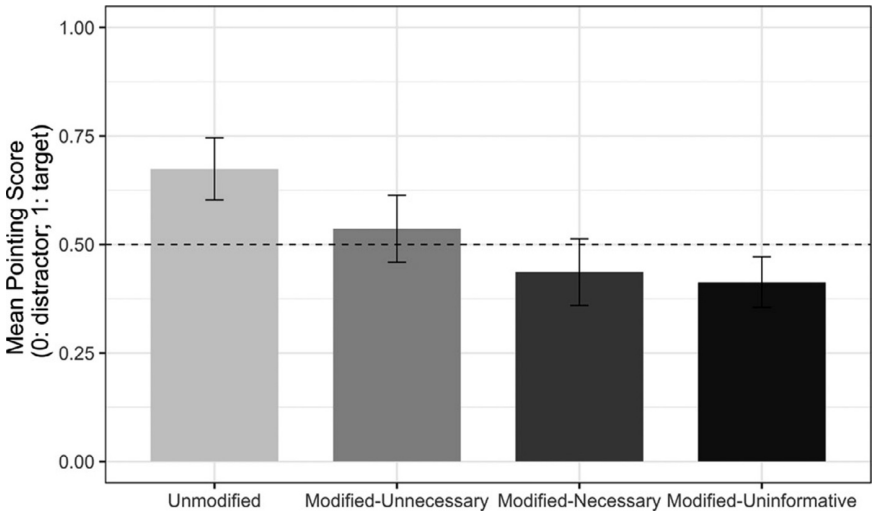


Figure 1. Mean pointing score at test (error bars represent standard error of participant means; the dashed line indicates chance level).

($M = 0.44$, $SD = 0.35$), and Modified-Uninformative condition ($M = 0.41$, $SD = 0.28$). See Figure 1.

By-condition analyses. We first compared pointing responses to chance level (i.e. 0.5) within each condition to determine whether there was evidence that children had learned the verb in each condition. We entered data from each condition, separately, into binomial mixed-effects regression models, with participant and trial as random factors, and evaluated the intercept parameter. Of the four conditions, only the Unmodified condition yielded above-chance pointing (intercept parameter = 0.69, $z = 2.27$, $p = .02$). All the other conditions did not: Modified-Unnecessary, intercept parameter = 0.32, $z = 1.00$, $p = .32$; Modified-Necessary, intercept parameter = −0.31, $z = -0.95$, $p = .34$; Modified-Uninformative, intercept parameter = −0.31, $z = -0.86$, $p = .39$.

Cross-condition analyses. We next entered data from all conditions into a binomial mixed-effects regression model to evaluate cross-condition differences, with participant and trial as random factors, condition as a fixed effect, and age (centred around the mean) as a continuous predictor.[3] We included age as a covariate in the model due to the wide age range in our sample, although previous research by He et al. (2020) found no significant effects of age in the study we are replicating. Here, too, we found no effect of age ($z = 1.50$, $p = .13$). We then conducted pairwise comparisons using the "emmeans" package, applying the Benjamini–Hochberg adjustment method to control for the false discovery rate across multiple comparisons. We found a difference between the Unmodified and the Modified-Necessary condition ($z = 2.42$, $p = .047$) and a difference between the Unmodified and the Modified-Uninformative condition ($z = 2.50$, $p = .047$). No other differences were found (all ps > .23) (see Table 5).

[3]Model formula: All.model = glmer(Correct ~ Condition + Age.global.centered + (1|Subject) + (1|Trials), data = data, family = binomial).

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Table 5. Pairwise comparison results of pointing data (results are given on the log odds ratio, not the response scale; *p*-value adjustment: Benjamini–Hochberg method for six tests)

Contrast	Estimate	SE	*z*	*p*
Unmodified versus Modified-Unnecessary	0.45	0.42	1.06	.35
Unmodified versus Modified-Necessary	1.03	0.43	2.42	.047
Unmodified versus Modified-Uninformative	1.07	0.43	2.50	.047
Modified-Unnecessary versus Modified-Necessary	0.59	0.41	1.44	.23
Modified-Unnecessary versus Modified-Uninformative	0.62	0.41	1.53	.23
Modified-Necessary versus Modified-Uninformative	0.036	0.41	0.090	.93

3.2. Gaze data during familiarization

Children had 6 seconds to look at the two scenes after hearing the critical sentence (e.g. "the (tall) man is *pilk*ing") (see familiarization 2 in Table 3). Following He et al. (2020), we selected the first 2.5 seconds of this period as our *window of analysis*. While recognizing that the older children in the current study may process information slightly faster than the toddlers in He et al. (2020), we nevertheless opted to maintain this 2.5-second window for consistency and comparability across studies, especially given that the existing literature offers little guidance on determining the appropriate window parameters for the current age range. However, to ensure the robustness of our findings, we also conducted the same sets of analyses using a shorter time window (i.e. the first 1 second of the 6 seconds), and the patterns and results from the inferential statistics remained consistent (see Appendix 2 of the Supplementary Material). Below, we present the results from our a priori 2.5-second analysis window.

By-condition analyses. We compared children's mean target looking in each condition to chance using a one-sample *t*-test. Each condition was evaluated against a chance level of 0.5. To maintain this true chance level, we included only data points on which the child was looking at either the target or distractor. Including additional areas would skew this chance level, which would not be suitable for this analysis. Therefore, we excluded looks at areas outside the areas of interest. Results indicated that children in the Unmodified condition looked at the target scene significantly above chance: $M = 0.80$, $SD = 0.16$, $t = 7.44$, $p < .001$. As for the three modified-subject conditions, both the Modified-Unnecessary ($M = 0.70$, $SD = 0.19$, $t = 4.13$, $p = .001$) and Modified-Uninformative conditions ($M = 0.71$, $SD = 0.21$, $t = 3.45$, $p = .005$) yielded above-chance results; only the Modified-Necessary condition did not ($M = 0.59$, $SD = 0.21$, $t = 1.66$, $p = .12$) (see Figure 2).

Cross-condition analyses. Next, we examined the time course of target fixation using growth curve analysis (Mirman, 2014). Unlike the by-condition analysis, this approach included all non-target looks, coding them as 0, which encompassed both distractor looks and looks at areas outside the areas of interest. Following He et al. (2020) and other studies utilizing the visual world paradigm (e.g. Barr, 2008), this method is more conservative because it acknowledges that children might be choosing not to look at either scene. An empirical logit transformation was applied following Barr (2008). We fitted the data with a second-order and a third-order orthogonal polynomial model[4], and model comparison

[4]While a linear model assumes a constant rate of change over time, higher-order models are more often used in the analysis of eye-tracking data to capture various patterns of change. A second-order polynomial

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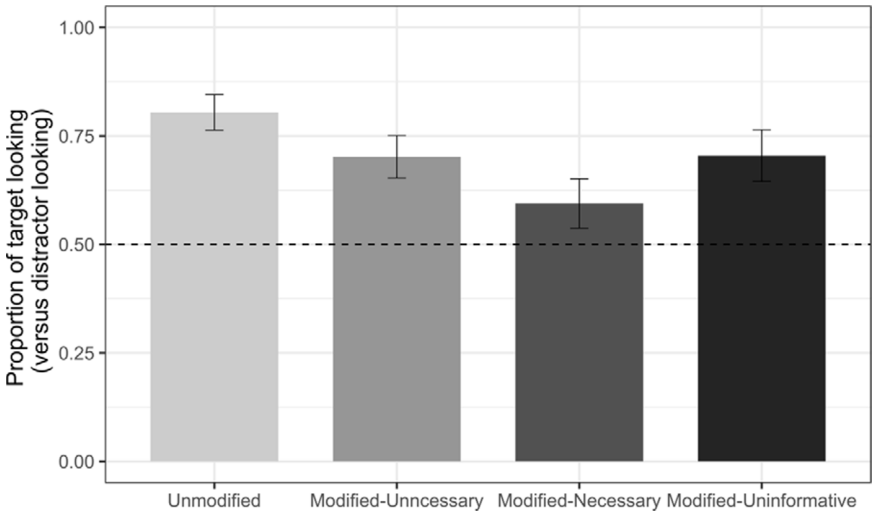


Figure 2. Mean proportion of target looks during familiarization 2 (error bars indicate standard error of participant means; the dashed line indicates chance level).

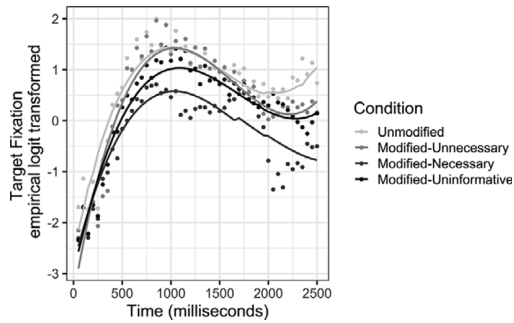


Figure 3. Fixation time course during familiarization 2 and growth curve model fit.

proved the latter to be a better fit ($\chi^2 = 1011$, $p < .001$, $\Delta AIC = -995$, $\Delta BIC = -947.7$). We therefore report the third-order model. The model included a fixed effect of condition, as well as a random effect of participant.[5] The data and model fits are shown in Figure 3. We then submitted model results to the "emmeans" package to perform pairwise comparisons among conditions. To control for the false discovery rate due to multiple comparisons, we applied the Benjamini–Hochberg adjustment method to the p-values. Notably, we found two significant differences: the Modified-Necessary condition had an overall

can capture both linear and simple curvilinear trends, which is useful when the data show acceleration/deceleration over time. A third-order polynomial can capture more complex patterns, including inflection points where the direction of the trend changes, making it useful when the data show more intricate temporal dynamics.

[5]Model formulus: data.modelB = lmer(elog ~ (ot1 + ot2 + ot3) * Condition + (ot1 + ot2 + ot3|Subj), control = lmerControl(optimizer = "bobyqa"), data = data, weights = 1/wts, REML = F)

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Table 6. Pairwise comparison results of gaze data (results are given on the log odds ratio, not the response scale; *p*-value adjustment: Benjamini–Hochberg method for six tests)

Contrast	Estimate	SE	df	*t*	*p*
Unmodified versus Modified-Unnecessary	0.26	0.23	58.86	1.12	0.32
Modified-Necessary versus Unmodified	0.92	0.24	59.63	−3.84	0.002
Unmodified versus Modified-Uninformative	0.46	0.24	59.00	1.90	0.10
Modified-Necessary versus Modified-Unnecessary	0.67	0.24	59.82	−2.77	0.02
Modified-Unnecessary versus Uninformative	0.20	0.24	59.18	0.82	0.41
Modified-Necessary versus Uninformative	−0.47	0.25	59.88	−1.88	0.10

lower target fixation probability than the Unmodified condition ($t = -3.84$, $p = .002$) and the Modified-Unnecessary condition ($t = -2.77$, $p = .02$). Two other differences might also be worth mentioning, although not reaching the threshold of statistical significance: Modified-Necessary was lower than Modified-Uninformative ($t = -1.88$, $p = .10$), and Unmodified was higher than the Modified-Uninformative ($t = 1.90$, $p = .10$). No other significant effects were obtained (see Table 6).

3.3. Discussion

These data reveal a clear difference between children's performance with unmodified subjects (e.g. "The man is *pilk*ing") and their performance with modified subjects (e.g. "The tall man is *pilk*ing"). Children successfully learned verbs from sentences with unmodified subjects, demonstrating above-chance pointing accuracy at test and above-chance gaze duration during familiarization. This replication of the finding in He et al. (2020) for younger English learners establishes the appropriateness of the paradigm for Korean-acquiring preschoolers.

In contrast to the unmodified-subject condition, all three modified-subject conditions yielded less successful verb learning. Children's pointing accuracy at test was at chance level in all modified-subject conditions, indicating that they did not learn the verbs. However, gaze duration during familiarization *was* above chance in two of the conditions (Modified-Unnecessary and Modified-Uninformative), suggesting successful parsing of the modified subject (e.g. "the tall man") and identification of its referent. This dissociation – successful parsing of the preverbal linguistic context but unsuccessful learning of the verb itself – was further underscored by the varying performance across the modified-subject conditions, as summarized below.

The Modified-Unnecessary condition, in which the modifier was informative but unnecessary, had identical visual stimuli to the Unmodified condition, only differing in the presence or absence of the prenominal modification. The fact that children succeeded in the Unmodified condition and not in the Modified-Unnecessary condition, as indicated by their test performance, highlights that they struggle specifically with learning novel verbs that occurred with modified noun phrases. However, it is noteworthy that neither their pointing behaviour at test nor their gaze behaviour during familiarization differed significantly from their performance in the Unmodified condition, indicating that this was the easiest of the three modified-subject conditions.

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The Modified-Necessary condition proved the most difficult. Children not only showed chance-level pointing at test, but they also exhibited chance-level gaze preference during familiarization, indicating a failure to process the modified noun phrase. This was the only condition without a significant preference for the target during the familiarization phase. It also showed the lowest target fixation probability, which was significantly lower than all other conditions except the Modified-Uninformative condition (where the difference approached significance, $p = .09$). We suspect that the difficulty of this condition is twofold: first, like the other two modified-subject conditions, it required children to process through the modified subject; but second, unlike the other modified-subject conditions, the visual stimuli were conceptually similar, involving an agent from the same basic-level category (e.g. tall man, short man). We return to this issue below in General Discussion.

The Modified-Uninformative condition was also daunting for children. Pointing at test was again at chance and significantly poorer than in the Unmodified condition. Aggregated gaze during familiarization was above chance, but target fixation probability was numerically lower (though not significantly so, $p = 0.09$) than in the Unmodified condition. This suggests that identifying the target may have been somewhat challenging, but only severely disrupted pointing at test.

4. General discussion

When faced with an unfamiliar verb, the information contained in the sentence context can help the learner engage in syntactic bootstrapping (e.g. Gleitman, 1990) – that is, to narrow down their hypotheses about the verb's meaning by using the syntactic and semantic information available in the sentence. However, this information can only be useful to the child if it is successfully processed. Given young children's limited processing abilities, the most supportive linguistic context should strike an optimal balance between informativeness and processability. Some prior work supports the notion that trade-offs between informativeness and processability should be part of word-learning theories. For example, He and Lidz (2016) found that 2-year-old English-learning children learned novel intransitive verbs better with pronominal subjects (e.g. "It is *gorp*ing.") than with lexical subjects (e.g. "The flower is *gorp*ing."). Similarly, He et al. (2020) showed that 2- to 4-year-old English learners learned novel intransitive verbs more effectively from unmodified subjects (e.g. "The man is *pilk*ing.") than from modified subjects (e.g. "The tall man is *pilk*ing."), demonstrating a "less is more" effect.

The current study builds directly upon He et al. (2020), using the same contrast (unmodified versus modified subjects), experimental paradigm, and similar stimuli to further validate the "less is more" hypothesis – that highly informative contexts can overwhelm young learners. We approach this validation from two angles. First, we extend the investigation to Korean, a language typologically different from English, in order to assess the cross-linguistic generalizability of the "less is more" effect; here, the key comparison is between the unmodified condition and modified conditions. Second, we incorporate a wider range of situational contexts to better understand the dynamic interplay between informativeness and processability underlying this effect; here, the focus is to compare across the different types of "more" (i.e. modified conditions with different situational contexts).

With respect to the first angle, our results demonstrate that 4- to 5-year-old Korean-learning children had little difficulty processing sentences with unmodified subjects

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(e.g. "The man is *pilk*ing.") and successfully learned novel verbs from this context (Unmodified condition). However, adding a modifier significantly reduced their learning, resulting in chance performance at test across all three modified-subject conditions. This clear disadvantage for modified subjects is consistent with He et al. (2020), despite the differences between English and Korean, and offers promising preliminary evidence that the "less is more" effect may apply across languages.

Caution is warranted in interpreting the implications of these findings. Recall that we specifically targeted slightly older children in this study because Korean sentences with modified subjects are generally more complex than their English counterparts. Our results showed that the "less is more" effect is also evident for these older Korean-learning children. This effect might disappear if the task involved simpler structures, such as those used in English, or even older children, for whom relative clause structures would be trivial to process. Therefore, we are not claiming that the *particular* difficulties we observed here are universal. Rather, our suggestion is that "less is more" trade-offs are likely to be observed in the preschool years when the more informative option is complex enough to make processing it a challenge – what precisely this informative option looks like will depend on the language and the abilities of the child.

A second question about generalizability that stems from these findings is related to grammatical class – the fact that this was a verb-learning study. Both the present study and He et al. (2020) showed that children have difficulty learning verbs in modified-subject conditions. However, earlier research has demonstrated that 3-year-olds can successfully parse modified noun phrases (e.g. Davies et al., 2021; Thorpe & Fernald, 2006) – indeed, our own results showed that children were able to identify the referents of the modified subjects in two of our three conditions and can even use them to acquire novel nouns. For example, Fernald, Marchman, and Hurtado (2008) found that 3-year-olds hearing a sentence like "There's a blue cup on the *deebo*" when presented with a red car and a blue car atop different novel objects used the modified subject to learn the new word *deebo*. Why, then, did preschoolers struggle with a similar task, both in the present study and in He et al. (2020)? One possible explanation lies in the nature of the novel words: while the novel nouns labelled static objects, the novel verbs in the current study labelled dynamic action scenes. This difference between the referents of early-acquired nouns and early-acquired verbs has been cited as a possible explanation, in part, at least, for the developmental decalage between noun and verb acquisition (e.g. Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005). Another possible explanation is that our test of learning was more rigorous, requiring children to extend beyond the particular situation in which they encountered the novel verb (e.g. in the context of a particular agent) to a new situation (e.g. to a new agent). But this, too, is inherently related to what verbs mean – action verb referents can be executed by many agents, and learning this is part of what it means to learn the verb. Therefore, we suggest that the differences between our study and Fernald et al. (2008) are related to differences between verb acquisition and noun acquisition more broadly, rather than idiosyncratic features of our task design.

Now turning to our second angle, we shift focus from the comparison between the "less" (i.e. unmodified condition) and "more" (modified conditions) to a closer examination of the differences between the three different types of "more," each representing a distinct situational context. To enable this comparison, we analysed each condition separately rather than collapsing them into a single "more" category. This analysis yielded fine-grained distinctions: although children failed to learn the verbs in all three modified conditions, differences between these conditions did surface in the *process* of learning, as

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reflected in gaze behaviour during familiarization. Two findings, in particular, warrant some discussion.

First, the Modified-Necessary condition demonstrated a salient relative disadvantage: while both the Modified-Unnecessary and Modified-Uninformative conditions yielded above-chance aggregated gaze, suggesting that children in these two conditions were able to process the modified subjects to find the events being talked about, in the Modified-Necessary condition, they struggled even to identify the referent of the modified noun. This is surprising given that the Modified-Necessary condition is the only one in which the modifier is pragmatically felicitous (Maxim of Quantity, Grice (1975)) – neither over-informative like that in the Modified-Unnecessary condition nor under-informative like that in the Modified-Uninformative condition. This suggests that children's difficulty with modified subjects does not have a pragmatic explanation. Rather, we think that it is related to some aspect of processing difficulty. One possibility is that because the modifier was necessary in this condition, children had to fully process it, phonetically, semantically, and syntactically, to be able to use the information for event identification. By contrast, when the modifier was not necessary (in the Modified-Unnecessary and Modified-Uninformative conditions), children may have adopted an easier "listen-through" strategy (e.g. Thorpe & Fernald, 2006), in which they partially process the modifier without fully integrating it. Therefore, in this sense, the Modified-Necessary condition imposed higher demands on language processing. Another possibility is that the visual similarity between the two agents from the same basic-level category in the Modified-Necessary condition posed a challenge for visual processing (Arias-Trejo & Plunkett, 2010; Bergelson & Aslin, 2017). Importantly, this relative disadvantage of the Modified-Necessary condition was also observed in He et al. (2020) (there, the condition was called "Heavy-Necessary"), although in that study, children did look at the target at above-chance levels, further suggesting that this pattern is robust across languages.

Second, although the Modified-Uninformative and the Modified-Unnecessary conditions both yielded above-chance aggregated gaze, their comparison to the Unmodified condition (our benchmark for successful processing) is suggestive of a difference between them. While neither condition differed significantly in target fixation from the Unmodified condition, performance in the Modified-Uninformative condition showed a suggestive trend ($p = 0.09$). If future work were to identify a significant difference between the Modified-Uninformative and Unmodified conditions, this would suggest that when the modifier was not *useful* (uninformative), processing it incurred costs without providing any benefits for identifying the referent. This pattern of increased difficulty when added information does not benefit comprehension is evident in the adult sentence-processing literature as well (e.g. Almor, 1999).

In summary, our results showed that successful processing of the sentence in which a novel verb occurs is necessary, but not sufficient, to support successful verb learning. Unmodified nouns are easy to process, leaving sufficient resources for learning the novel verb and identifying its referent again at test. Modified nouns are harder; although children can, in most situational contexts, successfully process them, they may have insufficient resources left to learn the novel verb that occurs afterward. Learning the meaning of a novel verb is cognitively demanding, vulnerable to processing overload, and thus sensitive to the "semantic heaviness" of sentential subjects. Even just partial processing (i.e. "listening through"), as children may have done in the Modified-Unnecessary and/or Modified-Uninformative conditions, might have taken up too much of young learners' cognitive resources, leaving insufficient capacities to fulfil all the other steps involved in learning a novel verb.

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These findings are consistent with He et al. (2020), which presented three of the four conditions (minus the Modified-Uninformative condition) to slightly younger English learners, aged 2.5–4 years. In that study, too, children failed to learn the verb, as indicated by at-chance pointing to the target in the test phase, when the verb had occurred with a modified subject; they succeeded only with the unmodified subject. Our results are also generally consistent with that study in terms of children's gaze behaviour during the familiarization phase and its relation to their performance at test. In both studies, successful processing of the modified noun phrase and identification of the target during the familiarization phase did not necessarily lead to successful verb learning – in the condition we have labelled "Modified-Unnecessary," children showed the same pattern in He et al. (2020) (condition labelled "Heavy-Unnecessary").

Our results do differ slightly from those of He et al. in the Modified-Necessary condition. While children in our study did not look at the target at above-chance levels during familiarization, English learners did in the previous study, although in both studies this condition showed the worst performance (least target looking). Direct comparison between the studies is difficult due to language and age differences. But given that children in our study are older and performed worse (in this particular condition), the findings warrant further investigation of whether cross-linguistic differences could explain these patterns. We considered the three linguistic differences between Korean and English outlined in Introduction, suspecting pro-drop status as the most relevant factor. However, our results do not seem to be driven by the fact that Korean allows arguments to be dropped when they are recoverable from discourse or environmental context; if this were the case, we might have expected Korean learners to do best when the modifier played a crucial role and to do worse when it was over-informative. However, Korean learners identified the target both when the modifier was informative but unnecessary and when it was both uninformative and unnecessary (because the noun provided the crucial disambiguating information) – but not when the modifier was necessary. Despite this small difference between Korean and English data in the *process* of learning, their learning *outcome* was the same – in both studies, children did not go on to acquire the novel verbs. Overall, our results are in line with other work showing cross-linguistic similarities in how processing and learning interact (e.g. Shi et al., 2023; Su & Naigles, 2019; Trueswell, Kaufman, Hafri, & Lidz, 2012).

Finally, the added condition unique to the current study (Modified-Uninformative), in which the modifier was uninformative but the noun was critical for disambiguation, showed similarly poor performance to the Modified-Necessary condition. Thus, although children did identify the target of the modified subject at above chance levels, "listening through" (Thorpe & Fernald, 2006) the uninformative adjective, they struggled to map the novel verb to meaning at test. They also showed a lower fixation probability during familiarization in this condition than in the Unmodified condition, suggesting that this "listening through" strategy came at a slight cost. Thus, we did not find support for our initial hypothesis that children might be more adept at recruiting head noun information than modifier information to disambiguate the two scenes.

We note two important limitations. First, our sample size, though similar to (slightly larger than) He et al. (2020) – which we aimed to replicate – was smaller for pointing data than eye gaze data. This was an unfortunate consequence of the effects of the COVID-19 pandemic on in-lab data collection; nevertheless, the fact that our results align nicely with those of He et al. (2020) lends some assurance. Second, although our use of the same visual stimuli as He et al. (2020) allows narrow comparison across language and age with the

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same materials, it will also be important to see how well these patterns generalize to new stimuli.

In summary, our results, adding to existing findings from English, reinforce the idea that the interplay between informativeness and processability is key to characterizing the optimal linguistic context for young children's verb learning. These findings also highlight the important distinction between the *input* provided by caregivers and the *intake* children actually absorb (e.g. He & Arunachalam, 2017; He, 2022, for reviews). As young children are resource-limited processors, their vulnerability to information overload – as suggested by the two studies from different languages and ages – may limit how much input is converted into intake, potentially leading to cascading challenges to learning downstream information. These results have both theoretical and practical implications. Theoretically, it is important to expand theories of parent language input to consider whether the naturalistic input to which children are exposed from caregivers respects this informativeness–processability trade-off – perhaps caregivers are implicitly sensitive to the kinds of input that will best support their child's learning (e.g. Arunachalam, 2016; He et al., 2022). Practically, the results may also have implications for interventions for children with language delays, in which the language input can be carefully controlled to optimize children's intake. Designers of interventions may need to consider that richly informative language input may not always lead to increased intake.

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