RUNNING HEAD: Learning verbs in English and Korean

Learning verbs in English and Korean: The roles of word order and argument drop

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Abstract (Word Count: 253)

To learn new words, particularly verbs, child learners have been shown to benefit from the linguistic contexts in which the words appear. However, cross-linguistic differences affect how this process unfolds. One previous study found that children's abilities to learn a new verb differed across Korean and English as a function of the sentence in which the verb occurred (Arunachalam et al., 2013). The authors hypothesized that the properties of word order and argument drop, which vary systematically in these two languages, were driving the differences. In the current study, we pursued this finding to ask if the difference persists later in development, or if children acquiring different languages come to appear more similar as their linguistic knowledge and learning capacities increase. Preschool-aged monolingual English learners (N = 80) and monolingual Korean learners (N = 64) were presented with novel verbs in contexts that varied in word order and argument drop and accompanying visual stimuli. We assessed their learning by measuring accuracy in a forced-choice pointing task, and we measured eye gaze during the learning phase as an indicator of the processes by which they mapped the novel verbs to meaning. Unlike previous studies which identified differences between English and Korean learning 2-year-olds in a similar task, our results revealed similarities between the two language groups with these older preschoolers. We interpret our results as evidence that over the course of early childhood, children become adept at learning from a larger variety of contexts, such that differences between learners of different languages are attenuated.

Keywords: language acquisition, word learning, syntactic bootstrapping, Korean, cross-linguistic

Languages vary along many dimensions, but strikingly, research on several languages spoken across the globe reveals a similar trajectory of language acquisition. Early on, children acquire words for many of the same concepts across languages (e.g., Frank, Braginsky, Yurovsky, & Marchman, 2021) and they show broad similarities in the timeline of grammatical development (e.g., Bowerman, 1973; Hyams & Orfitelli, 2015; Slobin, 1965). At the same time, however, these similarities may mask underlying cross-linguistic differences in the pathways by which children arrive at language knowledge (e.g., Bates et al., 1984; Slobin, 1985).

For example, one salient property that differs cross-linguistically is the basic word order in which elements appear in a clause. The vast majority of languages either have subject-object-verb (SOV) order, such as Korean, or subject-verb-object order (SVO), such as English. Research with adults has shown that these differences in word order result in differences in the process of sentence comprehension across languages (e.g., Rubio-Fernandez & Jara-Ettinger, 2020), which makes sense given that language unfolds over time and listeners comprehend language incrementally rather than waiting for the end of a sentence (e.g., Tanenhaus & Trueswell, 1995). For example, in Korean, listeners know about the “who” (subject) and “whom” (object) before they know what was done, while in English, the “whom” is revealed later. Children, too, process language incrementally (e.g., Swingley, Pinto, & Fernald, 1999; Trueswell et al., 1999), including in Korean (e.g., Choi & Trueswell, 2010), but we know less about how these cross-linguistic differences affect their comprehension.

Importantly, children, unlike adults, are still developing their language processing skills rapidly over the preschool years: children become faster at retrieving lexical items (e.g., Fernald et al., 1998; Peter et al., 2019) and more skilled at establishing a correct parse (e.g., Gertner & Fisher, 2012; Hirsh-Pasek, Golinkoff, & Naigles, 1996; Naigles & Swensen, 2007). But during

this same time period, they can use their abilities to rapidly parse and assign meaning to a sentence in order to learn new elements of language, in particular, new verb meanings (e.g., Trueswell & Gleitman, 2007). Verbs are understood to be particularly difficult to acquire, with children relying on informative linguistic contexts to help them narrow down the possible space of meanings (e.g., Gleitman, 1990). For example, by 2 years of age, children hearing a novel verb in a transitive frame (e.g., The duck is *gorping* the bunny) typically infer that it has a causative meaning (e.g., the duck spins the bunny) (e.g., Arunachalam & Dennis, 2019; Fisher, 2002; Naigles, 1990; Naigles & Kako, 1993).

However, the fact that children are still inexpert language processors does affect their ability to correctly assign meaning to a sentence (e.g., Trueswell et al., 1999; Trueswell, Kaufman, Hafri, & Lidz, 2012), and it can also disrupt their abilities to learn new words from their context (e.g., Fernald et al., 2008; He, Kon, & Arunachalam, 2020; He & Lidz, 2016; Huang & Arnold, 2016; Kon, Göksun, Bagci, & Arunachalam, 2015). He et al. (2020), for example, found that children failed to demonstrate acquisition of a novel verb meaning when the verb was preceded by a modified subject (e.g., The tall girl is *pilking*), though they succeeded when the subject was unmodified (e.g., The girl is *pilking*). These authors inferred that children's limited processing abilities did not allow them to both establish a referent for the modified subject argument and then posit a new lexical representation for the novel verb. On this account, processing load refers to the amount of information encountered, such that there are increased processing costs associated with accessing each contentful lexical item (e.g., the adjective *tall*).

Processing limitations may affect verb learning differently in languages that vary in word order. In principle, if the verb in a sentence is unknown, we might expect SOV word order to pose more challenges for young children than SVO word order because it requires parsing

through two noun phrase arguments stacked one after the other, perhaps exhausting children's processing capacity before they even encounter the new verb. In fact, parsing through two stacked arguments, at least in English, can be challenging even for older children and adults (e.g., Arunachalam, 2017; Conwell & Demuth, 2007; Frazier & Fodor, 1978; Rowland et al., 2014). While languages like Korean that have SOV order often also have case markers that help comprehenders assign the correct structure (e.g., Choi & Trueswell, 2010), the ability to use case markers in sentence comprehension is relatively late developing—Jin, Kim, and Song (2015) found that Korean-learning 3-year-olds, but not 2-year-olds, correctly interpreted OSV sentences with familiar verbs. Of course, sentences with novel verbs are likely to increase difficulty even further. Thus, these facts suggest a puzzle—all other things being equal, if children struggle to learn verbs from the SOV sentences that are omnipresent in their language, we might expect slower verb growth in such languages than in SVO languages. There is, however, no evidence that this is the case. This suggests that children manage to overcome these parsing difficulties at least in the context of simple SOV sentences during early childhood, a hypothesis we test in the current study.

Argument drop, another property that differs cross-linguistically, adds an extra dimension. In Korean, speakers often drop subjects and/or objects when their referents are inferable from the discourse or situational context. In child-directed Korean, subjects are dropped in about 60% of utterances, and objects are dropped in 45% of utterances (Kim, 2000). This is likely to have two opposing kinds of consequences. On one hand, dropped arguments should ease the parsing load, as they remove the need to listen through and process two stacked arguments. On the other hand, although caregivers are generally tuned to their children's level of understanding (e.g., Arunachalam, 2016; Leung et al., 2021; Masur, 1997) and should drop

arguments when it is likely that their referents can be easily inferred (e.g., Clancy, 2004; Guerriero, Oshima-Takane, & Kuriyama, 2006; Kim, 2000; Lee, 1989; Smith & Frank, 2012; Valleau, Frank, & Arunachalam, 2014), children may sometimes have to do more work to recover the referents of dropped arguments than they do with overt arguments. Here too, we would expect children to get better at recovering the referents of dropped arguments over development (Candan et al., 2012). While young children may struggle both with stacked arguments and with dropped arguments, older children—who have better processing abilities and better abilities to identify the referents of missing arguments—may be able to learn verbs in both kinds of contexts.

Given these cross-linguistic differences in word order and argument drop, and their consequences for learners, it is unsurprising that experimental studies find cross-linguistic differences in which kinds of linguistic contexts best support learning. For example, Arunachalam, Leddon, Song, Lee, and Waxman (2013) argue that these differences between Korean and English affect the verb learning process (see also Imai et al., 2008, for conceptually similar results in Japanese, Mandarin Chinese, and English). They presented Korean-learning 24-month-olds with novel verbs in sentences and tested which sentence types best supported learning. Korean learners were presented with a video of a dynamic visual scene in which an agent was performing an action on an object (e.g., a boy waving a balloon in a particular manner), and heard one of two sentence types: one with both arguments overt (e.g., boy-nom[1] balloon-acc *gorping* 'The boy is *gorping* the balloon'), or one with both arguments dropped (e.g., *gorping* 'Gorping'). Then at test, they saw two new scenes, one depicting the familiar action but on a new object (e.g., boy waving a rake) and the other depicting a different action but on the

[1] Case markers are abbreviated as follows: nom: nominative; acc: accusative

familiar object (e.g., boy tapping a balloon). They were asked to point to the referent of the novel verb. For English learners in a parallel study, the most helpful sentence type was similar to the Korean condition with overt arguments (e.g., boy-nom balloon-acc *gorping* 'The boy is *gorping* the balloon'), with content nouns labeling the subject and object (e.g., The boy is *gorping* the balloon) (Arunachalam & Waxman, 2010, 2011, 2015). But for Korean learners, this condition did not lead to successful learning. In fact, Korean learners showed a significant preference for the scene depicting the incorrect action, suggesting that they had wrongly mapped the novel word to the object (e.g., balloon). The authors suggested that Korean learners may have exhausted their processing resources on the subject and object and were not equipped to then process and establish a representation for the novel verb. In the condition with both arguments dropped, children's performance was no better than chance. The authors suggested that this was because the dropped argument condition provided insufficient information to help them learn the novel verb's meaning. Thus, these Korean-learning 2-year-olds struggled both with two overt arguments and with dropped arguments. However, their performance with dropped arguments was significantly better (i.e., they did not show a preference for the incorrect interpretation) than in the condition with overt arguments.

Thus, with respect to the question of what kind of linguistic context is most helpful for children learning new words, English learners and Korean learners demonstrated opposite patterns—English learners did better with rich linguistic contexts (two overt arguments), and Korean learners did better with sparser ones (both arguments dropped). Arunachalam et al.'s (2013) study thus raises an important question that we took up in the current study. How enduring are these differences across language groups? Given that Korean child-directed speech does sometimes present rich linguistic contexts, and English child-directed speech does

sometimes present sparse linguistic contexts, children must eventually develop the abilities to comprehend both. We asked in the current study whether cross-linguistic differences in verb learning between English and Korean learners would endure later in the preschool years, or whether they are relatively short-lived in toddlers, who are at the beginning stages of acquiring verbs and combining words in their own speech, and whose processing abilities are rapidly developing. We build on Arunachalam et al.'s (2013) work, addressing three of its limitations.

First, because 24-month-old Korean learners showed difficulty in both conditions, Arunachalam et al. (2013) did not find any evidence that they could learn novel verbs. Given this, and given the difficulties that even 2.5- and 3-year-old English learners showed with processing modified nouns in He et al. (2020), our choice to target slightly older children who should have better processing skills helps to address these limitations as well as to trace developmental change in verb learning ability. We focused on Korean learners aged 4 and 5 years. For English learners, because we had access to a larger sample, we tested a wider age range of 2.5 to 5 years, and we report both on the full sample and, where relevant, a subset matched in age to the Korean sample.

Second, the previous study (Arunachalam et al., 2013) presented Korean learners with two linguistic contexts that are relatively infrequent in Korean child-directed speech: one with both arguments overt, and the other with both dropped. Because subjects are dropped more often than objects (e.g., Clancy, 2004; Kim, 2000), in the current study we kept objects overt across linguistic conditions, manipulating only whether subjects were dropped.

Third, the previous study (Arunachalam et al., 2013) did not manipulate the real-world or discourse context to determine the role of informativeness. In the previous study, it is possible that Korean learners struggled with overt subjects because there was only one plausible referent

for the novel verb, and in a situation with only one plausible referent, the subject would normally be dropped. Therefore, the overt subject, in addition to carrying a processing load, was overinformative. In the current study, we manipulated whether the subject was informative. This manipulation necessitated one additional methodological change to Arunachalam et al.'s (2013) study. Like He et al. (2020), we used a verb learning paradigm in which children hear a sentence containing a novel verb (e.g., "The boy is *pilking* the balloon") while they see two potential referent events side-by-side. Only one of the two events can be labeled by the sentence (e.g., only one depicts a boy). This design more closely addresses the verb learning challenge identified by Gleitman and colleagues—that of needing a "zoom lens" to identify the relevant event and affix the appropriate perspective on it (Gleitman, 1990; Naigles, 1990). It also makes the task harder because children must attend closely to the linguistic context to succeed, and it allows us to manipulate whether the subject argument is informative (that is, whether the subject alone disambiguates between the two scenes). This methodological change has a further advantage: it permits us to evaluate children's eye gaze as they are in the process of learning the verb. Instead of only studying their behavior in a test phase, after they have learned the verb, we observe their behavior as they are in the very process of comprehending the critical sentence and mapping the verb to meaning. Few studies provide this insight (Childers et al., 2016; Childers et al., 2020; He et al., 2020; Valleau & Arunachalam, 2017 are exceptions), but it may help to reveal not only the fact that children learn or fail to learn in a particular condition, but potentially also offer some insight into why.

Therefore, this task requires children to do the following. First, they must parse the sentence containing the novel verb on a single exposure, at least well enough to be able to identify which of the two scenes is being referred to (presumably by looking for referents of the

noun or nouns named in the argument positions). Second, they must perceive this target scene and extract the visual event referent—that is, determine what action is ongoing. Third, they must map this action meaning to the novel verb's phonological form. Fourth, they must generalize this meaning to a new event participant in the test phase, when they are again asked to find (and point to) a referent for the novel verb given two new scenes.

We manipulated processing demand in Korean by changing the linguistic stimuli. The subject of the sentence was either overtly expressed or dropped (dropped subjects would not have been felicitous in English declarative sentences, so we did not include this manipulation for English learners); the overt subject condition requires processing stacked arguments in Korean, given its SOV word order, and not in English. We manipulated whether the subject was informative by changing the visual stimuli. The two visual scenes either had different gender agents (e.g., one male agent, one female agent) so that the subject argument was informative (e.g., "the girl") or they had same gender agents (e.g., two females) so that the subject argument was uninformative for identifying the correct referent (the objects differed in both cases). We addressed the following three research questions in two experiments:

Experiment 1:

- **Research Question 1:** Do English learners perform better with overt subjects than Korean learners?
- **Research Question 2:** Do English and Korean learners learn verbs more easily when overt subjects are informative for learning the verb than when they are uninformative?

Experiment 2:

- **Research Question 3:** Do Korean learners perform better with dropped subjects or overt subjects? Is the answer to this question affected by whether the subject is informative or

not?

We evaluated these questions with a forced-choice pointing task in which children were asked to find a scene depicting the novel verb's referent, but we also measured their eye gaze during the learning phase to provide further insight into which aspects of the learning task might be easier or more difficult.

Experiment 1

In a between-subjects design, we randomly assigned children to one of two conditions per language group. Specifically, we manipulated the agent type presented in the visual stimuli (same gender agent vs. different gender agents).

Participants. The final sample included 80 English learners (2;7-5;0, mean age 3;8) and 32 Korean learners (4;0-5;11, mean age 4;10). Both groups were recruited from major metropolitan areas in the United States and South Korea, respectively. According to parent report, all children were typically developing learners who were exposed to the target language at least 70% of the time. An additional 15 English learners and 11 Korean learners were excluded from the final sample due to equipment error (English: $n = 7$; Korean: $n = 3$), fussiness (Korean: $n = 1$), developmental delay or disorder (English: $n = 2$), or failure to point during the training or test trials (English: $n = 6$; Korean: $n = 7$). In addition, for eye gaze analyses only (but not for pointing analyses), we excluded one additional child from each sample for equipment failure in collecting eye-gaze data. Further, we calculated track loss for each of the three trials separately and excluded trials on which children had more than 65% track loss during the Familiarization phase of the trial (15 trials from 11 English learners, 10 trials from 8 Korean learners). In each language group there was one child for whom all three trials were excluded on this basis. Thus, the sample size for gaze analyses was 78 for the English-acquiring sample and

30 for the Korean-acquiring sample.

Materials. Materials were similar to those in He et al. (2020), except that the events and sentences differed; while He et al. presented intransitive sentences to describe events with one event participant (e.g., a woman marching), in the current study we used transitive sentences to describe causative events in which an actor acted on an object (e.g., "The lady is *larping* the sock"). Each child participated in three experimental trials.

Visual stimuli. The visual stimuli were digital video recordings of live actors (some white, some East Asian) performing actions on inanimate objects, such as folding a sock.

Auditory stimuli. The English auditory stimuli were produced by a female native speaker of American English, and the Korean auditory stimuli by a female native speaker of Korean, in a sound-attenuated recording booth. Both speakers used a child-directed speech register. The Korean stimuli were translations from the English by the third author, who aimed for naturalness while maintaining the intended manipulations. The Korean sentences had both subject and object case markers.

Apparatus and procedure. After providing informed consent on behalf of their child, caregivers brought children into the testing room. Children sat in front of a monitor fitted with an eye-tracker. In South Korea, the eye-tracker was a Tobii X2-30; in the United States, it was a Tobii T60 XL. The X2-30 samples at 30 frames per second, while the T60 XL samples at 60 frames per second. Given that children typically require about 200 ms, or approximately 6 frames for the slower X2-30, to program and launch an eye movement (e.g., Fernald et al., 2008), we did not worry about this difference in sampling rate; however, we downsampled the data from the faster machine to yield comparable numbers of data points across language groups. Caregivers were asked not to interact with the child during the session. Children's pointing

behavior was recorded in real-time by an experimenter and later verified with a video recording of the session.

Children first participated in a standard 5-point eye-tracking calibration. Then, before the experimental trials, they engaged in a brief training session designed to encourage pointing. They viewed two training trials, each introducing two dynamic scenes side-by-side on the screen. The experimenter asked children to point to one of the scenes (e.g., “Can you point to the cat?”). Children who pointed incorrectly or who were reluctant to point were gently encouraged. Those who failed to point or pointed incorrectly on both training trials were excluded from analysis and replaced in the design.

Next, children participated in the three experimental trials. Each presented different visual scenes and a different novel verb. Each trial included a Familiarization phase and a Test phase. See Figure 1. Task duration was approximately 5 minutes.

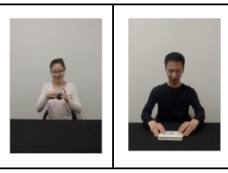
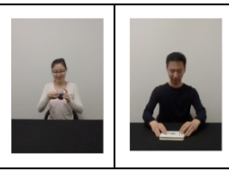
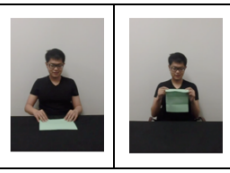
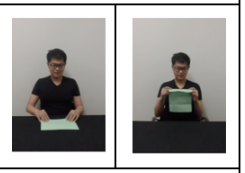
	Familiarization			Test			
Subphase	Event Familiarization	Verb Familiarization	Mapping	Attention Grabber	Baseline	Query	Response
Visual						★	
Auditory	Look!	The lady is *larping* the sock.	(Silence, eye gaze was measured)	Now look!		Where is *larping*?	
Duration	6s	1s	6s	1s	4s	2s	4s

Figure 1. Schematic example of visual and auditory stimuli for one trial in English in the Different Gender Agent condition.

Familiarization Phase. The Familiarization Phase on each trial had three subcomponents. In the Event Familiarization subphase (6 sec), children first saw two dynamic scenes presented simultaneously, side by side. In each of the two scenes, a different actor engaged in a different action with a different object (e.g., woman folding a sock, man sliding a box). The identity of the two actors varied by condition: In the Different Gender Agent condition, one scene depicted a female actor and the other depicted a male actor; in the Same Gender Agent condition, the two actors were either two different females or two different males. The audio during this subphase served to attract children's attention ("Look!"). This subphase was designed to allow children to view both dynamic scenes in their entirety. The left-right position of the visual scenes was counterbalanced across the three trials.

Then, in the Verb Familiarization subphase (approximately 1 sec, varying by trial), the screen went blank, and children heard the critical sentence introducing the novel verb, which could only describe one of the two scenes shown during the Event Familiarization subphase.

Next, in the Mapping subphase (6 sec), the visual scenes returned to the screen in their previous positions, and children viewed them in silence. This was children's first opportunity to match the sentence they had just heard to the most appropriate visual scene. We measured their eye gaze as they did so.

Test phase. Next, children viewed the Test phase, which also comprised three subphases. During the Baseline subphase, children viewed two new scenes. These featured a new actor and object, but the same two actions as in the familiarization scenes. During the Query subphase, the two scenes disappeared, and children heard a prompt to find the referent of the novel verb (e.g., "where's *larping*?"). Finally, during the Response subphase, the two scenes reappeared. On two of the trials, the scenes appeared in the same positions as they had during the Familiarization

phase, and on one trial, their positions switched. The experimenter encouraged the child to point if necessary by saying, e.g., "*Can you show me? Where's larping?*" No feedback was provided about whether the child's response was correct.

Analysis Plan

Our original planned analyses were identical to He et al. (2020) given its very similar design and trial structure (but see below for additional analyses of the gaze data). We evaluated two measures. Our outcome measure was children's pointing responses during the Response subphase of the Test phase. To assess whether children learned the novel verbs in each condition, we asked whether pointing accuracy was significantly better than chance by evaluating the intercept parameter of binomial mixed-effects models with a random effect of participant, separately for each condition for each language. We used deviation coding, with the Different Gender Agent condition coded as 0.5 and the Same Gender Agent condition as -0.5; and with Korean coded as -0.5 and English as 0.5. A significant intercept parameter indicated that performance was significantly better than chance. To answer our research questions about whether children learned better in one language or one condition than another, we evaluated models with the full data set but adding either language or condition as a fixed effect; because these analyses also contained more data, we also included age as a fixed effect, centering it around its mean.

Our second measure was of children's gaze as they were initially mapping the verb to meaning during the Mapping subphase of the Familiarization phase; this measure allowed us to further interpret the pointing accuracy data. He et al. (2020) analyzed children's eye gaze during the first 2.5 seconds of the Mapping subphase, reasoning that children would initially seek to map the verb to a visual scene and afterward would look at both scenes indiscriminately.

However, thanks to anonymous reviewer suggestions, we supplemented these analyses with cluster-based permutation analyses of the full 6 seconds of the Mapping subphase.

We analyzed gaze data in two ways. First, to assess whether children successfully identified the target event during the Familiarization phase, we compared their mean proportion of target looking to chance (0.5) using a *t*-test. Looks to other areas of the screen and track loss data points were excluded from analysis so that the two possible regions of interest included were the target scene and the distractor scene, making 0.5 interpretable as chance looking between them. Second, we evaluated differences between languages and between conditions. Our planned analyses for these cross-condition comparisons were growth curve analyses (Mirman, 2014). These analyses do include data points for which the child was looking to neither the target nor distractor (but not track loss data points) because looking at the space between the two scenes can reflect the child's saccades between them and is a relevant data point. We first binned the data into 100-ms time windows and applied the empirical logit transformation to the proportion of target looking (Barr, 2008) and then modeled the time course of target looking with the best-fitting orthogonal polynomial, with a fixed effect of condition and random effects of participant-by-condition on the linear time term. The lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2017) provided *p*-values, using *t*-tests fit by Satterthwaite's method.

Because of concerns about growth curve analysis (Huang & Snedeker, 2020) that we became aware of after He et al.'s (2020) paper and after we had established this analysis plan, we added cluster-based permutation analyses, which do not require pre-selecting a time window (e.g., Maris & Oostenveld, 2007) and have been widely used in research with young children (e.g., Chan et al., 2018; Abbot Smith et al., 2017). We used the eyetrackingR package (Dink & Ferguson, 2015) and mixed-effects regressions with participant as a random factor and either

language or condition as a fixed factor depending on the research question. We first ran the regression for each of the 100-ms time bins; adjacent significant time bins were put together to form clusters. Then, we examined the possibility of observing the effect (the sum of the *t*-value for all time bins in the same cluster) by chance by shuffling the data, permuting the labels of the predictor (e.g., English and Korean), and generating 1000 sample experiments with these shuffled data sets. For each sample experiment, we saved the largest summed *t*-values and compared the summed *t*-values in our real data to the distribution of summed *t*-values. If the summed *t*-value in our real data was larger than 95% of the summed *t*-values in the normal distribution, we concluded that it was a significant effect.

These two types of analyses showed different patterns for some research questions, as discussed below. For all gaze analyses, we report only the effects of interest in the main text; the full models are available in the Supplementary Materials.

Finally, because the English-acquiring sample was larger and had a wider age range than the Korean-acquiring sample, for Research Question 1, where we found a significant main effect of language, we repeated the comparison with a subset of the English sample that matched the Korean sample in size and was much closer (and not significantly different) in age range to the Korean sample. See Table 1.

Table 1. Participant information

Language group	Full Sample			Matched Subsample (Research Question 1 only)		
	N	Mean age, months (*SD*)	Age range, months	N	Mean age, months (*SD*)	Age range, months
Korean	32	58.61 (7.68)	48.16 - 71.96	16	53.15 (3.59)	48.36 – 61.14
English	80	45.40 (8.84)	30.50 – 59.60	16	53.40 (3.43)	48.50 – 59.60

Predictions

Research Question 1 (Do English learners perform better with overt subjects than Korean learners?): Prior work with 24-month-olds found that they did (Arunachalam et al., 2013). However, because we intentionally selected an older group of children for this study who should have better processing skills and be better able to handle the processing demands posed by the overt subjects, Korean learners in the current study were expected to be more successful than the 24-month-olds in prior work. Therefore, we had reason to predict that there would be no difference between the two language groups. For both language groups, we expected the patterns revealed in their pointing at test to be mirrored in their gaze during Familiarization.

Research Question 2 (Do children learn verbs more easily when overt subjects are informative for learning the verb than when they are uninformative?): Labeling the subject provides a benefit when it helps to disambiguate the two scenes. Therefore, we predicted that children, regardless of language group, would perform better—as indicated by their pointing at Test—in the Different Gender Agent condition, when the subject was informative, than in the Same Gender Agent condition, when it was not. We further predicted that looking to the target scene during Familiarization would show the same pattern.

Results

We begin by reporting comparisons to chance to provide an overview of the data, and subsequently describe the comparisons made between different combinations of the conditions to answer Research Questions 1 and 2. Although the Familiarization Phase occurred prior to the Test Phase on each trial, we report on the pointing data from the Test Phase first throughout, because it is the primary outcome measure. The pointing data from the Test Phase is shown in Figure 2. Binomial mixed-effects regressions for each condition and language group separately

confirmed that performance was above chance in all conditions (see Table 2). With respect to the gaze data from the Familiarization Phase (collapsing across the 6-second Mapping Subphase), *t*-tests for each condition and language group confirmed that children preferred the target—that is, they identified the referent of the critical sentence in all conditions (despite that the verb contained therein was novel and they were hearing it for the first time) (see Table 3).

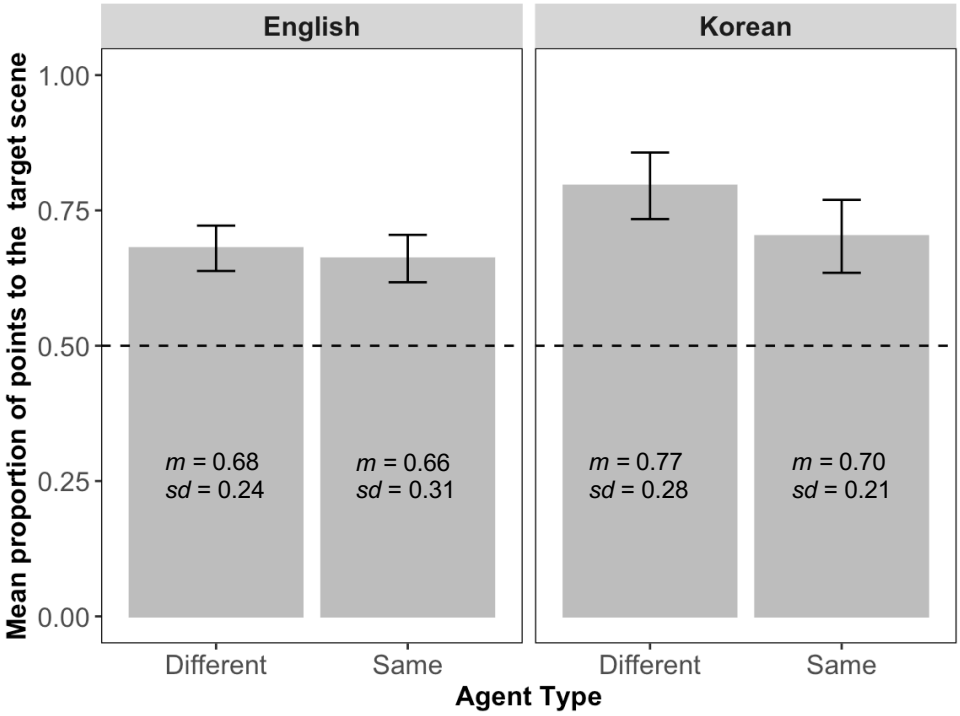


Figure 2. Mean proportion of accurate pointing responses for the four conditions in Experiment 1. The dashed line indicates chance performance (0.5 because there are two scenes to choose from). The numbers on the bars indicate means and standard deviation of participant means. Error bars indicate standard errors of participant means.

Table 2. Intercept parameter estimates from binomial mixed-effects regression analyses of children's pointing performance in the Test Phase for Experiment 1. These analyses reveal whether pointing accuracy was above the rate expected by chance.

Condition	Intercept parameter	Standard Error	*z*-value	*p*-value
English				
Different Gender Agent	0.76	0.20	3.85	< .001
Same Gender Agent	0.76	0.26	2.97	< .005
Korean				
Different Gender Agent	1.36	0.37	3.63	< .001
Same Gender Agent	0.86	0.32	2.69	< .01

Table 3. Proportion of looking to the target scene during the 6-second Mapping Subphase during Familiarization. One-sample *t*-tests comparing means to 0.5 reveal whether children preferred to look to the target scene at above-chance rates.

Condition	Mean proportion of target looking	Standard Deviation of participant means	*t*-value	*df*	*p*-value
English					
Different Gender Agent	0.77	0.15	11.25	37	< .001
Same Gender Agent	0.69	0.15	7.86	39	< .001
Korean					
Different Gender Agent	0.70	0.15	4.95	14	< .001
Same Gender Agent	0.65	0.10	5.95	14	< .001

Research Question 1. To address this question, we collapsed across the Different Gender Agent and Same Gender Agent conditions. It is evident from Figure 2 that performance at Test with overt subjects (averaging across the Different Gender Agent and Same Gender Agent conditions) was not better for English learners (mean pointing accuracy = 0.67, SD = 0.28) than Korean learners (mean pointing accuracy = 0.73, SD = 0.25). The analysis combining both language groups into a single analysis yielded no significant effect of age (β = -0.044, p = .32), but a significant difference in pointing accuracy between the Korean and English groups (β = 1.48, p = .046), in the *opposite* direction of what Arunachalam et al. (2013) found, with the English learners performing worse. For the subset analysis, we selected a subset of 16 participants within each language group, matching on age within one month, and repeated the analysis without age as a fixed factor (Korean mean age = 53.38 months, English mean age = 53.50 months; t (30) = 0.096, p = 0.92). This analysis showed no effect of language (Korean mean pointing accuracy = 0.77, SD = 0.19; English mean pointing accuracy = 0.78, SD = 0.22; β = 0.053, p = .92), indicating that English learners' poorer performance as compared to Korean learners in the full sample was likely due to their younger age.

Children's gaze during the 6-second Mapping Subphase of the Familiarization Phase is shown in Figure 3. The best-fitting model in the growth-curve analysis of the first 2.5 seconds, which included a third-order polynomial time term, revealed no significant effect of language (β = -0.08, p = 0.56). However, the cluster-based permutation analysis of the full 6-second window did reveal a significant cluster; English learners looked significantly more to the target than Korean learners from 3200-4000 ms (sum t = 20.11, p = 0.048), slightly later than the 2.5-second time window from our planned analysis. We therefore repeated this analysis with the age-matched subset (English: n = 15; Korean: n = 14), which found no significant clusters. We

interpret these results cautiously given the loss of statistical power with the smaller matched data set. In fact, Figure 4 does suggest that even when matched on age, children in the two participant groups behaved differently, with the English learners showing a stronger, more sustained preference for the target. The stronger preference for the target in the gaze data coupled with the poorer pointing performance at test suggests that English learners may have had an easier time parsing the sentence and identifying its visual referent, but still, due to their younger age, had more difficulty deploying this knowledge to learn the new verb. This interpretation is consistent with the hypothesized difficulty with processing two overt arguments for Korean learners but suggests that this difficulty is relatively fleeting for older word learners.

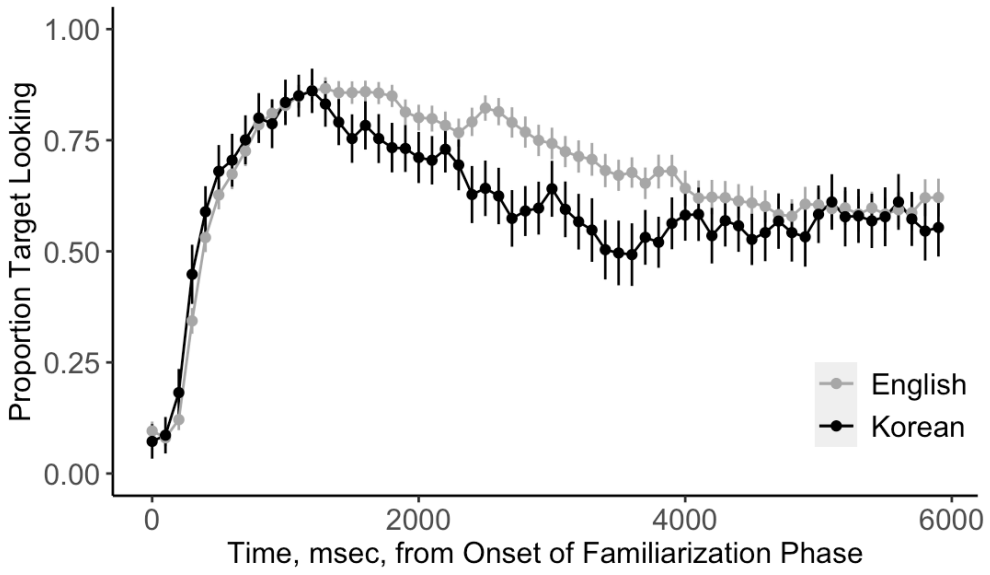


Figure 3. Eye gaze patterns for Research Question 1: Proportion of target looking during the Familiarization Phase for English and Korean learners. Error bars indicate standard errors of participant means.

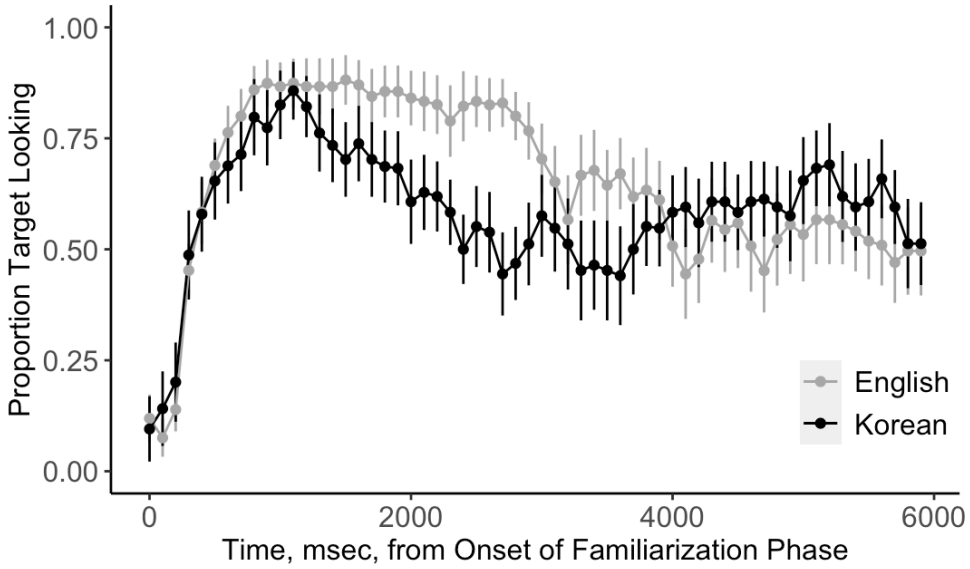


Figure 4. Eye gaze patterns for Research Question 1 with the age-matched subsample: Proportion of target looking during the Familiarization Phase for English and Korean learners. Error bars indicate standard errors of participant means.

Research Question 2. To address this question, we compared performance in the Different Gender Agent conditions—for which the subject was informative for distinguishing the two scenes—and the Same Gender Agent conditions—for which the subject was uninformative. Inspection of Figure 2 suggests that pointing performance is slightly diminished when the subject was informative than when it was not (condition 1 compared to condition 2) for both English learners and Korean learners. However, these differences are not statistically significant: A binomial mixed-effects regression including the same data as for Research Question 1, but with condition (Different Gender Agent, Same Gender Agent) rather than language as fixed effect revealed no main effect of condition on pointing accuracy (Different Gender Agent mean

accuracy = 0.72 (*sd* = 0.45), Same Gender Agent mean accuracy = 0.67 (*sd* = 0.47), β = -0.14, p = 0.56).

Gaze patterns during Familiarization showed a similar pattern, although the difference between conditions was statistically significant. The best-fitting growth curve model, which included a third-order polynomial time term, revealed a significant effect of condition; children looked to the target more in the Different Gender Agent condition than the Same Gender Agent condition (β = 0.30, p = .011). (But recall from Table 3 that they looked to the target at above-chance levels in both conditions.) The cluster-based permutation analysis, however, showed no significant clusters, although a cluster from 300-900 ms approached significance (sum t = -14.85, p = 0.095).

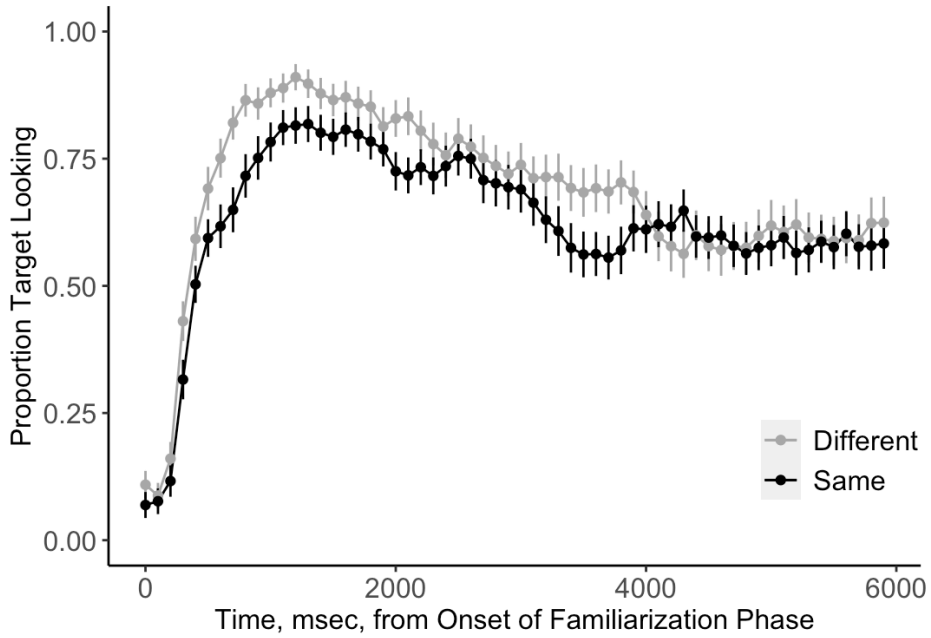


Figure 5. Eye gaze patterns for Research Question 2: Proportion of target looking across agent type conditions (Different Gender Agents, Same Gender Agent). Error bars indicate standard errors of participant means.

Experiment 2

To address Research Question 3, we conducted a very similar experiment with Korean learners only, with dropped subjects instead of overt subjects. We compared their performance to the two Korean conditions in Experiment 1.

Participants. The final sample included 32 Korean learners (4;1-5;9, mean age = 4;9) recruited as in Experiment 1. An additional 4 participants were excluded due to failure to point in the training or test trials. One participant in the final sample was excluded from the eye gaze analysis but not from the pointing analysis due to missing eye gaze data. Thus, the sample size for gaze analyses was 31.

Materials. Visual stimuli were identical to Experiment 1. The auditory stimuli differed in that the novel verb occurred with only an overt object; the subject was dropped (e.g., sock-acc *larping*).

Apparatus and Procedure. Identical to Experiment 1 except in the auditory stimuli. As in Experiment 1, there were two conditions: Different Gender Agent and Same Gender Agent.

Analysis Plan

The analysis plan was as in Experiment 1; we combined the data from the two Korean conditions in Experiment (in which the verb appeared with an overt subject) with data from the two conditions tested here (in which the verb appeared with a dropped subject). We again used deviation coding with the Overt Subject condition coded as 0.5 and the Dropped Subject condition as -0.5.

Predictions

Research Question 3 (Do Korean learners perform better with dropped subjects or overt subjects? Is the answer to this question affected by whether the subject is informative or not?):

Given children's performance in prior work with 24-month-olds, in which they struggled to map novel verbs to meaning when they occurred with overt subjects (Arunachalam et al., 2013), we expected that children would perform better—as indicated by their pointing at Test—with dropped subjects than overt subjects. Although the prior work found that Korean-learning 24-month-olds performed better, but still not above chance, when subjects were dropped, we expected above-chance performance in the Dropped Subject condition in this study for two reasons. First, the children are older. Second, the comparison condition with dropped subjects in the study with 24-month-olds also had dropped objects, while the present study had only overt objects in all conditions, making the dropped subject condition more informative in this study than the prior one.

With respect to the informativeness of the subject, just as with English, we expected that labeling the subject would provide a benefit when it helped to disambiguate the two scenes. Psycholinguistic research with adults shows that in some cases, the benefits of useful information for sentence interpretation can outweigh the processing load that information incurs (e.g., Almor, 1999; Almor, Arunachalam, & Strickland, 2007). Moreover, in Korean, subjects are less likely to be dropped when they provide useful information than when they do not (e.g., Huang, 1984), making the overt subject more felicitous when the subject is informative than when it is uninformative. Therefore, we predicted that Korean children would perform better—as indicated by their pointing at Test—in the Different Gender Agent condition where the overt subject was informative than in the Same Gender Agent condition. We expected the same pattern to be reflected in children's gaze during Familiarization, although because the Dropped Subject conditions contain less information, children might less quickly or less effectively settle their attention on the scene being described.

Results

We first computed comparisons to chance as for Experiment 1. The pointing data from the Test Phase is shown in Figure 6. Binomial mixed-effects regressions for each condition separately revealed that performance was above chance in the Different Gender Agent condition with dropped subject, but was at chance in the Same Gender Agent condition with dropped subject. See Table 4. With respect to the gaze data from the Familiarization Phase (collapsing across the 6-second Mapping Subphase), *t*-tests confirmed that children preferred the target in both conditions. See Table 5.

Table 4. Intercept parameter estimates from binomial mixed-effects regression analyses of children's pointing performance in the Test Phase of Experiment 2. These analyses reveal whether pointing accuracy was above the rate expected by chance.

Condition	Intercept parameter	Standard Error	*z*-value	*p*-value
Dropped Subject Different Gender Agent	0.79	0.32	2.47	< 0.02
Dropped Subject Same Gender Agent	0.23	0.35	0.65	0.52

Table 5. Proportion of looking to the target scene during the Familiarization Phase in Experiment 2. One-sample *t*-tests comparing means to 0.5 reveal whether children preferred to look to the target scene at above-chance rates.

Condition	Mean proportion of target looking	Standard Deviation of participant means	*t*-value	*df*	*p*-value
Dropped Subject	0.66	0.15	4.38	15	< .001

Different Gender Agent					
Dropped Subject Same Gender Agent	0.68	0.16	4.23	14	< .001

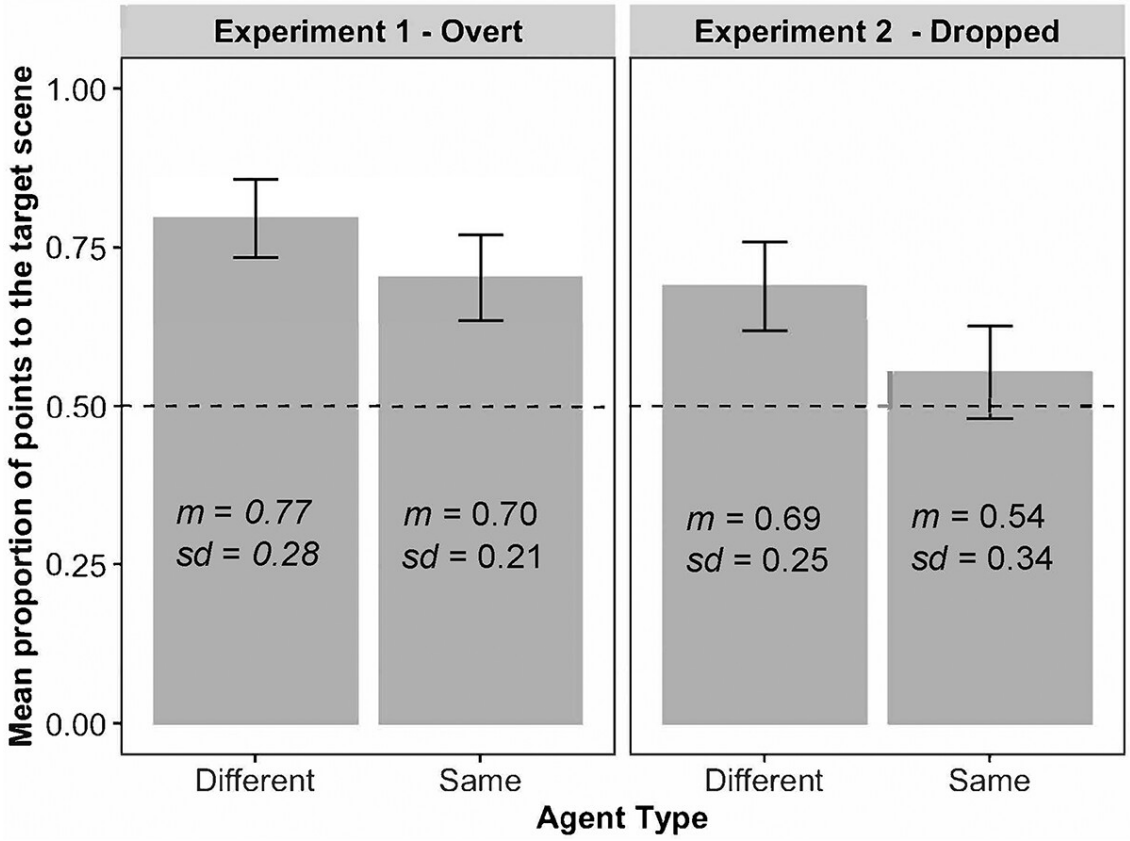


Figure 6. Mean proportion of accurate pointing responses for Experiment 2. The dashed line indicates chance performance (0.5 because there are two scenes to choose from). The numbers on the bars indicate means and standard deviation of participant means. Error bars indicate standard errors of participant means.

Research Question 3. For Korean learners, we ran a model including the two Korean conditions from Experiment 1 as well as the two Dropped Subject conditions from the present experiment. The model included sentence type, agent type, and children's mean age as fixed effects, and it revealed a significant effect of agent type ($\beta = 0.71$, $p < .05$), but no significant

effect of sentence type (β = -0.61, p = .067) or age (β = -0.04, p = .075), and no significant interaction between sentence type and agent type (β = 0.11, p = .87).

Gaze patterns during Familiarization showed a slightly different pattern. When all four conditions were added to a single model in a growth curve analysis, the best-fitting model, which included a third-order polynomial time term as fixed effect (due to convergence failures, we simplified the random-effects structure to include only a random slope for the linear time term) and fixed effects of sentence type, agent type, and their interaction, we found a significant main effect of sentence type (β = -0.39, p = .021), but no main effect of agent type and no interaction between sentence type and agent type. Two cluster-based permutation analyses conducted as for Experiment 1, one for sentence type and one for agent type, revealed no significant clusters for either sentence type or agent type. See Figure 7.

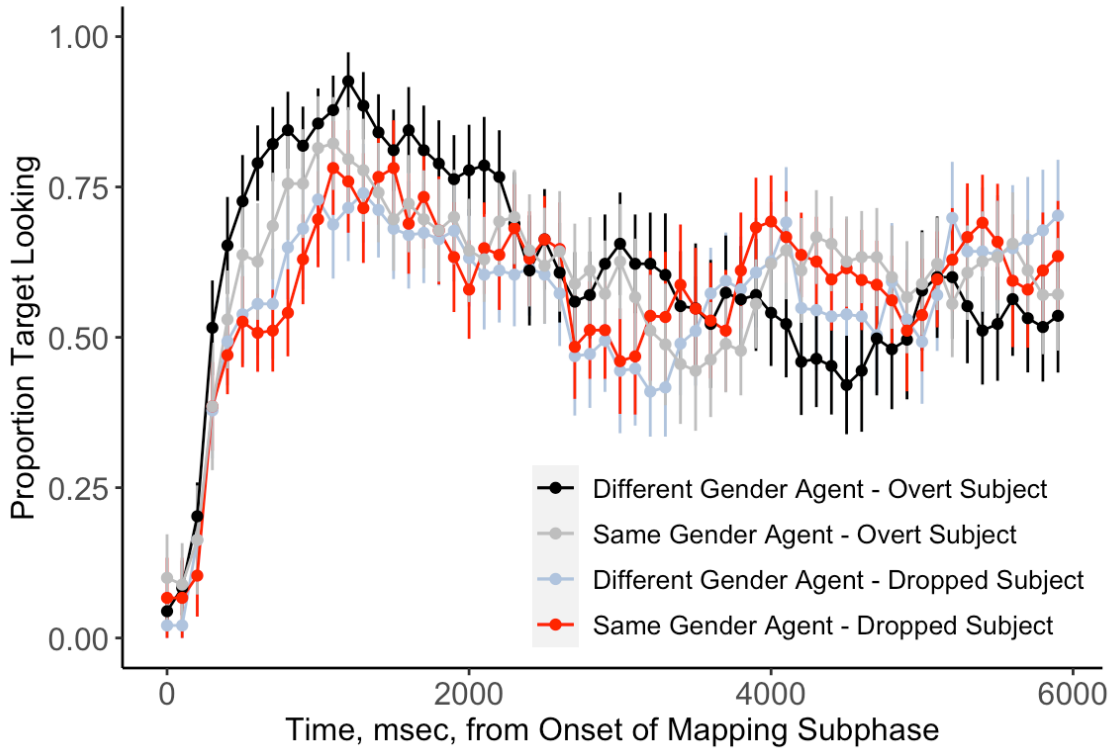


Figure 7. Eye gaze patterns for Korean learners across two Overt conditions in Experiment 1 and two Dropped conditions in Experiment 2. Error bars indicate standard errors of participant means.

General Discussion

Across two verb learning experiments, we found that children acquiring English and children acquiring Korean are strikingly similar in their abilities to acquire new verb meanings, even when the linguistic contexts and observational contexts differ. English and Korean differ in the properties of word order (English: SVO, Korean: SOV) and argument drop (English: rare, Korean: frequent). We additionally manipulated whether children heard novel verbs in sentences for which the subject was informative—disambiguating between two possible referents—or uninformative, and whether Korean learners heard overt subjects or not. While prior work focused on identifying differences in verb learning across these two languages due to the properties of word order and argument drop (Arunachalam et al., 2013), the current study involved older children and shows that by 4 to 5 years of age, children are much more adaptable and able to learn given a wider variety of learning situations.

We asked three research questions, whose answers are summarized below.

Research Question 1: Do English learners perform better with overt subjects than Korean learners? No, we did not find clear evidence that English learners performed better than Korean learners. Both groups' pointing accuracy was above chance when asked to point at Test, indicating that learners in both groups acquired the novel verbs when presented with overt subjects, and there was no difference between groups. This result is consistent with our prediction; because the Korean learners in the current study are older than the 24-month-olds in

Arunachalam et al. (2013), they were better equipped to process sentences with two overt arguments, and successfully learned the novel verb. As predicted, their accuracy at Test was consistent with their prior successful identification of the target scene during the Familiarization phase. However, we did see suggestive evidence that English learners preferred the target more in the Familiarization phase than Korean learners, suggesting that parsing sentences with overt subjects may have been slightly more difficult for Korean learners.

Research Question 2: Do children learn verbs more easily when overt subjects are informative for learning the verb than when they are uninformative? No, we did not find evidence that children performed better when the subjects were informative than when they were not. Although pointing accuracy at Test did show a trend in this direction, it was not statistically significant, and in all of the conditions included in these analyses, accuracy was above chance. These patterns were corroborated by the gaze data during Familiarization (in the growth curve analyses, which involved only the beginning of the Familiarization phase), except that the between-condition comparison was statistically significant; participants looked to the target scene at above-chance levels in both Different Gender Agent and Same Gender Agent conditions, but this preference for the target was significantly greater in the Different Gender Agent condition. This makes sense because when both genders were consistent with the subject argument label, they only had one piece of information to help them identify the target—the referent of the object argument. Thus, although it is true that children have an easier time identifying the referent event when the subject is informative than when it is uninformative, this difference does not substantially hinder their ability to learn the verb.

Research Question 3: Do Korean learners perform better with dropped subjects or overt subjects? Is the answer to this question affected by whether the subject is informative or not?

Because children's pointing results at Test neither showed a significant effect of Sentence Type, nor a significant interaction between Sentence Type and Agent type, the answer to both of these questions is no. However, it is telling that the only condition in which children failed to map the novel verb at Test was the Dropped Subject-Same Gender condition, which suggests that the confluence of these two factors did have an effect on learning. This result is somewhat puzzling at first glance. The Dropped Subject conditions offer less useful information than the Overt Subject conditions, to be sure, and therefore we might expect children to struggle in them more, but in the Same Gender Agent conditions (unlike the Different Gender Agent conditions), having this overt subject would not have helped to distinguish the two scenes anyway.

One possibility is that in a visual situation like the one we presented in the Same Gender Agent conditions, children expect *more* information, rather than less. That is, an informative interlocutor would not drop the subject simply because both subjects are from the same basic-level category, but would rather provide more modifying information (e.g., "the girl with the red shirt") to support disambiguation. We chose our manipulations only after careful consideration that the sentences we provided were natural; the native Korean speakers among our co-authors as well as other Korean speakers confirmed that the dropped subject was not unnatural given the context. However, it remains an empirical question whether caregivers would prefer more disambiguating information or a dropped subject in these scenarios, a question we leave for future work. Unfortunately, however, based on other work with both English learners (He, Kon, & Arunachalam, 2020) and Korean learners (He et al., in prep) at the same ages in a very similar experimental paradigm, it may be that even if we had provided more information in the form of a modified subject, children would not have been able to make use of it. In these studies, children heard a novel verb preceded by a modified subject (e.g., "The tall girl is gorping"). Children

looked to the referent of the subject (e.g., the tall girl) on hearing the sentence, but failed to identify a new exemplar of the novel verb at test; they succeeded with an unmodified subject (e.g., "The boy is gorping"). This suggests that modified subjects pose a high processing demand that limits children's abilities to learn a new word in the same sentence. Thus, the processing demands of additional modifying information may outweigh the possible benefit it could confer.

The eye gaze data are consistent with the pattern shown in the pointing accuracy data, but add an interesting additional perspective. Although Korean learners failed to map the novel verb at Test in the Dropped Subject-Same Gender condition, they did identify the target in the Familiarization phase. As evident in Figure 6, which shows Korean-acquiring children's gaze behavior in all four conditions, children in this condition did look at the target, if anything more than in the Dropped Subject-Different Gender condition, but they take longer to show a preference for it than in the Overt Subject conditions. Recall that children had already heard the entirety of the sentence before their gaze was measured; therefore, this delay is not in response to the unfolding of the sentence itself; instead, it indicates that children took longer to find the target scene when the only information they had access to was the object. This delay to identify the target scene would, however, mean that children have less time to establish a representation for the novel verb. Why, then, did children successfully do so in the Dropped Subject-Different Gender condition but not the Dropped Subject-Same Gender condition? We think that, as we surmised in Arunachalam et al. (2013), children need a robust representation of the referent event in order to learn the novel verb. The Same Gender Agent condition offered a less rich situation model—in a visual/conceptual sense—just as the dropped arguments condition offered less rich information to 24-month-olds in Arunachalam et al. (2013).

We note three limitations of the current study. One is the relatively small sample size for

the Korean sample; although this sample size is relatively common in syntactic bootstrapping studies (Cao & Lewis, 2021), it is important for future studies to incorporate larger samples so that effect sizes can be properly estimated.

The second is that the age range we chose for the current study was old enough that children performed relatively well in almost all conditions, and it is therefore difficult to draw conclusions about the precise developmental trajectory along which verb learning abilities increase over the preschool years. We intentionally chose to study older children than in prior work, but the current results taken together with results from 24-month-olds in Arunachalam et al. (2013) suggest that we should study 3-year-olds to see precisely when children's abilities to learn novel verbs in a variety of situations expand.

The third limitation is that we did not fully parallel the manipulation in Arunachalam et al. (2013) because we added overt objects to the sparser, Dropped Subject conditions, to better mimic the linguistic contexts in which Korean learners hear verbs in naturalistic child-directed speech. However, while this limits our ability to draw inferences about Korean learners' abilities to learn in sparse linguistic conditions, it does not affect the main conclusion we draw, which is about Korean learners' success in the Overt Subject conditions.

Despite these limitations, the current study demonstrates that by 4 years of age, both Korean and English learners have practiced parsing abilities and are adept at syntactic bootstrapping in ways they were not just a couple of years earlier. These results therefore reveal a possible pathway along which learners achieve the same learning trajectories across languages despite early differences in which learning situations they can and cannot benefit from.

Taken together, our results are consistent with the picture laid out in He and Arunachalam (2017), in which children need a certain amount of information to solve verb

learning tasks (e.g., the Korean condition in which subjects were dropped and only the object disambiguated between the two scenes was insufficient to lead to success in the task). Unlike evidence from younger children (Arunachalam et al., 2013; He & Lidz, 2016) who struggle with processing linguistic contexts that contain a lot of semantic information, in the current study, we found no evidence that processing posed a difficulty. Thus, as children develop, their processing abilities improve, and the range of linguistic contexts they can take advantage of to acquire verb meanings increases.

Our results add to a relatively small but robust literature showing cross-linguistic similarities in verb learning (e.g., Arunachalam, Syrett, & Chen, 2016; Childers et al., 2017; Göksun, Küntay, & Naigles, 2008; Kon, Göksun, Bagci, & Arunachalam, 2015; Imai et al., 2008; Jin & Fisher, 2014; Lee & Naigles, 2008; Matsuo, Kita, Shinya, Wood, & Naigles, 2011; Papafragou & Selimis, 2010; Waxman et al., 2016), although we caution that to date a very small percentage of languages has been studied (e.g., Kidd & Garcia, 2022). Although the specifics of the amount of information children can process, and the amount of information they need, differ across languages, we see similar patterns across development. The evidence from younger children suggests differences—young English learners appear to need more information, in the form of lexical content nouns, in this verb learning task, and can also process these when they occur in SVO order (e.g., Arunachalam & Waxman, 2015), while young learners of languages that allow argument drop, such as Japanese and Korean, may both need less information (e.g., Imai, Haryu, & Okada, 2005; Imai et al., 2008) and also have difficulty processing SOV sentences with overt arguments (Arunachalam et al., 2013). But, learners of both language types appear to arrive at the same destination by 4 to 5 years of age, as they are able to both process more information and benefit from less. Thus, while syntactic bootstrapping in 2-year-olds may

be somewhat limited to a small range of linguistic contexts that support learning (Horvath & Arunachalam, 2019), older children are much more flexible learners.

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Appendix

Description of stimuli in one condition

Novel Word (in IPA)	Familiarization Scenes		Test Scenes	
	Left	Right	Left	Right
/sɛm/	Boy passing eraser from hand to hand	Boy tossing apple (target)	Woman tossing Rubik's cube (target)	Woman passing Rubik's cube from hand to hand
/blɪk/	Girl tapping frying pan	Girl waving spoon (target)	Man tapping marker	Man waving marker (target)
/laɹp/	Girl folding sock in half (target)	Girl pushing book	Man pushing piece of paper	Man folding piece of paper in half (target)

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